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Info-Crop Model : A Tool of Yield Forecasting under Climate Change Scenario

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Abstract

Crop modeling has been applied by advanced countries in many research areas, such as geology, meteorology, climate change, crop productivity, environmental studies and land erosion. The crop model simulates the production processes of agriculture. The writing of this article is descriptive and qualitative using the Systematic Literature Review (SLR) method. Each model has its advantages and disadvantages but generally based on the physiology of the growth and development of crops in relationship with soil, climate, solar radiation energy, and various factors that hinder the plant growth. There have been many models for wheat that can forecast yield and biomass and predict future climate change dynamics on wheat. Meanwhile models need more data to operate their modeling, which in many cases data is not readily available. In this review, we would like to introduce the model Info-crop which will help in impact, adaption and vulnerable studies in agriculture

Key words : *Climate change, Info Crop, validation, simulation.*

Introduction

Environmental conditions have a detrimental effect on crop growth, development as well as yield. Crop yield influenced by several factors like climatic, edaphic, biological and management practices. The relationship between weather and crop production has been under stood through crop weather modeling and study on this aspect in a systematic manner started a century ago while in India it was initiated less than six decades ago. The understanding of the interactions between weather, soil, and management practices using simulation modeling. However, crop modeling is a modern tool for simulating or predicting plant growth and yield in the field and assessing climate change's impacts. Crop growth model is a very effective tool for predicting possible impacts of climatic change on crop growth and yield. Crop growth models are advantageous for solving various practical problems in agriculture. Adequate human resource capacity has to be improved to develop and validate simulation models across the globe. The crop simulation models are useful tools for considering the complex interactions between a range of factors that affect crop performance, including weather, soil properties and crop management (Shamim *et a*l., 2012). ***InfoCrop***- a crop simulation model is used to study the impact and adaptation of climate change on mustard, sorghum and maize to climate change in India. Model has been validated for dry matter and grain yields of several annual crops, losses due to multiple diseases and pests, and emissions of carbon dioxide, methane and nitrous oxide in a variety of agro environments.

Materials and Methods

Model description : The model InfoCrop (Aggrawal *et al.*, 2004) is a generic crop growth model which simulates the processes such as crop growth and development (phenology, photosynthesis, partitioning, leaf area growth, storage organ numbers, source: sink balance, transpiration, uptake, allocation and redistribution of nitrogen), effects of water, nitrogen, temperature, flooding and frost stresses on crop growth and development, crop-pest interactions (damage mechanisms of insects and diseases), soil water balance, soil nitrogen balance, soil organic carbon dynamics, emissions of greenhouse gases and climate change module.

Model inputs requirement

1. Weather : The daily weather data on maximum and minimum air temperature (°C), solar radiation (MJ m^{-2} day^{-1})/sun shine hours (h), wind speed and precipitation.

2. Site data : latitude, longitude, altitude of site.

3. Soil data : soil layer thickness, field capacity, wilting point, hydraulic conductivity, sand, clay, bulk density, soil organic carbon, EC, PH.

4. Cultivar coefficients: InfoCrop distinguishes varieties of a crop by their differences in phenology, growth and source: sink balance. In most cases, thermal times of three phenological phases, the sensitivity to photoperiod, early vigour (defined in the model as relative LAI growth rate during initial stages), index of storage organs formation (slope of the relation between SO and growth during SO formation stage), and the potential weight of the storage organs were sufficient to adequately characterize the varieties.

5. Plant data : seed rate, date of sowing, date of emergence, date of anthesis, date of physiological maturity, LAI, dry matter, grain number, grain weight etc.

6. Management data : date and amount of irrigation, date and amount of fertilizer application, sowing depth, cultivar coefficients

Calibration and validation of model : The model InfoCrop calibrated by computing the phenological and genetic coefficient of crop cultivars evaluated from the region. The parameters involved growing degree days, potential grain weight, potential grain filling rate and final grain number per unit weight, dry matter accumulation.

To test the accuracy of model with the parameters used, the model was run with observed crop management data from field, weather and soil data and calibrated cultivar genotypic coefficients, the predicted wheat grain yield were compared with actual grain yield. Different statistical tools were used to evaluate the performance of the model in predicting various parameters. The statistical analysis of Ambrose and Rosech (1982) was used to calculate the average error or Bias (Eqn. 1) and root mean square error (Eqn. 2) between the simulated and observed values. Normalized RMSE (nRMSE) gives a measure (%) of the relative difference of simulated versus observed data. The simulation is considered excellent with a normalized RMSE (Eqn. 3) is less than 10%, good if the normalized RMSE is greater than 10% and less than 20%, fair if normalized RMSE is greater than 20 and less than 30%, and poor if the normalized RMSE is greater than 30% (Jamieson *et al.,* 1991). M is the mean of observed variable. The index of agreement (d) proposed by (Willmott *et al*., 1985) was estimated in (Eqn.4). According to the d-statistic, the closer the index value is to one, the better the agreement between the two variables that are being compared and vice versa.

$$Bias \quad \sum_{i=1}^{n} (Si - Ob) / n \qquad \text{Eqn. 1}$$

$$RMSE \quad \sum_{i=1}^{n} \sqrt{(Si - Ob)^2} / n \qquad \text{Eqn. 2}$$

$$nRMSE \quad \sum_{i=1}^{n} \sqrt{(Si - Ob)^2} / n \quad \frac{100}{M} \qquad \text{Eqn. 3}$$

$$d \quad 1 \quad \sum_{i=1}^{n} \frac{(Si - Ob)^2}{(|S_i| \quad |O_b|)^2} \qquad \text{Eqn. 4}$$

Whereas,

$$S_i = Si - M$$

$$O_b = Ob - M$$

n, is the number of observations

Si, is the simulated values

Ob, is the observed values

M, is the mean of observed variable

Climate Change Impact Assessment using InfoCrop model : The impact of future climate change on grain yield of crops can be studied using InfoCrop simulation model. Scenarios derived from different Regional Climate Model and GCM can be used to depict the impact of climate change on crop production.

Simulation of temperature, CO_2 and rainfall using InfoCrop model : In the model, the total crop growth period is divided into following three phases *viz.*

(a) Sowing to seedling emergence.

(b) Seedling emergence to anthesis.

(c) The storage organ filling phases.

Aggarwal *et al* (2010) mentioned that in the InfoCrop model, change in temperature, CO_2, and rainfall are simulated as follows

1. The overall crop growth and development of a crop is calculated by integrating the temperature-driven development rates i all the phases. There is linear relationship between the rate of development and the daily mean temperature above base temperature up to the optimum temperature. Therefore, an increase in temperature generally accelerates phenology based on the threshold temperature of a location and hence the crop duration is reduced.

2. Dry matter (DM) production is a function of radiation use efficiency (RUE), photosynthetically active radiation (PAR), total leaf area index (LAI) and specific light interception coefficient of cultivar.

3. In the initial stages of crop growth, leaf area formation is controlled by temperature. The senescence of leaves is also dependent on temperature.

4. Potential evapo-transpiration (PET) is influenced by temperature. The water stress is determined as the ratio of actual water uptake and potential transpiration. It accelerates phenological development, decreases gross photosynthesis, alters the allocation pattern of assimilates to different organs and accelerates the rate of senescence.

5. Whenever there is any deviation from threshold values of maximum and minimum temperature during a short period between anthesis and a few days afterwards, a part of the storage organ becomes sterile. This reduces the number of storage organs.

6. The influence of rainfall is operated in the model through soil water balance.

Results and Discussion

A number of studies on climate change impact on various crops production around the world. Boomiraj *et al*. (2013) reported yield reduction in future climate change

scenarios in different locations of India, primarily attributed to reduction in crop growth period with rise in temperature in irrigated mustard. Under irrigated condition the yield reduction in 2020, 2050 and 2080 would be highest in eastern-IGP (19.8%, 50.2%, 67.3% in A1, 9.9%, 37.4%, 63.1% in A2 and 20.3%, 49.6% and 55.3% in B2) region followed by Central-IGP. This would be due to maximum projected rise in mean temperature in 2080 in eastern-IGP. Pidgeon *et al*. (2001) also reported that changes in climate affect crop radiation use efficiency (RUE). Spatial variation in temperature as well as rainfall and its distribution led to spatial variation in yield reduction. This study support the recent report of the IPCC and a few other global studies which indicate a probability of 10- 40% loss in crop production in India with increase in temperature by 2080-2100 (Fischer *et al*., 2002, Parry *et al*., 2004; IPCC, 2007). Simulation study conducted by Singh *et al*. (2008) also revealed that with rise in temperature, rain becomes deciding factor in regulating crop production. It is envisaged that the increase in temperature, if any, may be compensated by increase in rainfall.

Temperatures greater than 34°C have been found to decrease wheat yields by up to 50% due to increased leaf senescence (Asseng, 2011). An increase in winter temperature of 0.5°C would thereby translate into a 10% reduction in wheat production in the high yield states of northern India (Sinha and Swaminathan, 1991). Similar trend in wheat yield with increase in temperature using DSSAT was also reported by (Patil, 2009).

Prajapat *et al*., (2019) reported that the simulations showed that increasing the temperature by 1 °C from the baseline, there was decrease in grain yield and total biomass by 3.32% and 6.13%, respectively. Further increasing the temperature by 3 and 5 °C from the baseline scenario, the grain yield was estimated to be reduced by 19.17% and 37.72%, respectively. Similarly the estimated biomass yield was reduced by 22.69% and 41.43% under same magnitude change in temperature from the baseline. While, elevated CO_2 levels from 369 to 650 ppm, the grain yield of wheat was increased by 9.25%, whereas the biomass yield was increased by 13.27%.

(Leakey, 2009) who reported that in future increased crop yield might be due to fertilization effect of raising CO_2. A positive interaction between elevated CO_2 and high temperature on photosynthesis of C plants has been reported by some investigators (Borjigidai., 2006). Even though elevated CO_2 can mitigate the detrimental effects of the above-optimal temperatures on crop growth and yield, certainly temperatures near the upper limit for crops will negatively affect yields, regardless of CO_2 concentration (Polley, 2002). Several authors have reported interactive effects of temperature and CO_2 on wheat biomass (Mitchell., 1995) but the direction of the effects was not always the same or it varied from year to year. Thus, increase in CO_2 to some extent offset the negative effect of temperature (Anwar., 2007). (Lal, 1998) found that under elevated CO_2 levels, yields of wheat increased significantly 28% for a doubling of CO_2.

(Lobell, 2012) stated that with temperature increase, the yield of C_3 crops like wheat would decrease but with elevated CO_2 level photosynthesis would increase and that may compensate the negative effect of temperature. Yield gain moderated with increased CO_2 concentration at an elevated temperature, and in some cases decreased under a reduced rainfall scenario (Luo, 2003) in case of rainfed wheat. In India, Attri and Rathore (2003) observed that an increase of 1.0 C temperature and a doubling of the atmospheric CO_2 concentration could increase wheat yields by 29 – 37%. However, they found that further increases in temperature (beyond 3 C) would negate the beneficial impacts of enhanced CO_2, and wheat yield would decrease by 20%. Others have also reported similar results on wheat in India. (Pathak 2003; Lal, 1998).

Conclusions

Results from this simulation review study support the adverse impacts of future anticipated climate change on mustard, maize and sorghum and wheat growth and yield. But at the same time the yield gap among all crops in India is wider. Bridging the yield gap through available technology, the climate change effect could be nullified to ensure the food security in India. Future climate change studies should consider the uncertainties and limitations for crop simulation modeling and climate change scenarios. The assessment of climate change on Indian agriculture need to be more precise and provide sound basis for regional policy planning.

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Efficacy of Bioagents and Fungitoxicants against *Colletotrichum capsici* (Syd.) Butler and Bisby Causing Anthracnose of Chilli

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Abstract

Anthracnose disease of chilli is assuming the status of major disease in Kashmir. During the present investigation attempts were made to manage the disease by the use of bioagents as well as fungitoxicants. Dual culture studies revealed that the *Pseudomonas fluorescens* exhibited highest mycelial growth inhibition percentage (79.08%) of causal pathogen, followed by *Trichoderma harzianum* (72.78%), *T. viride* (61.91%) and *Bacillus subtilis* (37.96%). Among systemic fungitoxicants, flusilazole 40 EC proved to be the most effective with 86.01 per cent inhibition of mycelial growth and among non-systemic fungitoxicants metiram 55% + pyraclostrobin 5% was the most effective with 92.80 per cent inhibition of mycelial growth of test fungus. The treatments found most promising under *in vitro* studies when tested under field conditions in different combinations, treatment combination of seed treatment and seedling dip with *P. fluorescens* and two foliar sprays of metiram 55% + pyraclostrobin 5% @ 0.1% at 20 days interval starting from the initiation of the disease, proved most effective with least disease incidence (12.00%), intensity (3.60%) and maximum yield (4.80 kg/plot).

Key words : *Anthracnose, bioagent, chilli, Colletotrichum capsici, fungitoxicants.*

Introduction

Chilli (*Capsicum annuum* L.) a native of tropical America is grown throughout the world including tropics, subtropics and temperate regions (Pickersgill, 1997). The crop is grown for its green and red ripe fruits and forms an indispensable adjuvant almost in every household due to its pungency, spicy taste, appealing odour and flavours. It is used as a vegetable in several preparations. In India, chilli is cultivated over an area of 0.869 million hectares with an annual production of 1.446 million tonnes of ripe dry chillies (Anonymous, 2014a). In Jammu and Kashmir state chilli is cultivated over an area of 3.20 thousand hectares with an annual production of 64.00 thousand tonnes/annum (Anonymous, 2014b). Chilli is subjected to many fungal, bacterial and viral diseases *viz*., anthracnose/fruit rot (Saxena *et al*., 2014), Fusarium wilt, damping-off (Koike *et al*., 2007), Cercospora leaf spot (Cerkauskas, 2004), Phytophthora blight (Sanogo and Carpenter, 2006), Powdery mildew (Glawe *et al*., 2010), Bacterial spot (Abbasi *et al*., 2002) etc. affecting its yield potential and considerably limit their profitable production. Among these anthracnose incited by *Colletotrichum capsici* (Syd.) Butler & Bisby is thought to be the major constraints in production of chili crop. The pathogen *C. capsici* attacks mature fruits and the young twigs of chilli causing fruit rot and dieback, respectively (Than *et al*., 2008). The disease has been noticed on chilli in Kashmir regularly for the last few years inflicting heavy losses thereby warrants immediate action of plant pathologists. Control of plant disease by chemicals can be spectacular but this is relatively a short-term measure and moreover, the accumulation of harmful chemical residues sometimes cause ecological problems. In recent years, the increasing use of potentially hazardous pesticides and fungicides in agriculture has been the growing concern of both environmentalists and public health authorities. Moreover, use of such chemicals entails a substantial cost to the nation and developing country like India cannot afford it. The most efficient and cost-effective strategy to mitigate the menace of chilli anthracnose disease is therefore to integrate other non-chemical eco-friendly management strategies with chemical methods in order to manage the disease with reduced use of chemicals.

Materials and Methods

The present study was conducted in the Division of Plant Pathology, Faculty of Horticulture and Division of Plant Protection, Faculty of Agriculture, SKUAST-Kashmir.

***In vitro* evaluation of bioagents :** The bioagents *viz*., *Trichoderma viride*, *T. harzianum* and *Pseudomonas fluorescens* that were available with Seed Technology Laboratory, AICRP, NSP (Crops), SKUAST-Kashmir

Shalimar Campus and *Bacillus subtilis* available with Biofertilizer Laboratory, Faculty of Agriculture, SKUAST-Kashmir, Wadura were evaluated against *C. capsici* under *in vitro* conditions. The tested bioagents were maintained on PDA and periodically sub-cultured at monthly intervals. Antagonistic effect of the fungal and bacterial bioagents against the mycelial growth of *C. capsici* was investigated by dual culturing method of Zaidi and Singh (2003) in Petri-dishes containing PDA medium. For fungal bio-agents, each plate was divided into two equal halves, one half was inoculated with a disc (5 mm-diameter) of the antagonistic fungus taken from 7 days old culture, the opposite half was inoculated with a disc taken from 7 days old culture of the pathogenic fungus. For bacterial bioagents a 5 mm disc of pathogenic fungus was placed at the centre of a PDA plate between two parallel streaks of the test bacterial bioagent. Five replications were maintained for each treatment. The Petri plates were incubated at 25±1°C and observation on mycelial growth of tested fungus recorded after seven days of incubation. The growth of the test fungus on PDA without inoculation of bioagent served as check. The per cent inhibition in growth due to various bioagents was computed by the following formula of Vincent (1947).

Percent inhibition

$$= \frac{\text{Germination in check - Germination in treatment}}{\text{Germination in check}} \quad 100$$

***In vitro* evaluation of fungitoxicants :** Eight fungitoxicants were evaluated at three concentrations *viz*., 50, 100 and 200 µg ml^{-1} for systemic and 500, 1000 and 2000 µg ml^{-1} for non-systemic/combination fungicides against the test fungus by poisoned food technique (Nene and Thapliyal, 1993). Appropriate quantity of each fungicide was separately dispensed in molten sterilized PDA medium, contained in 100 ml Erlenmeyer flasks, under aseptic conditions to make a desired concentration. After thorough mixing, 20 ml of poisoned food, thus prepared, was poured in 90 mm diameter Petri plates. The mycelial discs of 5 mm diameter taken from 7 days old monosporic culture of the test fungus with the help of sterilized cork borer, were aseptically placed at the centre of solidified poisoned PDA. Five replications were maintained for each concentration. The Petri plates were incubated at 25±1°C and observation on mycelial growth of test fungus recorded after seven days of incubation. The growth of the test fungus on non-poisoned PDA served as check. The per cent inhibition in growth due to various fungitoxicant treatments at different concentrations was computed as per the formula of Vincent (1947).

***In vivo* management of the disease :**Among the four biocontrol agents and eight fungitoxicants evaluated under *in vitro*, two most effective bioagents and two most effective fungitoxicant one each from systemic and non-systemic/combination group were selected for their efficacy against the disease under field conditions. Two most effective biocontrol agents were used as seed treatment and seedling dip whereas the two effective fungitoxicants were used as spray. Two fungicidal sprays were given at 20 days interval starting from the initial appearance of the disease. The experimental trial conducted in randomized block design consisted of 7 treatments, each replicated thrice, was laid at Research Farm of Faculty of Agriculture, SKUAST-Kashmir, Wadura campus during cropping season, 2015. The treatments comprised of :

T_1 : Seed Treatment (4 ml/kg seed) + Seedling dip (10 ml/litre of water) with *Pseudomonas fluorescens*

T_2 : Seed Treatment (4 gm/kg seed) + Seedling dip (10gm/litre of water) with *Trichoderma harzianum*

T_3 : T_1+ two sprays of Metiram 55% + Pyraclostrobin 5% @ 0.1%

T_4 : T_2+ two sprays of Metiram 55% + Pyraclostrobin 5% @ 0.1%

T_5 : T_1+ two sprays of Flusilazole 40EC @ 0.02%

T_6 : T_2+ two sprays of Flusilazole 40EC @ 0.02%

T_7 : Check (Water spray)

After fifteen days of last spray, ten plants were randomly selected from each plot for recording observations on disease incidence and intensity. The observation with respect to yield was recorded at the time of harvest.

Per cent disease incidence was calculated by using the following formula :

% disease incidence

$$= \frac{\text{No. of diseased plants}}{\text{Total No. of plants examined}} \quad 100$$

Per cent disease intensity was recorded by using slightly modified 0-5 scale of Dasgupta (1981); where,

Category	Numerical value	Criterion
I	0	Healthy
II	1	1-2% fruit/twig area involved
III	2	2.1-5% fruit/twig area involved
IV	3	5.1-10% fruit/twig area involved
V	4	10.1-25% fruit/twig area involved
VI	5	> 25% fruit/twig area involved

Table-1 : *In vitro* efficacy of various bioagents in inhibiting the mycelial growth of *Colletotrichum capsici.*

Treatments	Average radial growth of *C. capsici* (mm)	Inhibition percentage of radial growth
Pseudomonas fluorescens	18.82	79.08 (8.94)*
Trichoderma harzianum	24.49	72.78 (8.59)
Trichoderma viride	34.28	61.91 (7.93)
Bacillus subtilis	55.83	37.96 (6.24)
Control	90.00	-
CD (p=0.05)		0.096

*Figures in the parenthesis are square root transformed values.

Table-2 : *In vitro* efficacy of various non-systemic fungitoxicants in inhibiting the mycelial growth of *Colletotrichum capsici.*

Treatments	Per cent inhibition			Mean
Conc. (ppm)	500	1000	2000	
Metiram 55% + Pyrachlostrobin 5%	86.88* (9.37)	91.52 (9.61)	100 (10.05)	**92.80** (9.68)[a]
Captan 70% + Hexaconazole 5%	85.01 (9.27)	87.25 (9.39)	92.00 (9.64)	**88.08** (9.43)[b]
Captan 50WP	83.61 (9.19)	86.70 (9.36)	91.13 (9.59)	**87.10** (9.38)[c]
Copper Oxychloride 50WP	76.56 (8.80)	82.10 (9.11)	84.94 (9.27)	**81.20** (9.06)[d]
Mean	83.01 (9.16)[C]	86.89 (9.37)[B]	92.01 (9.64)[A]	

*Mean of five replications; figures in parentheses are square root transformed values
CD (p=0.05) Fungitoxicant = 0.045, Concentration = 0.039, Fungitoxicant X conc. = 0.079

Table-3 : *In vitro* efficacy of various systemic fungitoxicants in inhibiting the mycelial growth of *Colletotrichum capsici.*

Treatments	Per cent inhibition			Mean
Conc. (ppm)	50	100	200	
Flusilazole 40 EC	83.75*	86.22	88.06	**86.01**
Hexaconazole 5 EC	77.33	82.73	86.40	**82.15**
Carbendazim 50 WP	75.74	81.85	84.53	**80.70**
Myclobutanil 10 WP	72.90	77.06	82.16	**77.37**
Mean	77.43	81.96	85.28	

*= Mean of five replications
CD (p=0.05) Fungitoxicant = 0.82, Concentration = 0.71, Fungitoxicant × concentration = 1.43

Table-4 : Effect of seed and seedling treatment with bioagents and fungicidal sprays on anthracnose of Chilli.

Treatment	Percent disease				
	Incidence	Control	Intensity	Control	Av. yield (kg/plot)
T_1 [Seed treatment (4ml/ kg seed) + seedling dip of *Pseudomonas fluorescens* (10ml/litre water)]	22.00 (4.79)*	45.00 (6.78)*	7.60 (2.93)*	54.76 (7.46)*	2.60
T_2 [Seed treatment (4g/ kg seed) + seedling dip of *Trichoderma harzianum* (10g/litre water)]	24.00 (4.99)	40.00 (6.40)	8.80 (3.13)	47.61 (6.97)	2.10
T_1 + two sprays of Metiram 55% + Pyraclostrobin 5% @ 0.1%	12.00 (3.60)	70.00 (8.42)	3.60 (2.15)	78.57 (8.92)	4.80
T_1 + two sprays of Flusilazole 40 EC @ 0.02%	14.00 (3.87)	65.00 (8.12)	5.20 (2.49)	69.04 (8.34)	4.00
T_2 + two sprays of Metiram 55% + Pyraclostrobin 55% @ 0.1%	14.00 (3.87)	65.00 (8.12)	5.60 (2.57)	66.66 (8.22)	3.80
T2 + two sprays of Flusilazole 40EC @ 0.02%	16.00 (4.12)	60.00 (7.81)	6.00 (2.64)	64.28 (8.10)	3.50
Control (water spray)	40.00 (6.40)	-	16.80 (4.22)	-	1.20
C.D (p = 0.05)	0.185	0.105	0.054	0.175	0.054

*Figures in the parenthesis are square root transformation value

Per cent diseases intensity was calculated as per the following formula :

$$PDI = \frac{\text{Sum of all numerical ratings}}{\text{No. of fruits observed} \quad \text{Maximum disease grade}} \quad 100$$

Results and Discussion

The results on effect of biocontrol agents against the mycelial growth of *Colletotrichum capsici* are presented in Table-1. The results revealed that on an average, maximum inhibition in mycelial growth of the test pathogen was exhibited by *Pseudomonas fluorescens* (79.08%) followed by *Trichoderma harzianum* (72.78%) and *Trichoderma viride* (61.91%). The least inhibition of 37.96 per cent in mycelial growth of the test pathogen was exhibited by *Bacillus subtilis*.

The data on *in vitro* efficacy of non-systemic/ combination fungitoxicants tested at 500, 1000 and 2000 ppm concentrations against mycelial growth of *C. capsici* is presented in Table-2. Perusal of data revealed that all the fungitoxicants at all the concentrations significantly inhibited the mycelial growth of *C. capsici*. Metiram 55% + Pyraclostrobin 5% proved significantly superior to other fungitoxicants exhibiting 92.80 per cent mycelial growth inhibition, followed by Captan 70% + Hexaconazole 5% (88.08%) and Captan 50 WP (87.10%). Copper oxychloride 50 WP proved least effective with mycelial growth inhibition of 81.20%. Comparing the various concentrations used, all the fungitoxicants showed increasing trend in mycelial growth inhibition with increase in their concentration. Average mycelial growth inhibition of 83.01 per cent was recorded at 500 ppm which increased to 86.89 and 92.01 per cent at 1000 and 2000 ppm, concentration, respectively. At 500 ppm concentration, Metiram 55% + Pyraclostrobin 5% showed maximum mycelial growth inhibition (86.88%) followed by Captan 70% + Hexaconazole 5% (85.01%), Captan 50 WP (83.61%) and least inhibition of 76.56 per cent was exhibited by copper oxychloride 50 WP. A similar trend was exhibited by all the treatments, when assayed at 1000 and 2000 ppm concentration.

The effect of systemic fungitoxicants at 50, 100 and 200 ppm concentrations on the mycelial growth of *C. capsici* is presented in Table-3. The data revealed that all the test fungitoxicants at all the concentrations significantly inhibited the mycelial growth of *C. capsici*. On an average, maximum inhibition in mycelial growth (86.01%) was exhibited by Flusilazole 40 EC followed by Hexaconazole 5 EC (82.15%) and Carbendazim 50 WP (80.70%). A minimum inhibition of 77.37 per cent in mycelial growth of test pathogen was exhibited by Myclobutanil 10 WP. Comparing the various concentrations used, all the fungitoxicants showed increasing trend in mycelial growth inhibition with increase in their concentration. Average mycelial growth inhibition of 77.43 per cent was recorded at 50 ppm concentration, which increased to 81.96 and 85.28 per cent at 100 and 200 ppm concentration, respectively. At 50 ppm concentration, Flusilazole 40EC showed maximum (83.75%) inhibition in mycelial growth followed by Hexaconazole 5 EC (77.33%) and Carbendazim 50 WP (75.74%) whereas least inhibition of 72.90 per cent was exhibited by Myclobutanil 10 WP. Similar trend in inhibition of mycelial growth was observed at 100 and 200 ppm concentrations.

The data on the effect of different treatments on incidence of chilli anthracnose on fruits revealed that all the treatments significantly reduced the incidence as compared to control (Table 4). Seed and seedling dip with *P. fluorescens* plus two foliar sprays of Metiram 55% + Pyraclostrobin 5% @ 0.1% proved superior over all other treatments with 12.0 per cent disease incidence as against 40.0 per cent observed in control. The next effective treatment combinations were seed treatment and seedling dip with *P. fluorescens* plus two foliar sprays of Flusilazole 40 EC @ 0.02% and seed treatment and seedling dip with *T. harzianum* plus two foliar sprays of Metiram 55% + Pyraclostrobin 5% with 14.0 per cent disease incidence recorded in both of these treatments. The least effective treatment combination was seed treatment and seedling dip with *T. harzianum* with 24.0% disease incidence. The data on efficacy of different treatments on disease intensity is presented in Table 4. It indicates that all the treatments recorded significantly lower disease intensity compared to control. Seed treatment and seedling dip with *P. fluorescens* in combination with two folair sprays of metiram 55% + pyraclostrobin 5% @ 0.1% was most effective treatment combination exhibiting 3.6 per cent disease intensity as against 16.8 per cent in control. The next effective treatment combinations were seed treatment and seedling dip with, *P. fluorescens* followed by foliar sprays of Flusilazole 40 EC @ 0.02%, seed treatment and seedling dip with *T. harzianum* in combination with foliar sprays of metiram 55% + pyraclostrobin 5% with disease intensity of 5.2 and 5.6 per cent, respectively. Seed treatment and seedling dip with *T. harzianum* without any fungicidal spray was the least effective treatment which recorded 7.60 per cent disease intensity.

Data on effect of various treatments on yield of chilli is presented in Tables-4. Perusal of data revealed that all the treatments significantly increased fruit yield compared to 1.20 kg/plot observed in control. Seed treatment and seedling dip with *P. fluorescens* in combination with two foliar sprays of metiram 55% + pyraclostrobin 5% produced the highest yield of 4.80 kg/plot which was

followed by treatment combination seed treatment and seedling dip with, *P. fluorescens* followed by foliar sprays of Flusilazole 40 EC and seed treatment and seedling dip with *T. harzianum* in combination with foliar sprays of metiram 55% + pyraclostrobin 5% with yield of 4.00 and 3.80 kg/plot, respectively. The least effective treatment with 2.10 kg/plot yield was seed treatment and seedling dip with *T. harzianum* when no fungicidal spray was given.

Biological control is gaining interest as an alternative or complement to chemical treatment in integrated disease management strategies. Besides being un-economical, chemical control of the disease embodies its ill effects, necessitating the need to find out some alternative measures of disease management. Therefore, in the present study, attempts were made in identifying the effective bioagents against *C. capsici*, the incitant of the anthracnose of chilli. The *in vitro* studies on screening of bioagents against *C. capsici* by dual culture method clearly revealed that among bacterial bioagents *P. fluorescens* exhibited maximum per cent mycelial growth inhibition followed by *B. subtilis*. The present findings are in consonance with Linu and Jisha (2013) who reported highest mycelial inhibition by *P. fluorescens*. Similar findings were put forth by Chacko and Gokulapalan (2014). Among the fungal biocontrol agents *T. harzianum* exhibited maximum per cent mycelia growth inhibition followed by *T. viride*. The present findings are in consonance with Reena *et al.* (2013) who found *T. harzianum* followed by *T. viride* superior in inhibiting the radial mycelial growth of *C. capsici* under *in vitro* conditions. Similar findings were put forth by Rahman *et al.* (2013). This might be ascribed to the production of various lytic enzymes and volatile/non-volatile substances with antifungal activity by the fungal bio-agents. Different lytic enzymes and volatile/non-volatile substances like harzianic acid, almethicins, tricholin, peptaibols, antibiotics, massoilectone, viridin, gliovirin, heptelidic acid etc. have been reported to be released by fungal bioagents (Vey *et al.*, 2007).

Chemical management is still widely used for the control of plant disease. The studies revealed that among systemic and non-systemic fungitoxicants, Flusilazole 40 EC and Captan 50WP proved most effective and among combinations fungicides Metiram 55% + Pyraclostrobin 5% proved most effective in inhibiting per cent mycelial growth. The superiority of Flusilazole 40 EC among systemic fungitoxicants observed in the present study is in agreement with the findings of Gopinath *et al.* (2006) who also recorded the promising activity of triazole fungicides as most effective against colony growth and sporulation of *C. capsici*. Captan 50 WP among non-systemic fungitoxicants was also found effective by Yadav *et al.* (2014). The high efficacy of combination fungitoxicants was also reported by Chacko and Gokulapalan (2014).

Field experiment was conducted to evaluate the efficacy two most effective bio-control agents and fungitoxicants found under *in vitro* conditions. All the treatments reduced the disease incidence and intensity over control. Similar results were observed by Anand *et al.* (2010) who found the combination treatment of *P. fluorescens* and propiconazole effective in reducing the incidence of chilli anthracnose. The present findings are also supported by the findings of Raj and Christopher (2009) who reported increased seedling vigour and lower disease incidence with seed treatment of *P. fluorescens.* The effectiveness of Metiram 55% + Pyraclostrobin 5% in combating the chilli anthracnose as found in the present study has been also reported by Machenahalli and Nargund (2015).

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Study on the Effect of Herbicides on Quality of Cut Flowers in Gladiolus (*Gladiolus Grandiflorus*)

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Abstract

The shift of farmers towards high-value floral crops and the increasing use of flowers in social and industrial contexts have made floriculture a lucrative venture. Manual weeding, a labor-intensive and costly practice for weed control, often results in crop damage. Globally, various weed control strategies, including preventive, cultural, mechanical, biological, and chemical methods, are employed in crops. Chemical control through herbicides has emerged as a recent and modern agricultural practice. The effectiveness of herbicide is decided by its specificity and mode of action under a soil conditions, its organic matter content, weather conditions and soil moisture prevailing at that particular area. Present study was conducted at college of Horticulture, Mudigere to study of herbicides on quality of cut flowers in gladiolus (*Gladiolus Grandiflorus*. Pre emergence emergence applications of herbicides improved the cut flower quality of Gladiolus plant. Pendimethalin at 1.0 kg a.i. / ha. applied as pre emergence herbicide significantly increased flower quality parameters of gladiolous cultivar summer sunshine (100.78cm).

Key words : *Gladiolus grandiflorus, herbicides, weeds, floriculture, floral crops.*

Introduction

Gladiolus (*Gladiolus grandiflorus*), otherwise known as "Sword Lily or queen of the bulbous plants is a popular ornamental bulbous plant originated in South Africa. Taxonomically placed under monocot family Iridaceae, (Lepcha *et al*., 2007). Iridaceae family includes perennial, rhizomatous bulbous plants distributed globally with greatest diversity in south Africa (Pragya *et al*, 2010). The genus gladiolus is comprised of about 265 species and is one of the largest genera of family Iridaceae. The Cape of Good Hope (South Africa) is considered to be the centre of diversity for the genus Gladiolus. It is distributed throughout the region of tropical Africa, Madagascar, Arabian Peninsula, Mediterranean basin, Europe and Asia, including Iran and Afghanistan.

Successful crop cultivation essentially encompasses all the cultural operations right from the planting to harvesting. Each and every operation must be carried out at right time in a right way to produce good crop. In gladiolus, menaces of weeds are well known. Weed management, one such cultural operation in any crop production practices requires special attention. Weeds are unwanted and undesirable plants which are compete with main crop for the utilization of land and water resources. Sometimes the losses caused by weeds exceed the losses caused by any other category of agricultural pests. Of the total annual loss in agriculture produce, weeds account for 45 per cent, insects 30 per cent, diseases 20 per cent and other pests 5 per cent.

Weeds remain highly competitive throughout the crop growth if left unmanaged. In gladiolus, however, the most critical period for crop weed competition is first six weeks after planting. It's already said that adverse effects caused by weeds on crop. Thus, it is crucial to initiate management practices to mitigate the initiation and further growth of the weeds. There are many weeding practices in vogue, both manual and mechanical, but, along with some inseparable consequences. Manual practices are time consuming, laborious and tedious, mechanical ones are hard to access and unaffordable to many farmers. Such unintended and indivisible outcomes necessitate search for other new better viable options for successful weed control. Considering all these factors, in the most highly mechanised era of 21st century, choosing a chemical weed control gives new hopes that it can be done efficiently with minimal cost in gladiolus.

Materials and Methods

The present investigation entitled "Study on effect of herbicides on quality of cut flowers of gladiolus (*Gladiolus grandiflora* L.) under hill zone of Karnataka", is carried out in the experimental block of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere. The experiment was laid out in Randomized Complete Block Design (RCBD) with 12 treatments and

Table-1 : Details of herbicides used for the experiment.

Treatment number	Treatment details
T_1	Atrazine @ 1.0 kg *a.i.* / ha
T_2	Atrazine @ 1.5 kg *a.i.* / ha
T_3	Metribuzin @ 0.25 kg *a.i.* / ha
T_4	Metribuzin @ 0.5 kg *a.i.* / ha
T_5	Butachlor @ 1.0 kg *a.i.* / ha
T_6	Butachlor @ 1.5 kg *a.i.* / ha
T_7	Pendimethalin @ 0.75 kg *a.i.* / ha
T_8	Pendimethalin @ 1.0 kg *a.i.* / ha
T_9	Oxyfluorfen @ 0.5 kg *a.i.* / ha
T_{10}	Oxyfluorfen @ 1.0 kg *a.i.* / ha
T_{11}	Weedy check
T_{12}	Weed free

Table-2 : Effect of different herbicides on flower quality parameters in gladiolus.

Treatment	Spike length (cm)	Rachis length (cm)	Number of florets per spike	Length of florets (cm)
T_1-Atrazine @ 1.0 kg a.i./ha	61.23	35.76	11.02	9.84
T_2-Atrazine @ 1.5 kg a.i./ha	63.29	36.03	11.13	10.03
T_3-Metribuzin @ 0.25 kg a.i./ha	60.08	33.82	10.54	8.92
T_4-Metribuzin @ 0.5 kg a.i./ha	52.33	32.78	10.21	9.79
T_5-Butachlor @ 1.0 kg a.i./ha	53.41	31.16	10.12	9.67
T_6-Butachlor @ 1.5 kg a.i./ha	55.09	33.51	10.31	9.41
T_7-Pendimethalin @ 0.75 kg a.i./ha	65.39	36.24	11.20	10.31
T_8-Pendimethalin @ 1.0 kg a.i./ha	65.91	38.94	11.50	10.92
T_9-Oxyfluorfen @ 0.5 kg a.i./ha	51.89	34.03	10.62	9.29
T_{10}-Oxyfluorfen @ 1.0 kg a.i./ha	52.34	34.18	10.87	9.32
T_{11}-Weedy check	50.81	30.02	9.54	8.53
T_{12}-Weed free	62.32	34.29	11.32	10.23
S.Em ±	1.76	1.52	0.50	0.42
CD @ 5%	5.16	4.46	1.47	1.24

Table-3 : Effect of different herbicides on flower quality parameters in gladiolus.

Treatment	Floret diameter (cm)	Spike girth (mm)	Weight of the spike (g)	Vase life (days)
T_1-Atrazine @ 1.0 kg a.i./ha	7.87	8.24	63.12	9.51
T_2-Atrazine @ 1.5 kg a.i./ha	7.97	8.44	64.31	9.92
T_3-Metribuzin @ 0.25 kg a.i./ha	8.18	7.84	61.62	9.04
T_4-Metribuzin @ 0.5 kg a.i./ha	8.64	6.51	46.91	8.02
T_5-Butachlor @ 1.0 kg a.i./ha	9.63	6.89	58.41	8.89
T_6-Butachlor @ 1.5 kg a.i./ha	9.02	7.12	49.05	8.12
T_7-Pendimethalin @ 0.75 kg a.i./ha	10.13	8.61	66.23	10.11
T_8-Pendimethalin @ 1.0 kg a.i./ha	10.21	8.73	68.87	10.16
T_9-Oxyfluorfen @ 0.5 kg a.i./ha	9.72	6.12	56.18	8.52
T_{10}-Oxyfluorfen @ 1.0 kg a.i./ha	9.81	6.81	52.29	8.24
T_{11}-Weedy check	7.13	5.42	42.12	7.35
T_{12}-Weed free	9.97	8.39	64.03	9.33
S.Em ±	0.57	0.57	2.05	0.50
CD @ 5%	1.67	1.68	6.01	1.48

three replications. The gladiolous cultivar "Summer Sunshine" was used for the experiment and planted at spacing of 30 x 20 cm. Mode of weedicide application was soil surface spray @ 2 days after planting. Details of herbicides used for the experiment is mentioned in Table-1. The observation different flower quality parameters were recorded *viz.* spike length (cm), length of the rachis (cm), number of florets per spike, length of florets, girth of the spike (mm), floret diameter (cm), length of the floret (cm), weight of the spike (g) and vase life (days).

Results and Discussion

Spike length (cm) and rachis length (cm) : It is evident from the Table-2 that, T8-pendimethalin @ 1.0 kg a.i./ha recorded significantly maximum length of the spike (65.91 cm), which was on par with T7- pendimethalin @ 0.75 kg a.i./ha (65.39 cm), T2- atrazine @ 1.5 kg a.i./ha (63.29 cm), T12- weed free (62.32 cm) and T1- atrazine @ 1.0 kg a.i./ha (61.23 cm). Whereas, significantly minimum length of the spike was recorded in the T11- weedy check (50.81 cm).

With respect to the rachis length, which was ranged from 30.02 cm to 38.94 cm. T8- pendimethalin @ 1.0 kg a.i./ha, recorded significantly maximum rachis length (38.94 cm), which was on par with T7- pendimethalin @ 0.75kg a.i./ha (36.24 cm), T2- atrazine @ 1.5 kg a.i./ha (36.03 cm) and T1- atrazine @ 1.0 kga.i./ha (35.76 cm). Whereas, significantly minimum rachis length was recorded in the T11- weedy check (30.02 cm).

Flower quality of gladiolus was measured in terms of spike length and rachis length. Significant differences in length of spike and rachis were observed due to different herbicidal treatments. The maximum length of spike and rachis was observed in the treatment pendimethalin (1.0 kg *a.i.*/ha). This may be due to better control of weeds during crop growth period in these treatments and also no phytotoxicity effects were observed on the crop which resulted in better growth and quality flowers. It might be due to pre-emergence application of herbicides which stimulated the elongation of the rachis and spike length Pal and Das, (1990) in tuberose.

Number of florets per spike, length of florets and floret diameter : The maximum number of florets per spike, length of florets and floret diameter was observed in the treatment pendimethalin (1.0 kg *a.i.*/ha). Flower quality measured interms of number of florets per spike, length of florets and floret diameter of the flowers which may be due to better utilization of photosynthates which were accumulated due to more number of leaves and leaf area because of better control of the weeds. These results are in line with the findings of Shalini and Patil (2004) in gerbera.

Spike girth (mm) and Spike weight : Significant differences in spike girth and spike weight were observed due to different chemical weed control treatments (Table-3). The maximum spike girth and spike weight was observed in the treatment pendimethalin (1.0 kg *a.i.*/ha). This may be due to better control of weeds during crop growth period in these treatments and also no phytotoxicity effects were observed on the crop which resulted in better growth of plants which intern increased uptake and assimilation of nutrients and photosynthates there by increased girth and weight of spike. These results are in line with the findings of Shalini and Patil (2004) in gerbera.

Vase life (days) : The data with regard to vase life of cut spikes are presented in the Table-3. The vase life varied significantly as influenced by differences among all the treatments in gladiolus and it ranged from 7.35 days to 10.16 days. Significantly maximum vase life was recorded in the treatment T8- pendimethalin @ 1.0 kg a.i./ha (10.16 days), which was on par with the treatment T7- pendimethalin @ 0.75 kg a.i./ha (10.11 days). Whereas, significantly minimum vase life was recorded in the treatment T11- weedy check (7.35 days)**.** This may be due better control of weeds and no phytotoxic effects on reproductive parts of the plants.

Conclusions

The pre emergence applications applied treatments gave better results regarding weed control and effect of weed control on flower quality of Gladiolus grandiflorus.It can be concluded that pendimethalin (1.0 kg *a.i.*/ha) was highly effective compare to other chemicals in controlling the weeds and improve the flower quality parameters in gladiolous. Pendimethalin (1.0 kg *a.i.*/ha) can be good choice for gladiolous crop production.

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Navigating the Nanofertilizer Frontier: Synthesis, Applications and Environmental Considerations

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Abstract

Present review investigates the significance of agriculture to human civilization, emphasizing its global effects on food security and economic development. It addresses the environmental issues and inefficiencies related with conventional methods while emphasizing the modern dependency on fertilizers for the crop optimization. The review introduces nanofertilizers as a potential remedy and positions them as a competitive substitute with special qualities like controlled nutrient delivery and enhanced absorption. In addition to addressing traditional drawbacks, nanofertilizers improve the condition of the soil, plant as well as microbial activity, and insect and disease resistance. The study recommends for its efficient nutrient control matched with precise agricultural principles. The review emphasizes how nanofertilizers can advance phyto-nanotechnology and imagines cutting-edge delivery strategies that increase nutrient uptake, crop yields, and general quality. It highlights how important nanofertilizers are for cutting down on manufacturing costs and waste. The evaluation acknowledges advances while advocating multidisciplinary cooperation along with research coordination with the developing use of new nanotechnology in agriculture. In its conclusion, it presents nanofertilizers as a potential means of nourishing the growing population responsibly, resolving environmental issues, and fostering resilient farming methods.

Key words : *Nanofertilizers, agriculture, disease resistance, healthy environment, nutrient dynamics, cost effective.*

Introduction

The foundation of human civilization is agriculture which provides food and a living for billions of people worldwide. Present population is forecasted to outreach 9.6 billion by 2050, however, the present agricultural production levels would need to increase by 70 per cent in order to feed such outnumbered population (Shubham *et al.*, 2022). Its significance cannot be overstated because it not only feeds our expanding population but also promotes economic growth. Modern agriculture is dependent on fertilizers because they provide crops with the essential nutrients they need to develop and produce at their highest levels. The importance of fertilizers to sustainable and effective food production ought to be stressed in a world where arable land is becoming more and more rare. These necessary chemical or organic compounds give plants the nutrients they require to grow, filling the gap between the need for higher crop yields and the deficiency of certain nutrients in the soil. It is estimated that more than half of the chemical fertilizers and pesticides used are wasted, building up in the soil and water due to processes including leaching and mineralization. Over the past years, there has been major research efforts focused on microbiomes, bio-fertilizers, nanofertilizers and the improvement of soil health in response to the growing.

Role of Nanoparticles in agriculture : With a focus on sustainable production, efforts have been undertaken to use nanotechnology applications in the field of agriculture (Abobatta, 2018). Nanotechnology has been used to create innovative and novel agrochemical agents that will improve agricultural productivity and new delivery systems. Nanoformulations used in crop development as fertilizers and insecticides, as well as nanodevices created for genetic enhancements are some of the primary uses of nanotechnology in the field of agriculture. Due to the fragile nature of crops and the tenacity of insects and pests, a sizable amount of agricultural waste is produced each year (Sekhon, 2014). In turn, this has reduced the need for plant protection goods by revolutionizing our ability to comprehend the mechanisms underlying pesticide resistance in real-time. To address illness outbreaks and facilitate early disease diagnosis, nanocapsules have been creatively created (Sekhon, 2014). The creation of dependable, affordable, and quick technologies for tracking biological host molecules in the agriculture industry is urgently needed in the current situation. The manufacturing of agrochemicals like fertilizers and insecticides has to become more efficient and sustainable as a result of the continual improvements in modern agriculture. Notably, nanobiosensors with excellent sensitivity, stability, and compact usability have been developed to facilitate biochemical evaluation and the recognition of mycotoxins in food products (Sehgal *et al.,* 2021).

Nanofertilizers overview : Nanofertilizer is composed of nutrients that have been synthesized or altered to produce particles with a typical size range of 1 to 100 nanometers,

designed to supply at least one nutrient to plants. They possess a substantial surface area, excellent nutrient absorption capabilities, and a well-designed delivery mechanism, enabling controlled and gradual nutrient release to targeted regions (Chhipa and Joshi, 2016;). They are more cost-effective than chemical fertilizers and have the advantage of using less of them. The main benefits of nanofertilizers are their capacity to boost soil carbon content, foster soil health similar to organic fertilizers, sustain increased physiological activities in plants and microbes, stimulate plant enzyme release, reduce susceptibility to pests and diseases, improve moisture retention in the soil, strengthen plants' resilience under stressful conditions, and improve nutrient utilization efficiency, ultimately leading to higher crop yields (Tarafdar, 2021).

This focused strategy of controlled release of active substances matches the nutrient needs of the plants, reducing fertilizer waste while boosting soil fertility for increased crop quality, yields, and nutrient utilization efficiency (Tarafdar *et al.,* 2015). Furthermore, nanofertilizers may protect plants from a variety of biotic and abiotic stressors, boosting agricultural production and adaptability (Burman *et al.,* 2013). The key benefits of nanofertilizers include their extensive surface area and greater reactivity, improved cell penetration, ability to operate as an efficient catalyst for microbial and plant metabolism, and capacity to cause the release of enzymes.

Growing evidence points to the potential advantages of using and producing nanofertilizers (NF) as an effective substitute for conventional inorganic fertilizers. The benefit of NFs is that they can reduce environmental effects while improving nutrient utilization efficiency. This is mainly because of their sizable dimension and the availability of macro- and micronutrients, that are given to crops gradually and under controlled conditions (Mejias *et al.,* 2021). In this situation, phyto-nanotechnology can be used to create NFs with sophisticated delivery systems, improving nutrient uptake, yield, and quality, extending plant resistance to stressors, enhancing plant defense mechanisms, minimizing fertilizer waste, and lowering production costs (Iqbal *et al.,* 2020). Notably, nanofertilizers succeed in precision agriculture because they provide nutrients to crops precisely, allowing for precise nutrition management. Hence, they are hailed as one of agriculture's most promising applications of nanotechnology (Bhardwaj *et al.,* 2022).

Types of nanofertilizers

1. Macronutrient nanofertilizers : Macronutrients are essential for encouraging plants' healthy growth. Nitrogen, phosphorus, potassium, calcium, sulphur, magnesium, as well as the non-mineral nutrients carbon, oxygen, and hydrogen, are among these vital elements. Each of the macronutrient based nanofertilizer is described below:

(a) Nitrogen based nanofertilizers : The most important nutrient that limits worldwide agricultural production is nitrogen. The low (20%) utilization efficiency of current nitrogen fertilizers causes eutrophication and raises emission of greenhouse gases (Kahrl *et al.,* 2010). Due to quick leaching and rapid volatilization after application, the majority of the nitrogen present in urea is lost. Nitrogen nanofertilizers blend nitrogen atoms with NPs such metal oxides, carbon nanotubes, and nanotubes of carbon. This mixture of particles aids in increasing the amount of nitrogen that is readily available in the soil, enabling plants to obtain more nutrients. These fertilizers' progressive release of nitrogen into the soil lowers the concentration of nitrogen in aquatic systems, lowering the possibility of environmental harm from leaching and runoff (Yadav *et al.,* 2023).

(b) Phosphorous based nanofertilizers : Phosphorus is a crucial nutrient essential for the growth and vitality of plants. It is essential to photosynthesis and facilitates the uptake of other nutrients like nitrogen and potassium. A recent development in the field of fertilizers, phosphorus nanofertilizers have the potential to revolutionize how agriculture is conducted. When compared to conventional fertilizers, they offer greater effectiveness and environmental friendliness. To help preserve this important element, slow-release phosphorus nanofertilizers can be used to give crops a consistent supply of phosphorus throughout their growth cycle (Saraiva *et al.,* 2022). The administration of nano-rock phosphate to maize plants in a specific experiment reported in the source produced phosphorus utilization results comparable to those attained with superphosphates. It's noteworthy that a higher degree of phosphorus utilization was attained at a lower cost (Adhikari *et al.,* 2014).

(c) Potassium based nanofertilizers : Potassium nanofertilizers also known as nano potassium fertilizers, are a cutting-edge development in agricultural science. These fertilizers are made up of tiny particles that allow them to effectively reach the plant roots and permeate the soil more deeply. As a result, they demonstrate a higher rate of absorption than conventional fertilizers, enabling the quick and effective delivery of vital nutrients to plants. Additionally, nano potassium exhibits enhanced water solubility and greater resistance to leaching, lowering the chance of being washed away by irrigation or rainfall. Together, these qualities improve the ability of potassium-based nanofertilizers to sustain increased crop yields over time (Sheoran *et al.,* 2021).

(d) Calcium based nanofertilizers : Calcium contributes to the development of cell walls, the division of cells, and the movement of nutrients and water within plants, among other processes. In signal transduction mechanisms, calcium ions also act as secondary messengers, particularly in response to diverse stressors. Different kinds of calcium-based nanofertilizers with various formulas have been produced. While some of these nanofertilizers are made of calcium carbonate (Ruiqiang and Rattan, 2016), others are made by mixing calcium nitrate with calcium phosphate (Carmona *et al.,* 2020). Nanofertilizers made of calcium have proven to be excellent at promoting crop growth and raising agricultural yields. Additionally, they have shown to improve the overall quality of vegetables and fruits while boosting plant resistance to pests and diseases.

The possibility of using calcium phosphate nanoparticles (CaP) as nanofertilizers rich in macronutrients like phosphorus has recently attracted a lot of attention. These slow-solubility nanofertilizers are essential for their role as slow-release phosphorus nanofertilizers which eventually help to enhance the nutrient-use efficiency when compared to conventional fertilizers.

(e) Magnesium based nanofertilizers : Magnesium is a crucial mineral for several key plant functions, including protein synthesis, enzyme activation, and photosynthetic activity. Based on their chemical makeup, the many magnesium-based nanofertilizers that have been developed can be divided into groups. While few of these nanofertilizers are made with magnesium sulphate, others are made with magnesium oxide (Liao *et al.,* 2021). These magnesium-based nanofertilizers have proven to be excellent at boosting agricultural yield and encouraging plant development. Additionally, magnesium helps improve the nutritional value of fruits and vegetables while also boosting plants' resistance to pests and disease. Numerous crops, such as rice, potatoes, sugarcane and tomatoes also benefit from these favourable effects (Yadav *et al.,* 2023).

(f) Sulphur based nanofertilizers : Sulphur is an essential mineral for plants, taking part in many essential processes like synthesis of proteins, the activation of enzymes, and the creation of vital substances like vitamins and hormones (Ingenbleek and Kimura, 2013). Sulphur-based nanofertilizers are made by utilizing sulphur compounds, such as sulphur-coated urea or potassium sulphate, while some are made using elemental sulphur (Li *et al.,* 2019). These slow-release sulphur nano-coated fertilizer materials have the advantage of supplying a source of sulphur, which is crucial for the development and growth of plants, in addition to fundamental nutritional elements.

2. M**icronutrient nanofertilizers**

Micronutrient-based nanofertilizers represent a cutting-edge innovation in agriculture, utilizing nanoparticles to deliver essential micronutrients to plants with greater efficiency compared to traditional fertilizers. Micronutrients like zinc, boron, iron, nickel and copper are essential for a variety of aspects of plant growth, development, and general health but are only required in trace amounts. Plants can benefit from micronutrient nanofertilizers in a number of ways, including better nutrient uptake, increased crop yields, and increased resistance to biotic and abiotic stresses (Yadav *et al.,* 2023).

(a) Boron based nanofertilizers : Even though boron is a crucial element for plant growth, it's concentration is always deficient in soil. Boron-based nanofertilizers have been created, providing crops with a more targeted and concentrated dose of boron. These nanofertilizers create nanoparticles (NP's) by combining borate with other substances, such humic acid. These NPs can be applied to the soil or sprayed directly onto the crop as a foliar spray because they can be suspended in either liquid or solid forms. The capacity of boron-based nanofertilizers to enter plant cells ensures that vital micronutrients are supplied effectively (Gehlout *et al.,* 2022).

(b) Copper based nanofertilizers : Copper nanofertilizers are made up of tiny copper particles that can enter plant cells and supply vital nutrients right to the roots. The plants will be able to absorb nutrients quickly and effectively thanks to this direct delivery strategy. The safety of using copper nanofertilizers has been thoroughly tested, and there are no safety issues for either humans or animals. They are also resistant to runoff and leaching making them a sensible option for sustainable agricultural methods (Chhipa and Joshi, 2016).

(c) Iron based nanofertilizers : Despite being an essential element for plant growth, soils usually lack iron because of its poor solubility. In order to increase the availability of iron to plants, iron nanofertilizers have been produced. The many types of these iron nanofertilizers include nanosized iron particles, nanocomposites and nano encapsulated iron. The simplest kind of iron nanofertilizers are nanosized iron particles, which are commonly made of iron oxide or sulphide. These particles are more effectively absorbed by plants than conventional iron fertilizers because they are sufficiently small to penetrate the soil's surface. This increased nutrient absorption efficiency can aid in addressing iron deficiency

in plants and fostering healthier growth (Sharipova *et al*., 2020).

(d) Nickel based nanofertilizers : Nickel is indeed essential for several crucial metabolic processes in plants like respiration, photosynthesis and nitrogen metabolism. There are currently many different formulations of nickel nanofertilizers available, including powder, liquid and granular forms (Brown *et al.,* 1987).

(e) Zinc based nanofertilizers : Zinc forms the base component of plant enzymes that are responsible for effective metabolic activities. Zinc is applied as zinc oxide nanofertilizer to the soil. It increases the zinc's availability to plants, improving crop production. Additionally, it has been discovered that zinc oxide nanofertilizers lower the amount of zinc that leaches from the soil, reducing the chance of environmental pollution (Sheoran *et al.,* 2021). Additionally, studies suggest that these nanofertilizers may improve a plant's capacity to withstand biotic and abiotic challenges, which would increase their potential for use in sustainable agricultural practices (Kumar *et al.,*2021).

Nutrient release and uptake mechanism

The distinctive characteristics of nanoparticles are what make nano-based fertilizers efficient. Nano-structured materials stand out thanks to their unusual chemical, optical, magnetic, electrical, mechanical, and surface area to volume ratio properties. Certain performance-related qualities, which include stability, precise time release, superior solubility, specific target activity, effective delivery mechanism, and decreased toxicity, are required in the formulation of nanofertilizers. The study found that because precursor materials are derived from natural sources, nanofertilizers provide a practical option with little harm to the environment and toxicity. The development of manganese, iron, and zinc foliar fertilizer products based on nanotechnology has shown encouraging results for squash plants (Kaushal *et al*., 2015). Significant improvements were seen in plant output, chlorophyll content, and vegetative properties. The values of organic material, lipids, proteins, and energy was increased with use of nanoparticles made of iron oxide A slow-release fertilizer using a nano-based NPK formula produced seeds with 100% germination and a high "vigor index" (Madzokere *et al*., 2021).

Nanofertlizers for targeted delivery

(a) Nanoaptamers : Nanoaptamers are a ground-breaking method for delivering fertilizer in agriculture that is revolutionizing the growing process. Nanoaptamers effectively transfer plant hormones as well as enzymes to the plant by binding to them, which improves the uptake of nutrients from the soil. They are made of oligonucleotides or peptides, which are essential because they change the surface of nanofertilizers. With the help of signals from the rhizosphere, this alteration enables controlled discharge of nutrients inside the nanostructure (Yadav *et al.,* 2023).

(b) Plant growth-stimulating : Some nanofertilizers, such as carbon nanotubes (CNT's), interact with plant roots and improve hormone synthesis to stimulate plant growth. They add additional carbon along with additional nutrients to the soil. CNT's can have a favorable effect on root growth, water transport, and seed germination even at low concentrations without generating phytotoxicity. They show considerable contact with plant cells by moving to systemic regions of plants, such as fruits, leaves, and roots. This covering improves the seed's capacity of absorbing nutrients and water while assisting in pest prevention (Yadav *et al.,* 2023).

(c) Water and nutrients loss-controlling fertilizers : Use of fertilizers can be decreased by using nanofertilizers while, which are composed of nanoparticles with the ability to control the pace at which fertilizers are released into the soil. Nanofertilizers are designed using a variety of techniques, such as :

1. Enclose nanofertilizers in a porous matrix, which allows nutrients to be released gradually over time.

2. Another technique focuses on modifying nanofertilizers' surfaces to make them hydrophilic, which improves their ability to store water and reduces the loss of water through evaporation.

This idea is demonstrated, for instance, by urea that has been encapsulated with nanoparticles of iron oxide, sulfur, calcium, magnesium, zinc, copper, molybdenum, boron, and ammonium sulfate (Yadav *et al.,* 2023).

(d) Nanobeads : These tiny granules are intended to distribute nutrients slowly, which prevents plants from losing water. Iron, carbon, and other metals are the components of nanobeads, which are so tiny that can enter even the smallest soil fissures and help fertilize plants. For instance, the commercial fertilizer NanoFert, which is based on nanobeads, provides a combination of macro and micronutrients (Yadav *et al*., 2023).

(e) Nano emulsions-based fertilizers : These tiny droplets are designed to carry a combination of nutrients that are both water-soluble and insoluble. In order to maintain a uniform distribution of liquid droplets throughout the solution, the surfactant makes sure that the droplets stay suspended within the water-soluble matrix. These droplets are easily absorbed and used by plants, increasing crop health and yields. According to a study, adding a one percent paraffin oil nanoemulsion to Blue-green 11 media dramatically enhanced the fresh water based microalgal strain Chlorella pyrenoidos'

biomass yield, chlorophyll synthesis, cell count, CO_2 absorption, and biochemical content. Another study combined nanoemulsions of nanophosphate with potash fertilizer to create a nanostructured slow-release fertilizer system (Yadav *et al.,* 2023).

Synthesis of nanofertilizers

Nanofertilizers differ from their original bulk ingredients in terms of their chemical and physical characteristics. The creation of nanoparticles, which are frequently used in the manufacturing of nanofertilizers, involves a number of components, includes metal oxides, ceramics, and magnetic compounds. There are various methods for getting nanomaterials and nanofertilizers:

(a) The Top-Down Approach : It is a physical process that begins with bigger bulk material particles and evolves down to the nanometric level. This method frequently yields more contaminants and has difficulties in terms of managing the consistency and size of nanoparticles.

(**b) The Bottom-Up Approach** : In this method, chemical reactions at the atomic or molecular level are used to create nanoparticles. It benefits from more effective impurity reduction and fine control over particle size.

(**c) The Biological Approach (biosynthesis) :** This strategy, sometimes referred to as the green approach, depends on organic sources including plants, fungus, and bacteria for synthesis. Greater control over toxicity and size of particles is possible with the biological method (Alkhader and Asad, 2023).

For instance, zeolites that are nanopore-sized and rich in nutrients work well as nanofertilizers for plants. These minerals, which produce a honeycomb-like structure with great porosity when volcanic ash and alkaline lake water react, improve moisture, nutrient, and compound absorption and retention. Thus, making zeolite fertilizers an excellent option for enhancing soil. Natural zeolite is ground into a powder and combined with nitrogen, phosphorous, and potassium to create nanofertilizers that are tailored to the needs of particular crops. This increases the surface area and improves nutrient absorption. Engineered nano-porous zeolites or aluminosilicates, have micro (2 nm), meso (2–50 nm), and macropores (>50 nm), which enhance their ion-exchange and adsorption capabilities and make them good fertilizer carriers. These zeolite fertilizers raise soil fertility, which encourages the best crop growth (Shubham *et al.,* 2023). Additionally, their capacity to retain water lessens the need for frequent watering, notably. Additionally, their water retention ability lessens the need for frequent irrigation, which is especially advantageous in locations with poor water supplies or high resource costs. Additionally, by improving the ability of zeolite particles to retain water, zeolite fertilizers aid in reducing soil erosion (Zahra *et al*., 2022).

Methods of nanofertilizer application

Application of nanofertilizers can be done in three different ways: foliar, seed nanopriming, and soil treatment. Nanoparticles can enter plants in a variety of ways, including through the shoots and roots of the plants. These particles can pass through the cuticle, epidermis, stomata, hydathodes, and stigma in plant shoots. Nanoparticles can penetrate plant roots through lateral root connections, wounding areas, cortical tissue, root tips and rhizodermis (Tarafdar *et al.,* 2012).

The size and surface characteristics of the nanoparticles play a major role in how quickly plants absorb them. When compared to bigger particles, smaller nanoparticles move through plant tissues more quickly, which can affect how well they distribute nutrients or other substances to plants. In order to achieve optimal plant growth, the method of administering nanofertilizers is crucial, and the choice of approach should be matched to the particular soil and climate circumstances. The choice of the best application technique is influenced by a number of variables, including nutrient availability, soil quality and climate, which all have an impact on how well plants absorb and use nutrients. Methods of nanofertilizer application are described below:

(a) Foliar spray : Foliar spraying is a sophisticated technology that applies liquid fertilizers directly to a plant's leaves or foliage to speed up the absorption of nutrients via the leaf surface. This technique ensures precise, effective, and quick nutrient transport to the plant by delivering nanofertilizers to the surface of the leaves. Nanoparticles (NPs) applied by foliar application have shown promise in the delivery of plant-necessary compounds such nanofertilizers, fungicides, preservatives and herbicides. To increase the potency of these drugs, this approach uses controlled release mechanisms. The efficacy of NPs applied to leaves can be significantly impacted by the size of the particles. These processes include stomata penetration, direct absorption and endocytosis (Hong *et al.,* 2021). However, barriers like cell walls and leaf wax may prevent these particles from being absorbed. The majority of nanoparticles build up inside vacuoles after being ingested. However, a number of variables, such as plant traits, NPs' physical qualities, and environmental circumstances, might affect how well nanoparticles are absorbed and transported. Comparing foliar spraying to traditional soil-based applications, there are a number of benefits. These advantages include a faster reaction time, improved nutrient uptake, and a lower risk of leaching and overflow (Hong *et al.,* 2021). Numerous studies have shown that

applying nanofertilizers to leaves can significantly improve nutrient uptake, accelerate plant development, and eventually increase agricultural yields.

(b) Seed nanopriming : Seed priming is a pre-sowing procedure that causes physiological alterations in seeds, boosting quicker germination and enabling plant growth and development by influencing metabolic and signaling systems. This technique involves soaking seeds in nanofertilizers, which has the advantage of halving the amount of fertilizer needed while still producing great results (Pereira *et al.,* 2021). By entering seed pores, distributing inside the seeds, and activating the plant hormones that promote growth, nanobiofertilizers operate as stimulants, promoting germination and development. By reducing the effects of reactive oxygen species and fine-tuning the control of plant development hormones, the use of nanofertilizer during seed priming improves seed germination (Shubham and Dixit, 2021; Sharma *et al.,* 2023). Additionally, seed priming causes the expression of numerous genes during germination, especially those linked to plant resilience, which enhances the plant's tolerance to external stressors (Liu and Lal, 2015). In order to soften the seed coat, traditional seed priming techniques frequently include water, nutrients, or hormones. Advanced seed nano-priming techniques, in contrast, apply nanofertilizers directly to the seed surface while leaving a sizable part behind to act as a barrier to prevent disease entry.

(c) Soil Treatment : The soil can be fertilized using nanofertilizers by the use of traditional techniques like side-dressing, fertigation or broadcasting. Nanoparticles (NPs) interact with plant roots once they have settled in the soil by sticking to the root surface or by entering root cells via endocytosis (Ahmed *et al*., 2021). Nanofertilizers may communicate with soil particles, microbes, and plants when they are introduced to the soil, thereby affecting their behaviour and functions. These NPs' carefully regulated nutrient release assures a steady supply of vital substances, which in turn encourages productivity and development of plants (Madzokere *et al*., 2021). Although this form of application is generally trustworthy, it has several drawbacks, such as regulatory concerns, greater costs (Dimkpa and Bindraban, 2018), and uncertainty concerning the long-term impact of NPs (Raliya *et al*., 2018; Kaushal and Sharma, 2018). When using nanofertilizers in agricultural practices, it is important to carefully consider these issues.

Advantages of nanofertilizers

By directly supplying vital nutrients to plants, crop yields are increased while fertilizer's negative environmental consequences are reduced. Providing a steady supply of nutrients, slow-release nanofertilizers boost plant development and yield while reducing nutrient loss and the requirement for frequent reapplication.

(a) Greater surface area : Particle sizes of nanofertilizers under 100 nm show improved plant penetration through surfaces as soil or leaves. This helps to increase nutrient absorption as well as various metabolic processes inside plant systems, along with increased photosynthate production. The increased surface area increases the ability to react of nanofertilizers with other chemicals substances as well as nutrient absorption and utilization efficiency (Yadav *et al*., 2023).

(b) High solubility : Due to larger surface area and smaller particle size, nanofertilizers have a higher solubility, which makes them easier to dissolve in soil solutions. These nanofertilizers easily dissolve in a variety of solvents, including water, increasing the soluble capacity of previously insoluble nutrients within the soil and enhancing their accessibility to environmental organisms (Yadav *et al*., 2023).

(c) Encapsulation of fertilizers within nanoparticles : Crops are better able to absorb nutrients when fertilizers are enclosed in nanoparticles (NPs). As an illustration, zeolites are used as nanoscale carriers in zeolite-based nanofertilizers that store nutrients inside their porous structure. With this method, nutrients are more readily available during crop development, nutrient loss from mechanisms like denitrification, volatilization, and leaching is reduced, and nutrients are fixed (Yadav *et al.,* 2023).

(d) Easy penetration and controlled release of fertilizers : In order to optimize fertilizer uptake and usage by plants, nanofertilizers play a critical role in boosting the ability to penetrate of fertilizers within plant tissues. The nano-sized particles are principally responsible for this improved penetration. Additionally, these nanoparticles (NPs) can be functionalized with particular targeting molecules, enabling specific uptake by plant tissues and precise delivery of vital nutrients. The increased nutrient penetration of nanofertilizers reduces the requirement for fertilizer, minimizes nutrient runoff, and helps to reduce environmental pollution (Bernela *et al*., 2020).

(e) Effective duration of nutrient release : The length of the release of nutrients in nanofertilizers has been extensively researched in a number of studies. For instance, a study demonstrated that nutrient release from chitosan-based nanofertilizers occurred over a 45-day period. Another study showed that polymer-coated nanofertilizers might release nutrients for up to 60 days (Yadav *et al.,* 2023).

(f) Improved microbial activity : The interaction of nanoparticles (NPs) and microorganisms, the longevity of

biofertilizers, and the dispersion of nanofertilizers are among the crucial elements affecting plant growth. Plants benefit from the interaction of rhizobacteria that promote plant growth and gold nanoparticles. In a different study, chitosan-based NPs were used to transfer nitrogen-fixing bacteria to plants (Yadav *et al*., 2023).

(g) Improved soil water-holding capacity : Nanofertilizers improve soil structure, increase soil organic matter, increase soil water-holding capacity, and create a favorable environment for beneficial microbes. They efficiently bind soil particles thanks to their humic acid and clay enrichment, reducing water loss from runoff and evaporation (Bernela *et al*., 2020).

(h) Ecofriendly nature : In addition to being more effective than conventional fertilizers, nanofertilizers offer a safer environmental alternative. Traditional fertilizers produce large dosages of nitrogen and phosphorus, causing problems including eutrophication and algal blooms in adjacent water bodies. Contrarily, nanofertilizers are made to release nutrients gradually, giving you precise control over the soil's nutrient balance and minimizing the environmental harm caused by nutrient runoff (Yadav *et al*., 2023).

(i) The value of food for health : Larger protein, oil content, sugar content, and other quality metrics in crops are all influenced by better nutrient availability. The increased availability of nanonutrients to plants protects them from diseases, nutrient shortages, and other biotic and abiotic stressors. Better yields and higher-quality food products are produced as a result, suitable for consumption by humans as well as animals (Bernela *et al.,* 2020).

(j) Low production cost : Due to increased efficiency in using nutrients, controlled release, and targeted delivery, which reduce fertilizer wastage in the field, lower manufacturing costs for nanofertilizers. Nanofertilizers are typically more cost-effective than conventional fertilizers because they require less work, use less fertilizer per application, and have higher absorption rates. Additionally, the rate of applications is decreased due to their prolonged residence in the soil, which lowers expenses (Yadav *et al*., 2023).

(k) Improves plant stress tolerance : Plants experience diverse environmental challenges during their life cycle, which trigger genetic, biochemical, and physiological changes to strengthen their defense mechanisms. According to studies, nanoparticles (NPs) have a dose-dependent effect on plant growth. Their tiny particles can quickly transfer nutrients to the root system and other plant sections because they can effectively penetrate plant cell walls. Furthermore, they might make plants more resistant to environmental stresses like drought and high temperatures. Nanofertilizers support plant life notwithstanding water shortages or heat waves by supplying necessary nutrients and protective elements like antioxidants (Yadav *et al*., 2023).

Limitations and challenges

Although the benefits of nanofertilizers were discussed, there are also known drawbacks and negative effects. The majority of research on nanofertilizers has only been done in laboratories or on a limited scale. Foliar application is difficult since a great amount of usable leaf surface is required, and high spray rates increase the possibility of scorching or burning. Weather conditions have an impact on the effectiveness of nanofertilizers, necessitating careful timing for application. Further research is needed on issues including standardizing nanoformulations, achieving homogeneity in nanoparticle sizes, and optimizing foliar sprays. It is unclear if all nanofertilizers are transformed to ionic forms in plants and integrated into metabolites because of the impact of nanofertilizers on the availability of nutrients in pastures, how they transform within plants, and their impacts on the environment (Yadav *et al*., 2023).

Despite the potential advantages of nanofertilizers in agricultural activities, such as improved nutrient availability and decreased losses, their possible hazards have not been fully investigated. The following sections specifically highlight the need for additional study to address issues:

(a) The possible influence of nanofertilizers on human health is one of the main issues raised. Small size makes it easy for organisms to absorb NPs, which could be hazardous. According to studies, ingesting nanofertilizers can harm experimental animals' kidneys, liver, and gastrointestinal tract. Additionally, NPs have the ability to pass across biological barriers like the blood-brain barrier, potentially resulting in neurological damage. To fully comprehend the long-term implications of nanofertilizer being exposed on human health, more research is required (Yadav *et al*., 2023).

(b) The pollution of soil, water, and air may result from the ejection of NPs into the ecosystem. NPs may build up in the soil and alter soil ecosystems while also reducing soil fertility. Additionally, the introduction of NPs from the soil into aquatic environments may have a negative impact on aquatic life, which could result in bioaccumulation and biomagnification within the food chain. In order to reduce negative effects, it is necessary to conduct further research on the potential concerns related to the release of nanoparticles into the environment (Thavasleen and Priyadarshana, 2021).

(c) The possible influence of nanofertilizers on organisms other than their intended targets is a significant worry. Numerous creatures, which includes insects, fish, and birds, can suffer negative impacts from exposure to NPs, according to studies. Nanofertilizers have the potential to interfere with an organism's ability to reproduce, grow, and develop, which could result in population decreases. It is yet unclear how nanofertilizers affect helpful microorganisms such mycorrhizal fungus and bacteria that fix nitrogen. To assess the potential ecological dangers of using nanofertilizers, more research is required (Shubham *et al*., 2022).

(d) The cost of nanofertilizers is extremely high, which is one of their drawbacks (Sachan *et al.,* 2021). Potential toxicity caused by the interaction of nanomaterials with soil components. The potential buildup of nanofertilizers in plant tissues, which could limit growth, cause the production of oxygen species that are reactive, and cause cell death. The buildup of nanofertilizers in consumable food components, which could be harmful if consumed (Sachan *et al*., 2021).

Future prospects of Nanofertilizers

A number of nations, like India, have long-standing agricultural methods that are firmly ingrained in rural areas. Raising knowledge of the advantages of nanocarrier-mediated fertilizer delivery needs grassroots initiatives to win the support of farmers, who are the primary stakeholders in such complex situations. Nanofertilizers have the ability to dramatically increase nutrient delivery, absorption, and transport efficiency, maximizing their usage. As a result, it is essential that scientists and media professionals work together and earnestly to guarantee that the scientific case for utilizing nanofertilizers is understood, with reliable government backing (Bernela *et al*., 2020). Utilizing nanoparticles in fertilizers has the potential to increase plant nutrient uptake, boost agricultural output, and lessen the environmental effect of conventional fertilizers. Diverse nanomaterials, including as nanozeolites, nanochitosan, and metal oxide nanoparticles, are being actively investigated by researchers to see whether they have the potential to improve nutrient uptake and retention in soils. The production of controlled-release nanofertilizers has advanced significantly, offering a steady supply of nutrients that lowers the frequency of treatment and decreases potential nutrient losses (Yadav *et al.,* 2023; Shubham *et al.,* 2023).

Work should be put into creating formulations that make use of "smart" nanofertilizers responsive to environmental cues like pH or temperature which allow the controlled release and targeted delivery of nutrients. This strategy aims to decrease nutrient losses, improve the efficiency with which plants utilize nutrients, and support sustainable agriculture practices. The use of nanosensors into nanofertilizers could enable accurate application and reduce nutrient waste by enabling real-time monitoring of soil nutrient levels (Kaushal *et al.,* 2022). Research initiatives should also concentrate on comprehending the possible threats that nanofertilizers pose to the environment and public health. To ensure its safe and efficient usage, clear regulatory frameworks and established rules must be created. For long-term safety, it is essential to look into the possible toxicity of nanofertilizers on soil organisms, crops, and people. The adoption and use of nanofertilizers in agriculture depend heavily on outreach and education programs aimed at farmers and other stakeholders. For nanofertilizers to be widely used, information on their advantages, safety, and efficacy must be widely disseminated. Precision agriculture can assist optimize the delivery of nutrients in the field and reduce resource waste by using technologies such as drones equipped with cameras for multispectral photography. However, it is crucial to comprehend the long-term sustainability of land used for agriculture in light of the advantages and disadvantages of using nanofertilizers (Gade *et al*., 2023).

Conclusions

Agriculture progress has been crucial to the expansion of human civilization since it has fed billions of people around the world and stimulated economic development. Fertilizer use has become crucial due to the rising need for food generation and the decreasing amount of arable land. However, the usual application of synthetic fertilizers has sparked worries about their effects on the environment and their ineffectiveness in utilizing nutrients. A promising solution that addresses the shortcomings of conventional fertilizers while opening up new levels of agricultural efficiency is the introduction of nanofertilizers. Modern agriculture has many difficulties, and the special characteristics of nanofertilizers, such as their regulated nutrient delivery, significant surface area, and better nutrient absorption capacities, have placed them as a feasible alternative. Beyond only providing nutrients, nanofertilizers also improve soil health, stimulate plant and microbial activity, reduce sensitivity to pests and diseases, and strengthen resistance to adverse environmental circumstances. They provide a targeted and efficient technique for controlling nutrition since the precision with which they administer nutrients is in line with the principles of precision agriculture. The investigation of nanofertilizers prepares the way for developments in phyto-nanotechnology as we navigate the complexities of sustainable and effective food production. This enhanced method makes it possible to

create nanofertilizers with cutting-edge delivery methods that enhance nutrient absorption, increase crop yields, and enhance crop quality in general. The ability to lower production costs and fertilizer waste further highlights the significance of nanofertilizers in determining the direction of agriculture. While recognizing the advancements made in the field of nano-fertilizer research, it is necessary to keep encouraging multidisciplinary work. Research projects on soil health, bio-fertilizers, and microbiomes should be in line with the changing application of nanotechnologies in agriculture. By doing this, we can fully utilize nanofertilizers as a catalyst for resilient and sustainable farming practices in addition to replacing conventional fertilizers. Nanofertilizers are a ray of hope in the fight to feed an expanding population and ease environmental concerns since they show the potential to transform and advance agriculture.

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Varietal Influence on Physiological Loss under Ambient Storage of Guava Fruits

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Abstract

An experiment was carried out with an aim to determine the effect of different guava varieties on physiological changes under ambient storage conditions. Study comprises of fifteen varieties which were stored at room temperature in completely randomized design at Department of Horticulture, Chaudhary Charan Singh Haryana Agriculture University, Hisar, Haryana during rainy and winter season of 2018-2019. All varieties exhibited significant variation for most of the physiological parameters and organoleptic ratings. It was observed that there is significant increase in physiological loss in weight, decay percentage and specific gravity in both the season, irrespective of cultivars. On the other hand, moisture content and firmness was found to be decreased with passage of storage time, regardless of the varieties. Among varieties, Hisar Safeda exhibited minimum loss in weight, decay loss and moisture content and maximum organoleptic ratings in both the seasons and maximum specific gravity and firmness in rainy season. However, in winter season maximum firmness and specific gravity was recorded in Pant Parbhat. It was also observed that winter season fruits of all the varieties are much superior to fruits harvested in rainy season.

Key words : *Ambient, hisar safeda, storage, firmness, physiological.*

Introduction

Guava (*Psidium guajava*) is a tropical fruit-bearing plant that holds substantial economic, nutritional, and botanical value. It has become a widely cultivated and cherished fruit in more than sixty tropical and subtropical countries throughout the world. Guava has earned the title of "the apple of the tropics" and has become a cherished part of local cuisines, traditions, and folklore. It valued for its deliciously sweet and tangy flavor, mouthwateringly fragrance, and vibrant colors (Tiwari *et al.,* 2016). It is a rich source of dietary fiber, potassium, magnesium, and calcium, as well as vitamin C and other important minerals. This combination of nutrients makes guava a potent fruit for strengthening the immune system, enhancing digestion, and endorsing overall well-being.due to high content of vitamin C, guava act as a powerful weapon against free radicals, which are a major factor in the development of many degenerative diseases (Kadam *et al.,* 2012). Guava is also known for its wide range of pharmacological potential, as numerous research have demonstrated its anti-inflammatory, antibacterial and antioxidant qualities. Guava fruits are normally consumed as fresh or processed into several products like jam, jelly, cheese, nectar, paste, etc. (Dhillon, 2013).

Owing to wider adaptability, tolerance to various biotic and abiotic stresses and high productivity along with low input requirements, high nutritional content and good remunerative value at lower cost, the demand of guava fruit remains high not only in fresh form but also in form of processed products. But being a climacteric and exceedingly perishable fruit, fresh guava fruits have short shelf life, which results in about 15.88% post-harvest losses in guava. Out of which, nearly 4% of fruits are spoiled in storage only (Jha *et al.,* 2015), due to lack of post-harvest infrastructure in India. Therefore, farmers are more likely to identify cultivars with long shelf life and minimal quality degradation. There is a clear need to maintain a natural balance for growing best varieties with desirable characteristics and to supply fresh fruits throughout the year. In spite of the fact that there are many different varieties of guava but very little research has been done to categorize cultivars with longer shelf lives. Therefore, the present investigation was conducted to study the effect of varietal influence on physiological changes in guava fruits stored at ambient conditions.

Materials and Methods

The experiment was conducted in P.G. lab of Department of Horticulture, College of Agriculture, CCSHAU, Hisar. The experiment was laid out in Completely Randomized design (CRD) with fifteen guava varieties. Uniform mature fruits of all the varieties, free from pest, disease and bruises, were harvested from orchard of the Guava Demonstration Centre, Bhuna and thereafter stored in corrugated fiberboard boxes at ambient conditions in both the seasons *viz;* rainy season (32-34°C ± 2 and 70 ± 5% RH) and winter season (20-22 °C ± 2 and 70 ± 5% RH) in the P.G. lab.

Guava varieties used for experiment :

Allahabad Safeda	Hisar Safeda	Hisar Surkha	Lalit	Shweta
Sardar (L-49)	Pant Parbhat	Barf Khana	Aishwarya	Arka Kiran
Banarsi Surkha	Pant Red	Punjab Pink	Kg Guava	Arka Mridula

Observation Recorded : Fruit samples were analysed for physiological changes like, Physiological Loss in Weight (PLW) (%), Decay loss or spoilage (%), Moisture content, Specific gravity (g/cm^3), Fruit firmness (kg/cm^2) and organoleptic ratings. Cylindrical plunger probe penetrometer used for measurement of firmness. Organoleptic ratings was given per the 9 points hedonic rating scale. Observation was recorded on alternate days.

Statistical Analysis : The experiment was carried out under Completely Randomized Design with factorial arrangements. The data recorded were analyzed by using Analysis of Variance (ANOVA). The statistical analysis was carried out by using OPSTAT statistical software.

PLW (%) : Data depicted in Table-1 and Table-2 demonstrated significant loss in weight in fruits during storage of both the seasons. It was observed that during rainy season, Hisar Safeda (7.23%) exihibited the minimum loss in weight, which was at par with Shweta (7.90%), Arka Mridula (7.87%) and Pant Parbhat (7.70%), whereas, maximum loss was observed in Lalit (11.38%). In winter season also Hisar Safeda (8.43%) exhibited the minimum loss in weight, which is statistically at par with Pant Parbhat (8.66%) and maximum PLW was observed in Banarsi Surkah (11.76%). Storage period also had the

Table-1 : PLW (%) of fruits of guava cultivars under ambient storage during rainy season.

Varieties	Storage period (Days)			
	0	2	4	Mean A
Allahabad Safeda	0.00 (0.00)	8.83 (17.28)	16.70 (24.11)	8.51 (13.80)
Hisar Safeda	0.00 (0.00)	6.87 (15.19)	14.83 (22.64)	7.23 (12.61)
Hisar Surkha	0.00 (0.00)	9.07 (17.49)	21.80 (27.81)	10.29 (15.10)
Pant Parbhat	0.00 (0.00)	7.20 (15.56)	15.90 (23.49)	7.70 (13.01)
Lalit	0.00 (0.00)	11.37 (19.66)	22.77 (28.48)	11.38 (16.05)
Shweta	0.00 (0.00)	8.47 (16.87)	15.23 (22.96)	7.90 (13.28)
L-49	0.00 (0.00)	10.53 (18.91)	18.47 (25.44)	9.67 (14.78)
Barf Khana	0.00 (0.00)	8.63 (17.08)	16.77 (24.16)	8.47 (13.75)
Aishwarya	0.00 (0.00)	7.70 (16.10)	16.91 (24.27)	8.20 (13.46)
Arka Kiran	0.00 (0.00)	7.73 (15.56)	16.17 (26.95)	7.97 (14.17)
Arka Mridula	0.00 (0.00)	7.83 (16.24)	15.77 (23.34)	7.87 (13.21)
Banarsi Surkha	0.00 (0.00)	12.13 (20.22)	21.47 (27.59)	11.20 (15.94)
Pant Red	0.00 (0.00)	11.87 (20.14)	22.20 (28.10)	11.36 (16.08)
Punjab Pink	0.00 (0.00)	11.40 (19.73)	20.33 (26.79)	10.58 (15.51)
KG Guava	0.00 (0.00)	8.67 (17.11)	16.70 (24.11)	8.46 (13.74)
Mean B	0.00 (0.00)	9.22 (17.58)	18.45 (25.37)	
C.D. at 5%	Varieties = 0.71, Storage period = 0.32 and Varieties×Storage period = 1.23			

Table-2 : PLW (%) of fruits of guava cultivars under ambient storage during winter season.

Varieties	Storage period (Days)					
	0	2	4	6	8	Mean A
Allahabad Safeda	0.00 (0.00)	5.07 (13.00)	8.93 (17.38)	13.57 (21.60)	19.50 (26.20)	9.41 (15.63)
Hisar Safeda	0.00 (0.00)	3.90 (11.38))	8.27 (16.70)	12.50 (20.68)	17.47 (24.69)	8.43 (14.69)
Hisar Surkha	0.00 (0.00)	6.50 (14.76)	9.62 (18.06)	15.03 (22.80)	23.30 (28.85)	10.89 (16.90)
Pant Parbhat	0.00 (0.00)	4.13 (11.71)	8.03 (16.46)	13.40 (21.46)	17.71 (24.87)	8.66 (14.90)
Lalit	0.00 (0.00)	6.95 (14.53)	11.03 (18.87)	15.36 (23.98)	24.72 (30.32)	11.61 (17.54)
Shweta	0.00 (0.00)	4.63 (12.42)	8.77 (17.21)	12.57 (20.75)	18.77 (25.66)	8.95 (15.21)
L-49	0.00 (0.00)	5.77 (13.89)	9.10 (17.53)	13.33 (21.41)	22.01 (27.97)	10.04 (16.16)
Barf Khana	0.00 (0.00)	4.83 (12.66)	8.64 (17.09)	13.00 (21.12)	21.51 (27.62)	9.60 (15.70)
Aishwarya	0.00 (0.00)	4.73 (12.53)	8.20 (16.63)	12.58 (20.76)	19.27 (26.02)	8.96 (15.19)
Arka Kiran	0.00 (0.00)	5.98 (14.15)	9.48 (17.93)	14.76 (22.58)	26.02 (30.66)	11.25 (17.06)
Arka Mridula	0.00 (0.00)	5.97 (14.12)	9.67 (18.10)	15.04 (22.81)	22.23 (28.12)	10.58 (16.63)
Banarsi Surkha	0.00 (0.00)	6.30 (15.28)	10.47 (19.39)	16.54 (23.06)	25.50 (29.80)	11.76 (17.51)
Pant Red	0.00 (0.00)	6.23 (14.44)	9.73 (18.l7)	15.02 (22.79)	24.99 (29.98)	11.19 (17.08)
Punjab Pink	0.00 (0.00)	6.61 (14.89)	10.94 (19.31)	15.24 (22.97)	24.70 (29.79)	11.50 (17.39)
KG Guava	0.00 (0.00)	6.44 (14.70)	10.53 (18.93)	15.60 (23.25)	22.37 (28.21)	10.99 (17.02)
Mean B	0.00 (0.00)	5.60 (13.63)	9.43 (17.85)	14.24 (22.14)	22.00 (27.92)	
C.D. at 5%	Varieties= 0.34, Storage period= 0.19 Varieties× Storage period= 0.75					

significant impact on the PLW. Singh *et al.* (2008) revealed that the differences in water vapour permeability might be the possible reason for weight loss in different varieties of guava. In addition to this, the loss of moisture from the fresh fruits might be one of the major factors responsible for the loss in weight (Siddiqui *et al.,* 1991).

Tiwari *et al.* (2017) also evaluated five guava varieties and found that minimum loss in weight was in cv. L-49 and maximum was in Gorakh Bilas Pasand. Similar gradual loss in weight with passage of storage period was observed by Tiwari *et al.*(2017), Killadi *et al.*(2007) and Kumar *et al.*(2003) in guava, Pandey *et al.*(2006) and Kishor *et al.*(2018) in apple, Hoda *et al.*(2001) and Karuna *et al.* (2015) in mango, Singh *et al.* (2005) in aonla and Kumar (2006) in ber. Continuous transpiration and respiration might be feasible reason for the loss in weight of fruits.

Decay (%) : It is clear from the Table-3 that decay loss was significantly varied among the varieties in rainy season crop. Minimum decay loss was observed cv. Hisar Safeda (23.45%), which was statistically at par with Pant Parbhat (25.92%) and Barf Khana (26.98%) and maximum decay was observed in cv. Lalit (40.17%). Similarly, in winter season also, varieties significantly influenced the decay loss (Table 4). Minimum decay loss was observed in Minimum decay loss was observed in Hisar Safeda (23.70 %), which was statistically at par with Pant Parbhat (26.66%) and Barf Khana (27.62%), while, maximum decay loss was observed in cv. Punjab Pink (44.44%). According to Reyes and Paull (1995) the decay in guava fruits might be caused by anthracnose and rhizopus rot. Regardless of varieties, storage period also significantly influenced the decay loss. With the passage of storage session, more decayed fruits were found in all

Table-3 : Decay (%) of fruits of guava cultivars under ambient storage during rainy season.

Varieties	Storage period (Days)			
	0	2	4	Mean
Allahabad Safeda	0.00	18.52	70.36	29.63
	(0.00)	(25.23)	(57.09)	(27.44)
Hisar Safeda	0.00	11.11	59.25	23.45
	(0.00)	(19.46)	(50.35)	(23.27)
Hisar Surkha	0.00	25.92	81.47	35.80
	(0.00)	(30.49)	(64.73)	(31.74)
Pant Parbhat	0.00	14.81	62.96	25.92
	(0.00)	(22.35)	(52.53)	(24.96)
Lalit	0.00	28.20	92.30	40.17
	(0.00)	(31.90)	(73.86)	(35.25)
Shweta	0.00	22.22	70.36	30.86
	(0.00)	(27.61)	(57.09)	(28.23)
L-49	0.00	19.04	76.18	31.74
	(0.00)	(25.56)	(61.03)	(28.86)
Barf Khana	0.00	14.28	66.66	26.98
	(0.00)	(22.19)	(54.80)	(25.67)
Aishwarya	0.00	14.81	74.07	29.63
	(0.00)	(22.35)	(59.47)	(27.27)
Arka Kiran	0.00	29.63	85.18	38.27
	(0.00)	(32.67)	(67.61)	(33.43)
Arka Mridula	0.00	19.04	80.95	33.33
	(0.00)	(25.56)	(64.39)	(29.99)
Banarsi Surkha	0.00	29.63	88.88	39.50
	(0.00)	(32.87)	(70.49)	(34.45)
Pant Red	0.00	25.64	89.74	38.46
	(0.00)	(30.03)	(71.53)	(33.85)
Punjab Pink	0.00	18.52	88.88	35.80
	(0.00)	(25.23)	(70.49)	(31.91)
KG Guava	0.00	25.92	77.77	34.56
	(0.00)	(29.99)	(62.35)	(30.78)
Mean	0.00	21.15	77.67	
	(0.00)	(26.90)	(62.52)	
C.D. at 5%	Varieties= 5.75, Storage period= 2.6 Varieties× Storage period= 9.96			

the cultivars during both the seasons. Similar results of decay loss was also observed by Pandey *et al.*(2006) and Kishor *et al.*(2018) in apple, Hoda *et al.*(2001) in mango and Kumar (2006) in ber.

Moisture Content (%) : Data depicted in Fig.-1 and 2 shows that varieties had significant domination on moisture content of fruits harvested during both the seasons. Highest moisture content was spotted in cv. Pant Red (83.03%) followed by Lalit (82.36%) and Banarsi Surkha (81.61%) whereas, cv. Hisar Safeda (78.37%) contained the least moisture content. Storage period also affected significantly the moisture content of guava. At ambient storage conditions, it was noticed that moisture content decreased with the passage of storage time. In rainy season maximum and minimum moisture content was observed in Pant Red and Hisar Safeda respectively, while cv. Lalit had the moisture content in winter season which was statistically at par with Banarsi Surkha, while, Hisar Safeda had minimum moisture content in winter season. Tiwari *et al.* (2017*),* in his findings*,* observed highest moisture content in Lalit whereas L-49 had the minimum moisture content. According to Munoz *et al.* (2008), pressure gradient and storage temperature between the fruit tissue and the surroundings temperature moisture levels of stored fruits might be the main reason for change in moisture content.

Specific gravity (g/cm^3) : It is discernible from the data dispensed in the Table 5, when fruits of various varieties of guava in rainy season stored at ambient conditions, then varieties significantly influenced the specific gravity. Hisar Safeda (1.017 g/cm^3) had the highest specific gravity, which was statistically at par with Pant Parbhat (1.014

Table-4 : Decay (%) of fruits of guava cultivars under ambient storage during winter season.

Varieties	Storage period (Days)					
	0	2	4	6	8	Mean A
Allahabad Safeda	0.00 (0.00)	7.41 (12.98)	25.92 (30.49)	48.14 (43.92)	74.07 (59.47)	31.11 (29.37)
Hisar Safeda	0.00 (0.00)	0.00 (0.00)	18.52 (25.23)	37.03 (37.43)	62.96 (52.53)	23.70 (23.04)
Hisar Surkha	0.00 (0.00)	14.81 (22.35)	37.03 (37.43)	66.66 (54.71)	81.47 (64.73)	40.00 (35.84)
Pant Parbhat	0.00 (0.00)	3.70 (6.49)	22.22 (28.11)	40.74 (39.61)	66.66 (54.71)	26.66 (25.78)
Lalit	0.00 (0.00)	17.94 (24.95)	38.45 (38.25)	71.79 (58.06)	87.17 (69.20)	43.07 (38.09)
Shweta	0.00 (0.00)	7.41 (12.98)	29.63 (32.87)	51.85 (46.04)	77.77 (61.84)	33.33 (30.75)
L-49	0.00 (0.00)	9.52 (14.80)	28.57 (32.30)	57.14 (49.21)	80.95 (64.39)	35.24 (32.14)
Barf Khana	0.00 (0.00)	4.76 (7.40)	19.04 (25.56)	42.85 (40.87)	71.42 (57.66)	27.62 (26.30)
Aishwarya	0.00 (0.00)	4.76 (7.40)	23.81 (28.93)	47.61 (43.61)	66.66 (54.80)	28.57 (26.95)
Arka Kiran	0.00 (0.00)	11.11 (19.46)	44.44 (41.74)	74.07 (59.97)	88.88 (73.91)	43.70 (39.02)
Arka Mridula	0.00 (0.00)	9.52 (14.80)	23.81 (28.93)	52.38 (46.35)	76.18 (61.03)	32.38 (30.22)
Banarsi Surkha	0.00 (0.00)	14.81 (18.74)	40.74 (39.61)	70.36 (57.09)	85.18 (67.61)	42.22 (36.61)
Pant Red	0.00 (0.00)	15.38 (23.08)	35.89 (36.77)	76.92 (61.26)	84.61 (66.88)	42.56 (37.60)
Punjab Pink	0.00 (0.00)	11.11 (19.46)	44.44 (41.74)	74.07 (59.47)	92.58 (76.79)	44.44 (39.49)
KG Guava	0.00 (0.00)	9.52 (14.80)	23.81 (28.93)	52.38 (46.35)	76.18 (61.03)	32.38 (30.22)
Mean B	0.00 (0.00)	9.45 (14.64)	30.42 (33.13)	57.60 (49.60)	78.18 (63.11)	
C.D. at 5%	Varieties= 4.35, Storage period= 2.51 Varieties×Storage period= NS					

g/cm^3) and Barf Khana (1.011 g/cm^3) and the least was observed in cv. Pant Red (0.990). Data on specific gravity of winter season crop is presented in Table-6. The specific gravity significantly varied among all the cultivars. Highest specific gravity was observed in the cv. Pant Parbhat (1.029 g/cm^3) and minimum specific gravity was found in Pant Red (1.00 g/cm^3). Regardless of varieties, specific variety increased significantly with the passage of storage period in both the seasons. Similar increasing trend of specific gravity with the passage of storage period was also recorded by Pandey *et al.*(2006) in apple up to 7 days of storage.

Firmness (kg/cm^3) : Data for firmness demonstrated in Table-7 clearly showed the significant variations in fruit firmness among the different varieties of rainy season crop. Hisar Safeda (3.77 kg/cm^3) had the significantly higher firmness, which was statistically at par with cv. Pant Parbhat (3.76 kg/cm^3) followed by Barf Khana (3.65 kg/cm^3), Allahabad Safeda (3.56 kg/cm^3) and Shweta (3.52 kg/cm^3) and cv. Lalit (2.95 kg/cm^3) had the lowest firmness. In winter season also, firmness varied significantly among the varieties (Table 8). Maximum firmness was observed in Pant Parbhat (5.00 kg/cm^3) followed by Hisar Safeda (4.94 kg/cm^3), Shweta (4.77 kg/cm^3) and L-49 (4.72 kg/cm^3), whereas, cv. Pant Red (4.23 kg/cm^3) had the minimum firmness. Fruit firmness also significantly varied with the advancement of storage. Firmness in fruits of all the cultivars decreased with passage of time. Maximum firmness was recorded in on the day of harvest and lowest on last day (1.54 kg/cm^3) of storage in both the seasons. According to Kishor *et al.* (2018) decrease in the firmness of fruits might be due to disintegration of insoluble protopectins into soluble pectin. Ali *et al.*(2004) proposed that softening of guava fruits might be due to increases in the activities of exo-polygalacturonase (PG), pectin methylesterase, (1?4)-glucanase, and –galactosidase which abated the increase in pectin solublisation and disruption of the the xyloglucan–cellulose micro fibril networks.

Table-5 : Specific gravity (g/cm^3) of fruits of guava cultivars under ambient storage during rainy season.

Varieties	Storage period (Days)			
	0	2	4	Mean A
Allahabad Safeda	0.993	1.01	1.018	1.007
Hisar Safeda	1.003	1.020	1.028	1.017
Hisar Surkha	0.987	1	1.014	1
Pant Parbhat	0.997	1.018	1.028	1.014
Lalit	0.977	0.997	1.022	0.999
Shweta	0.987	1.013	1.02	1.007
L-49	0.987	1	1.018	1.002
Barf Khana	0.993	1.013	1.027	1.011
Aishwarya	0.987	1.01	1.017	1.005
Arka Kiran	0.983	1	1.017	1
Arka Mridula	0.990	1.013	1.021	1.008
Banarsi Surkha	0.977	0.993	1.01	0.993
Pant Red	0.973	0.99	1.007	0.99
Punjab Pink	0.983	1.003	1.007	0.998
KG Guava	0.983	1.017	1.023	1.008
Mean B	0.987	1.007	1.018	
C.D. at 5%	Varieties= 0.004, Storage period= 0.002 and Varieties×Storage period=0.008			

Table-6 : Specific gravity (g/cm^3) of fruits of guava cultivars under ambient storage during winter season.

Varieties	Storage period (Days)					
	0	2	4	6	8	Mean A
Allahabad Safeda	0.980	1.000	1.01	1.022	1.029	1.008
Hisar Safeda	1.003	1.016	1.023	1.029	1.035	1.021
Hisar Surkha	0.983	1.003	1.015	1.022	1.027	1.010
Pant Parbhat	1.013	1.024	1.031	1.036	1.038	1.029
Lalit	0.98	1.00	1.019	1.024	1.030	1.010
Shweta	1.003	1.015	1.023	1.028	1.033	1.020
L-49	0.983	1.015	1.023	1.030	1.032	1.017
Barf Khana	1.003	1.017	1.025	1.030	1.035	1.022
Aishwarya	1.003	1.02	1.027	1.032	1.040	1.024
Arka Kiran	0.983	1.00	1.008	1.021	1.029	1.008
Arka Mridula	0.993	1.013	1.020	1.026	1.032	1.017
Banarsi Surkha	0.983	1.013	1.021	1.029	1.031	1.015
Pant Red	0.973	0.987	1.003	1.015	1.022	1.00
Punjab Pink	0.997	1.014	1.023	1.032	1.036	1.02
KG Guava	0.993	1.013	1.024	1.031	1.036	1.019
Mean B	0.992	1.010	1.021	1.028	1.033	

Organoleptic quality : It is evident from the data presented in Fig.-3 that the hedonic based organoleptic rating of rainy season crop was significantly influenced by the different varieties. Highest ratings was secured by cv. Hisar Safeda (7.7), which was statistically at par with Pant Parbhat (7.6) followed by Barf Khana (7), Allahabad Safeda (6.9) and Shweta (6.9) and lowest ratings was observed in Pant Red (5.5). It is perusal from the data presented in the Fig 4 that organoleptic ratings for winter

Table-7 : Firmness (kg/cm^3) of fruits of guava cultivars under ambient storage during rainy season.

Varieties	Storage period (Days)			
	0	2	4	Mean
Allahabad Safeda	5.36	3.53	1.78	3.56
Hisar Safeda	5.54	3.79	1.99	3.77
Hisar Surkha	5.07	3.19	1.33	3.20
Pant Parbhat	5.54	3.75	1.99	3.76
Lalit	4.97	2.79	1.08	2.95
Shweta	5.18	3.48	1.90	3.52
L-49	5.19	3.28	1.56	3.34
Barf Khana	5.46	3.69	1.79	3.65
Aishwarya	5.33	3.54	1.53	3.47
Arka Kiran	5.08	3.12	1.09	3.10
Arka Mridula	5.39	3.41	1.54	3.45
Banarsi Surkha	5.06	3.05	1.30	3.14
Pant Red	5.00	2.92	1.12	3.01
Punjab Pink	5.08	3.28	1.31	3.22
KG Guava	5.25	3.39	1.74	3.46
Mean	5.23	3.35	1.54	
C.D. at 5%	Varieties= 0.05, Storage period= 0.02, Varieties×Storage period= 0.08			

Table-8 : Firmness (kg/cm^3) of fruits of guava cultivars under ambient storage during winter season.

Varieties	Storage period (Days)					
	0	2	4	6	8	Mean
Allahabad Safeda	7.04	5.76	4.58	3.41	2.15	4.59
Hisar Safeda	7.29	6.27	4.96	3.83	2.36	4.94
Hisar Surkha	6.80	5.75	4.28	2.95	1.68	4.29
Pant Parbhat	7.27	6.32	5.07	3.94	2.38	5.00
Lalit	6.64	5.41	4.13	3.64	1.50	4.26
Shweta	7.28	5.92	4.73	3.69	2.23	4.77
L-49	6.99	5.75	4.60	3.77	2.48	4.72
Barf Khana	6.97	5.82	4.56	3.56	2.31	4.64
Aishwarya	7.20	5.76	4.57	3.32	2.17	4.60
Arka Kiran	6.80	5.55	4.22	3.13	1.81	4.30
Arka Mridula	7.05	5.76	4.42	3.48	2.23	4.59
Banarsi Surkha	6.76	5.75	4.23	3.10	1.79	4.33
Pant Red	6.76	5.56	4.17	3.03	1.60	4.23
Punjab Pink	6.89	5.74	4.29	3.11	1.81	4.37
KG Guava	7.14	5.86	4.57	3.62	2.16	4.67
Mean	6.99	5.80	4.49	3.44	2.05	
C.D. at 5%	Varieties= 0.05, Storage period= 0.03, Varieties × Storage period= 0.12					

season crop significantly varied among the varieties. Pant Parbhat (7.5) topped the table with highest organoleptic ratings, which was statistically at par with Hisar Safeda (7.4) whereas Pant Red (6.1) secured lowest ratings. Storage period also influenced the ratings significantly. Under ambient conditions, organoleptic ratings decreased continuously and at the time of termination of storage.

Fig-1: Moisture Content (%) of fruits of guava cultivars under ambient storage during rainy season

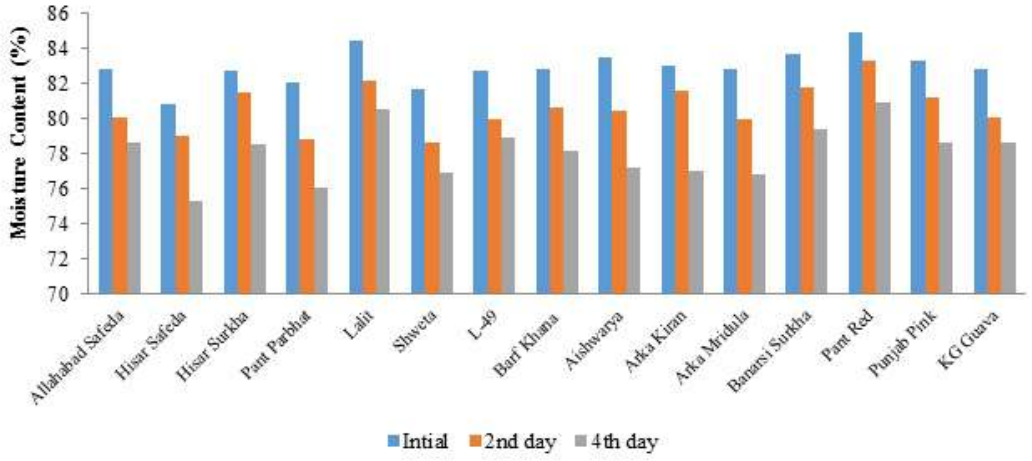


Fig-2: Moisture Content (%) of fruits of guava cultivars under ambient storage during winter season

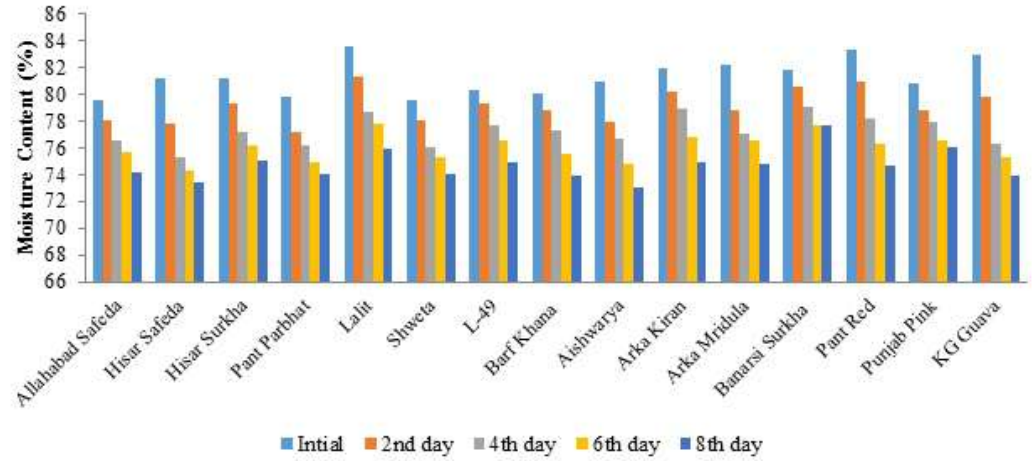
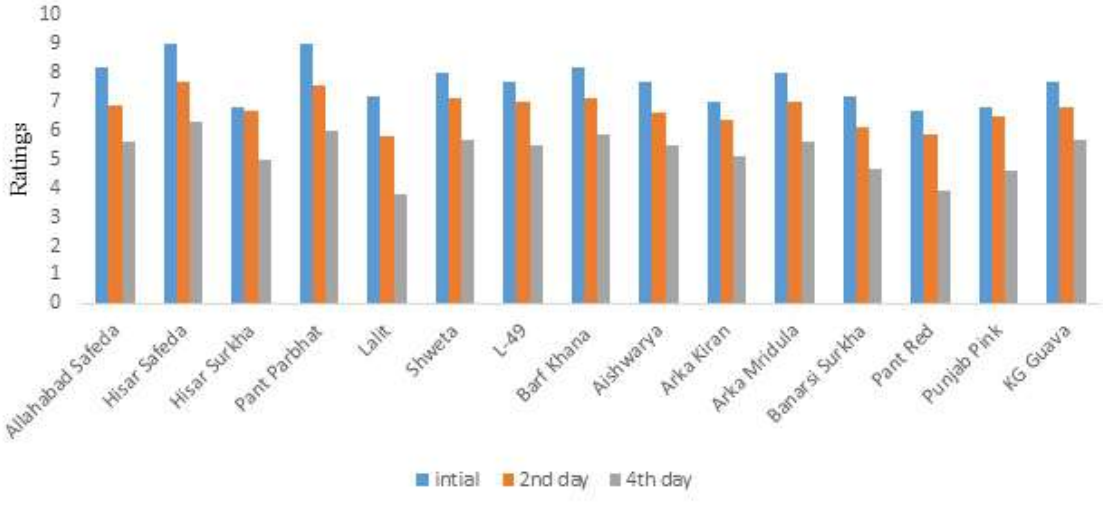
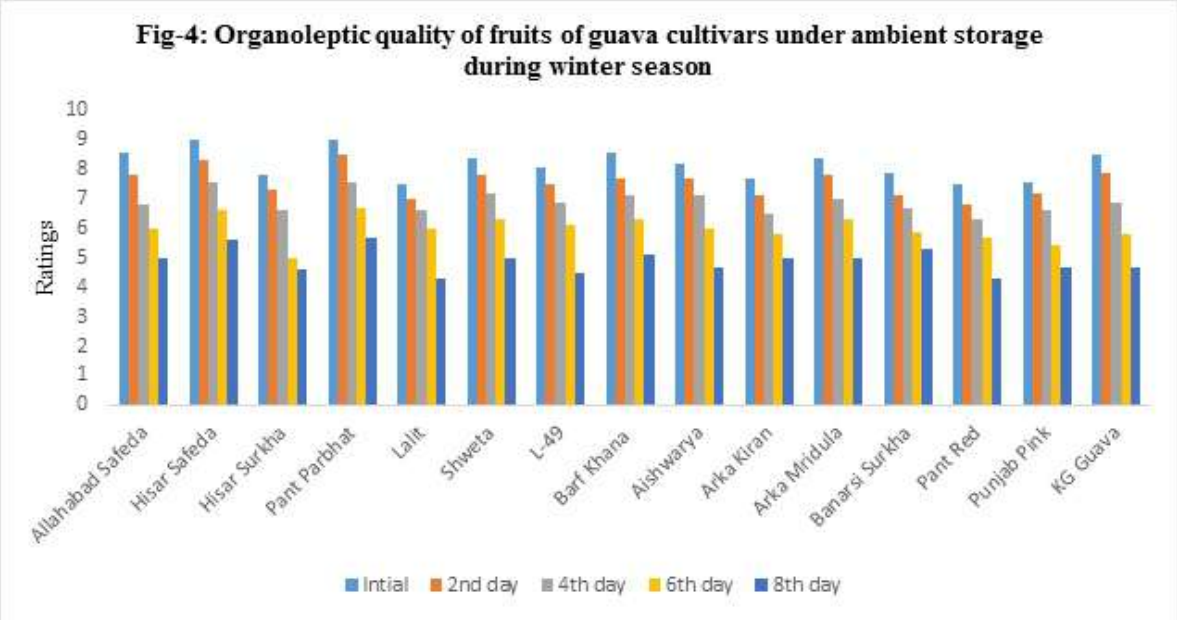


Fig-3 : Organoleptic quality of fruits of guava cultivars under ambient storage during rainy season





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Optimization of Foliar Nutrition and Nipping for Plant Growth and Seed Yield of Pigeonpea [*Cajanus cajan* (L). Millsp.]

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Abstract

A field experiment was conducted in red sandy clay loam soil at UAS, GKVK, Bengaluru during *kharif*, to know the influence of foliar nutrition and nipping on crop growth and seed yield in pigeonpea cv. BRG-2. The experiment replicated six times in split plot design with treatments of foliar nutrition of three different concentrations, F_0 (100 % RDF), F_1 (75 % RDF + 25 % WSF (19: 19:19), F_2 (75 % RDF + 12.5 % WSF (19: 19:19) in combination with nipping (N_1) and no nipping (N_0). The results revealed that significant higher dry matter accumulation plant^{-1} (305.4 g) and higher stover yield ha^{-1} (3959 kg) recorded in F_2N_1 (75 % RDF + 12.5 % WSF (19: 19:19) + nipping). Yield attributing characters *viz*., pods plant^{-1} (119), pod weight plant^{-1} (182.80 g), hundred seed weight (13.08 g) recorded higher in F_2N_1 (75 % RDF + 12.5 % WSF (19: 19:19) + nipping), which results in higher seed yield (16.54 q ha^{-1}).

Key words : *Foliar nutrition, nipping, pigeoppea, water soluble fertilizer.*

Introduction

Pulses are the wonderful gift of nature. They provide vital protein and vitamins in the diet. Pulse form a cheapest and major source of dietary protein especially for vegetarians who form a major part of our population. The UN general assembly declared 2016 as the International Year of Pulses? which reflects the importance of pulses in global concerns regarding food security, preserving cultural heritage and sustainable development. It provides unprecedented opportunity to raise awareness and to celebrate the role of beans, chickpea, pigeonpea and other pulses in feeding the world. Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a perennial crop native to Africa, belongs to family *Fabaceae*. It is also known as no-eye pea, gungo pea in Jamaica, tropical green pea and arhar in India (Anon., 2017). It is one of the protein rich legumes of the semi-arid tropics grown predominantly under rainfed conditions. It is cultivated throughout the tropical and sub-tropical regions of the world, between 30°N and 35°S latitudes. However, major area under pigeonpea in India is lying between 14°S and 28°N latitudes. Globally, redgram is grown in an area of 63.57 lakh hectares with a production of 54.75 lakh tonnes and productivity of 861.25 kg/ha (FAO STAT, 2021). India ranks first in redgram production globally with 43.4 lakh tonnes cultivated under 49.8 lakh hectares with productivity of 871 kg/hectare in 2021-22 (agricoop.nic.in). In Kharif 2022-23, redgram production was 38.9 lakh tonnes (1st advance estimates) in an area of 46.2 lakh hectares (agricoop.nic). Application of foliar nutrients along with soil application has several benefits in supplementing the nutritional requirements to crops. Foliar nutrient spray is designed to exclude the problems like immobilization and fixation of nutrients. Hence, foliar nourishment recognized as an important method of fertilization in modern-day agriculture. This method provides for exploitation of nutrients more efficiently and for correcting deficiencies rapidly. Foliar spray of macronutrients is most important factor in determining the yield (Reddy *et al.,* 2010). In almost all the pulses, flower drop determines the yield and yield attributing characters. Retention of flowers that are produced by the plant helps realize higher yield than expected.

Nipping of young tender top shoots though traditionally practiced by the farmer but its associated beneficial effects are not scientifically documented. Apical bud nipping is known to alter the source-sink relationship by arresting the vegetative growth and hastening the reproductive phase. It also helps in production of more pod bearing branches with luxuriant foliage thus, enhances the photosynthetic activity, accumulation of more photosynthates, ultimately resulting in better seed quality with higher seed yield (Thakral *et al*., 1991).

Materials and Methods

The field experiment was carried out during kharif-2017 at Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, GKVK, Bengaluru. The experiment consist of six treatment combinations they are as follows F_0N_0: Recommended dose of fertilizer 25: 50: 25 kg NPK ha^{-1} (100 % RDF) + No nipping, F_1N_0: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water

Table-1 : Influence of foliar nutrition and nipping on plant height, number of branches, in pigeonpea cv. BRG-2.

Treatments	Plant height			Number of branches		
	Before nipping	120 DAS	At harvest	Before nipping	120 DAS	At harvest
Main plot (nutrient management)						
F_0	80.98	203.4	209.3	6.20	6.52	6.52
F_1	79.23	208.8	212.2	6.60	7.22	7.22
F_2	79.67	212.5	219.7	6.43	7.05	7.05
S.Em±	1.91	2.75	2.14	0.28	0.20	0.20
CD (p=0.05)	NS	NS	6.3164	NS	NS	NS
Sub plot (nipping)						
N_0	80.86	214.3	218.6	6.36	6.71	6.71
N_1	79.07	202.2	208.8	6.47	7.14	7.14
S.Em±	1.21	3.44	3.30	0.29	0.31	0.31
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Interaction						
F_0N_0	83.30	212.1	215.4	5.77	6.30	6.30
F_1N_0	79.50	211.7	213.8	6.73	7.10	7.10
F_2N_0	79.77	219.2	226.6	6.57	6.73	6.73
F_0N_1	78.67	194.8	203.1	6.63	6.73	6.73
F_1N_1	78.97	206.0	210.6	6.47	7.33	7.33
F_2N_1	79.57	205.8	212.7	6.30	7.37	7.37
Different levels of F means at the same or different levels of N						
S.Em±	2.70	3.89	3.03	0.39	0.29	0.29
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Different levels of F means at the different levels of N						
S.Em±	2.52	4.68	4.12	0.43	0.39	0.39
CD (p=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	6.4	7	6.55	14.98	10.09	10.09

Main plot treatment (nutrient management)

F_0: Recommended dose of fertilizer 25: 50: 25 kg NPK ha^{-1} (100 % RDF).

F_1:18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

F_2:18.75: 37.5: 18.75 kg NPK ha^{-1} (75% RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

Sub plot treatments (nipping)

N_0: No nipping

N_1: Nipping at 45-60 DAS

soluble fertilizer (19: 19: 19) at 45 and 75 DAS + No nipping, F_2N_0: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS + No nipping, F_0N_1: Recommended dose of fertilizer 25: 50: 25 kg NPK ha^{-1} (100 % RDF) + Nipping, F_1N_1: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS + Nipping, F_2N_1: 18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS + Nipping, laid out in split plot design with six replications. The following parameters were recorded plant height at before nipping, 120 DAS and at harvest, Number of branches at 60 DAS, 120 DAS and at harvest, Total dry matter 120 DAS and at harvest, Number of pods plant $^{-1}$, Number of seeds pod^{-1}, Pod weight plant^{-1} (g), Seed weight plant^{-1} (g), 100 seed weight, Seed yield ha^{-1} (q), Stover yield ha^{-1} (kg), Seed recovery (%).

Results and Discussion

The plant height and number of branches did not differ significantly due to different concentration of water soluble fertilizer (WSF) as well as nipping and also their interaction. The plant height recorded lower in nipped plants because nipping arrest the vertical growth of plants [1]. Significant difference was recorded for dry matter accumulation and stover yield. Higher dry matter was observed in F_2N_1 (172.3 g plant^{-1}) and lower in control F_0N_0 (159.6 g plant^{-1}) and for the stover yield highest was observed in F_2N_1 (3959 kg ha^{-1}) and lower in control F_0N_0 (3180 kg ha^{-1}) Dry matter accumulation is an important index that reflects the growth and metabolic efficiency of the plant which ultimately influence the crop yield. The amount of dry matter produced is an indication of the overall efficiency of resources utilization. Increase in dry matter of plant due to foliar spray might be due to

Table-2 : Influence of foliar nutrition and nipping on dry matter accumulation, stover yield in pigeonpea cv. BRG-2.

Treatments	Dry matter accumulation plant^{-1} (g)		Stover yield ha^{-1} (kg)
	120 DAS	At harvest	
Main plot (nutrient management)			
F_0	163.9	222.4	3317
F_1	169.9	258.5	3581
F_2	171.4	300.1	3750
S.Em±	2.00	6.09	23.89
CD (p=0.05)	5.89	17.98	70.46
Sub plot (nipping)			
N_0	167.2	258.8	3361
N_1	169.6	261.8	3737
S.Em±	1.63	4.90	38.65
CD (p=0.05)	NS	NS	140.5
Interaction			
F_0N_0	159.6	211.0	3180
F_1N_0	169.7	270.8	3363
F_2N_0	170.5	294.7	3541
F_0N_1	168.2	233.7	3455
F_1N_1	170.1	246.1	3798
F_2N_1	172.3	305.4	3959
Different levels of F means at the same or different levels of N			
S.Em±	2.83	8.62	33.78
CD (p=0.05)	NS	25.42	99.65
Different levels of F means at the different levels of N			
S.Em±	2.83	8.57	47.48
CD (p=0.05)	NS	27.21	NS
CV (%)	6.21	8.11	7.42

Main plot treatment (nutrient management)

F_0: Recommended dose of fertilizer 25: 50: 25 kg NPK ha^{-1} (100 % RDF).

F_1:18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

F_2:18.75: 37.5: 18.75 kg NPK ha^{-1} (75% RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

Sub plot treatments (nipping)

N_0: No nipping

N_1: Nipping at 45-60 DAS

adequate and synchronized supply of N, P and K as per crop demand. Foliar nutrients usually penetrate the leaf cuticle or stomata and enter the cells facilitating easy and rapid utilization of nutrients. The availability nutrient helps in physiological mechanisms of plants that in turn increase the dry matter [2]. Nipped plants also showed higher dry matter accumulation due to enhanced lateral branches [3]. As a result of increase in the dry matter accumulation with foliar application of water soluble fertilizer and nipping treatments thus there is increase in the stover yield of pigeonpea in the same treatments [4].

Yield Parameters

The data pertaining to yield parameters like number of pods plant^{-1}, pod weight and number of seeds pod^{-1}, Seed weight plant^{-1},Seed yield plot^{-1} and Seed yield ha^{-1} influenced by concentration of water soluble fertilizer spray, nipping and their interaction effects is presented in Table 3. Significant differences were observed in number of pods plant^{1} F_2N_1 (119) recorded higher pods and lower number of pods plant^{-1} was observed in control (F_0N_0: 98.17). Higher numbers of pod per plants have been documented in foliar application of macronutrient, nipping and their combination. This might be due to flower retention by foliar spray of water soluble fertilizer, increase in flower retention might have lead to increased pods per plant [5]. Nipping increased the reproductive branches or pod bearing branches [6]. Pods weight recorded higher in (F_2N_1: 182.80 g) and lower pod weight in (F_0N_0: 133.21 g). Higher seed weight plant^{-1} was recorded in F_2N_1 (44.66 g) and lower was recorded in control (31.79 g). Similarly higher seed yield plot^{-1}was recorded in F_2N_1 (2.68 kg) and lower was recorded in control (1.91 kg) this inturn resulted in higher seed yield ha^{-1} in F_2N_1 (16.54 q ha^{-1}) lower was recorded in control (11.77 q ha^{-1}). Seed yield is governed by number of factors having direct or indirect impacts. The

Table-3 : Influence of foliar nutrition and nipping on number of pods plant^{-1}, pod weight andnumber of seeds pod^{-1}, Seed weight plant^{-1},Seed yield plot^{-1} Seed yield ha^{-1} and seed recovery in pigeonpea cv. BRG-2.

Treatments	Number of pods plant^{-1}	Pod weight (g)	Number of seeds pod^{-1}	Seed yield plot^{-1} (kg)	Seed yield ha^{-1} (q)	Seed recovery (%)
Main plot (Nutrient management)						
F_0	98.33	138.79	5.70	2.13	13.15	92.05
F_1	108.83	155.54	5.71	2.28	14.09	92.84
F_2	115.33	157.95	5.75	2.45	15.12	92.84
S.Em±	2.05	9.25	0.02	0.05	0.34	0.39
CD (p=0.05)	6.05	NS	NS	0.16	0.998	NS
Sub plot (nipping)						
N_0	104.89	136.86	5.71	2.11	13.00	91.62
N_1	110.11	164.66	5.73	2.47	15.24	93.53
S.Em±	1.20	5.13	0.01	0.05	0.31	0.44
CD (p=0.05)	4.37	18.66	NS	0.18	1.12	NS
Interaction						
F_0N_0	98.17	133.21	5.72	1.91	11.77	91.43
F_1N_0	104.83	134.26	5.67	2.19	13.51	92.30
F_2N_0	111.67	143.10	5.73	2.22	13.70	91.45
F_0N_1	98.50	143.32	5.68	2.35	14.52	92.67
F_1N_1	112.83	167.88	5.75	2.38	14.67	93.39
F_2N_1	119.00	182.80	5.77	2.68	16.54	94.53
Different levels of F means at same or different levels of N						
S.Em±	2.90	13.09	0.02	0.08	0.48	0.56
CD (p=0.05)	8.55	38.60	NS	0.23	0.41	1.65
Different levels of F means at different levels of N						
S.Em±	2.66	11.85	0.02	0.08	0.50	0.63
CD (p=0.05)	8.21	36.49	NS	0.23	1.60	2.07
CV (%)	6.61	14.45	0.98	8.30	8.30	2

Main plot treatment (nutrient management)

F_0: Recommended dose of fertilizer 25: 50: 25 kg NPK ha^{-1} (100 % RDF).

F_1:18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

F_2:18.75: 37.5: 18.75 kg NPK ha^{-1} (75% RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

Sub plot treatments (nipping)

N_0: No nipping

N_1: Nipping at 45-60 DAS

Table-4 : Economics of different treatments in pigeonpea cv. BRG-2.

Treatments	Cost of cultivation ha^{-1} (Rs.)	Gross returns ha^{-1} (Rs.)	Net return ha^{-1} (Rs.)	B : C
F_0N_0	45907	75351	29444	1.64
F_1N_0	50700	86476	35776	1.71
F_2N_0	50532	87684	37152	1.74
F_0N_1	50187	92951	42764	1.85
F_1N_1	52700	93893	41193	1.78
F_2N_1	52532	105850	53318	2.01

Main plot treatment (nutrient management)

F_0: Recommended dose of fertilizer 25: 50: 25 kg NPK ha^{-1} (100 % RDF).

F_1:18.75: 37.5: 18.75 kg NPK ha^{-1} (75 % RDF) + 25 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

F_2:18.75: 37.5: 18.75 kg NPK ha^{-1} (75% RDF) + 12.5 % Foliar spray of water soluble fertilizer (19: 19: 19) at 45 and 75 DAS.

Sub plot treatments (nipping)

N_0: No nipping

N_1: Nipping at 45-60 DAS

improvement in seed yield is achieved through improvement in yield attributing characters *viz.,* number of pods plant^{-1}, pod weight plant^{-1}, number of seeds pod^{-1} and test weight. The practice of nipping of terminal bud carried between 45-55 days after sowing and foliar spray might have efficiently altered the crop architecture by activating the dormant lateral branches which ultimately increased the lateral branches and might led to increased number of pods plant^{-1}, which may resulted in greater chance for development of source and sink features and thereby would have facilitated the significant increase in the yield attributes and yield in pigeonpea [7] [8]. Among interactions significant difference was observed in seed recovery percentage. Higher seed recovery percentage was recorded in F_2N_1 (94.53 %) and lower seed recovery percentage in control F_0N_0 (91.43 %). This might be due to bolder seed size as compared to control. The bolder seed size might be attained by better photosynthates accumulation in the seeds which might be due to better nutrient availability to the sink [9].

Economics

Highest cost of cultivation was recorded in F_1N_1 Rs. 52700 and lowest was recorded in control Rs.45907 ha^{-1}. Gross returns were ultimately the result of seed yield of different treatments in pigeonpea. Higher gross returns was recorded in F_2N_1 (Rs.105850 ha^{-1}) and lowest in control (Rs.75351 ha^{-1}). Foliar spray of 12.5 % WSF (19:19:19) with nipping has given the higher net returns of Rs. 53318 ha^{-1} and lower in control (Rs.29444 ha^{-1}). B: C ratio highest was recorded in Foliar spray of 12.5 %WSF (19:19:19) with nipping (F_2N_1) (2.01) and lowest in control (1.64).

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PDKV Kanak – Wilt and DDR Disease Resistant Chickpea Variety

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Abstract

The major goals of chickpea breeding are to increase production either by upgrading the genetic potential of cultivars or by eliminating the effect of diseases. More than 50 pathogens have been reported to affect chickpea. Fusarium wilt is the major disease affecting chickpea crop in the whole country. Incorporation of disease resistant against Fusarium wilt in improved varieties has always been an important part of chickpea breeding programme for reduced losses due to diseases and stabilized chickpea yield. PDKV Kanak (AKG-1303) is a multiple disease resistance, high yielding and suitable for mechanical harvesting variety of chickpea (*Cicer arietinum L.)* derived through hybridization followed by pedigree selection method from a cross of SAKI-9516 X AKG-70. It has high yielding suitable for mechanical harvesting, early and synchronous maturity with medium bold grain size (21.76 g per 100 seed). In AICRP (AVT-2 trial) seventeen entries were evaluated against wilt at 12 locations in different zones. Out of these, entries PDKV Kanak showed Resistant to moderately resistant for *Fusarium* Wilt,at 6 or more locations, and also for Dry root rot.

Key Words : *Chickpea, disease resistant and machine harvestable.*

Introduction

Chickpea *(Cicer arietinum* L.) is the world's third most important pulse crop, after dry beans (Phaseolus vulgaris L.) and dry peas (*Pisum sativum* L.) (Although, chickpea is predominantly consumed as a pulse, dry chickpea is also used in preparing a variety of snack foods, sweets and condiments and green fresh chickpeas are commonly consumed as a vegetable. Fusarium wilt caused by Fusarium oxysporium, is one of the major soil / seed borne disease of chickpea (*C.arietinum* L.). At national level the yield losses encountered due to wilt may vary between 40 to 60 per cent The pathogen is both seed and soil borne; facultative saprophyte and can survive in soil up to six years in the absence of susceptible host (Haware et al. 1978 and 1986). Considering the nature of damage. Development of disease resistance ,variety is essential to reduce the cost of cultivation and crop damage.

Use of resistant varieties is the only economical and practical solution. Most of the resistant varieties have been found to be susceptible after some years because of breakdown in their resistance and evolution of variability in the pathogen. Wilt complex, which manifests itself by vascular wilting or root rots, is one of the most devastating and challenging diseases, which can damage crop at any stage. The wilt pathogen can survive in soil in the absence of host.

Thus there is considerable potential of augmenting the yield of chickpea by minimizing the losses inflicted by the wilt complex. Keeping in view the importance of disease, socio-economic status of the crop and the inadequate research work carried out on the

Materials and Methods

The chickpea genotype PDKV - Kanak has been evolved from a cross of SAKI-9516 X AKG-70. at Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S). Among the several selections made in segregating population, a promising strain PDKV- Kanak (AKG-1303) was evaluated in station trial at Akola during 2013-14 and in multilocation trials during 2014-15 to2017-18.

Tested in All India Coordinated Research Project on Chickpea for three years during 2016-2017, 2017-18 and 2018-19 in Western Central Zone & it was found superior over the check GCP-101 (17.03%), JG-16(6.37%) and JAKI 9218(13.47%).(Table-1) In advance Varietal trial (AVT2+1Desi), variety PDKV-KANAK was Resistant to moderately resistant for *Fusarium* wilt at 6 or more locations in different zones of India.

Results and Discussion

AKG-1303 was evaluated in station trial at Akola during 2013-14 and in multilocation trials during 2014-15 to 2017-18, genotype PDKV- Kanak was showed promising over the predominantly grown varieties under irrigation. It has been again rigorously tested in state multilocation trials during 2014-15 to2017-18, for its confirmation.

Then tested in All India Coordinated Research Project on Chickpea for three years during 2016-2017, 2017-18 and 2018-19 in Western Central Zone & it was found superior over the check GCP-101 (17.03%), JG-16(6.37%) and JAKI 9218(13.47%). (Table-1). In advance Varietal trial (AVT2+1Desi), variety PDKV-KANAK was Resistant to

Table-1 : Summary of grain yield data of Coordinated Varietal Trials.

Particulars	Year of testing	No. of trials/ locations	Proposed variety	National Check 1	Zonal Check 2	Local check 3	Latest release Check 4	Qual. Var. 1
			AKG-1303	GCP-101	JG 16	JAKI-9218	DCP 92-3	Phule G 0818
Mean grain yield (Kg/ha)	1st year (IVT) 2016-17	10	2610	2360	2466	—	—	2706
	2nd year (AVT-1) 2017-18	8	2341	1722	2123	—	—	2205
	3rd year (AVT-2) 2018-19	8	2460	2217	2340	2168	2129	—
	Weighted Mean	26	2481	2120	2322	2168	2129	2483 (18)
Percentage increase or decrease over the checks & qualifying varieties	1st year (IVT) 2016-17			10.59	5.84	—	—	0.00
	2nd year(AVT-1) 2017-18			35.95	10.27	—	—	6.17
	3rd year(AVT-2)2018-19			10.96	5.21	13.47	15.54	—
	Weighted mean	26		17.03	6.85	13.47	15.54	0.00
Frequency in the top three group	1st year (IVT) 2016-17		5/10	3/10	3/10	-	5/10	5/10
	2nd year(AVT-1) 2017-18		5/8	1/8	2/8	—	—	5/8
	3rd year(AVT-2)2018-19		5/8	3/8	4/8	2/8	1/8	—
Frequency in the top three group (pooled for three years)	Weighted mean 2016-2019	26	15/26	7/26	9/26	2/8	6/18	10/18

Table-2 : Reaction to major diseases at different locations (*Fuarium* Wilt Sick Plot).

Disease name	Year of testing	No. of trials/ locations	Proposed Variety		National Check 1		Zonal Check 2		Local check 3		Latest release Check 4		Qual. Var. 1	
			AKG-1303		(R)		(S)		JG 16		—		Phule G 0818	
			Locations		Locations		Locations		Locations		Locations		Locations	
			R	MR	R	MR	R	MR	R	MR	R	MR	R	MR
Wilt (%)	1st year (IVT) 2016-17	13	2	-	-	-	-	-	-	-	-	-	-	-
	2nd year (AVT-1) 2017-18	11	6	1	8	2	-	-	-	-	-	-	2	3
	3rd year (AVT-2) 2018-19	12	4	3	7	-	-		3	5	-	-	- -	- -
DDR (%)	1st year (IVT) 2016-17	-	-	-	-	-	-	-	-	-	-	-	-	-
	2nd year(AVT-1) 2017-18	6	1	1	3	-	-	-	-	-			1	1
	3rd year (AVT-2)	7	2	2	1	1	-	-	3	2	-	-	-	-

moderately resistant for *Fusarium* wilt at 6 or more locations in different zones of India. For Dry root rot variety PDKV-KANAK observed resistant at NEPZ location sabour found resistant(7.921%) in south zone also observed moderately resistant at two locations & For Collar rot these entry in AVT2 +1 Desi trial at NEPZ location these variety observed moderately resistant at Shillongani (10.56%) and at CZ location at Jabalpur observed totally resistant (0.00). (Table-2) Hence there is vital need to developed new variety suitable for mechanical harvesting along with higher yield , hence this genotype PDKV KANKA (AKG-1303) showed the ray of hope for saving farmers cost and breaking yield plateau in chickpea.

Hence there is vital need to Development of disease resistance ,variety is essential to reduce the cost of cultivation and crop damage ,also suitable for mechanical harvesting along with higher yield ,hence this genotype PDKV KANAK (AKG-1303) showed the ray of hope for saving farmers cost and breaking yield plateau in chickpea.

Therefore, it was release for commercial cultivation to the farmers of Western Central Zone (Maharashtra, Gujarat and Western Madhya Pradesh) due to it's special character i.e. multiple disease resistant ,high yielder, tall semi-erect growth habit suitable for mechanical harvesting.

Table-3 : Reaction to major diseases.

Disease name	Year of testing	No. of trials/ locations	Proposed Variety	National Check 1	Zonal Check 2	Local check 3	Latest release Check 4	Qual. Var. 1
			AKG-1303	JG 315(R)	JG 62(S)	JG 16	-	Phule G 0818
Wilt (%)	1st year (IVT) 2016-17	7	37.22	-	63.84 (6)	-	-	15.11
	2nd year (AVT-1) 2017-18	6	17.22(MR)	5.80()	98.28 (S)	-	-	-
	3rd year (AVT-2) 2018-19	6	14.62(MR)	8.32 (R)	86.16 (S)	22.68(S)	-	-
DDR (%)	1st year (IVT) 2016-17	2	44.57		50.51(1)	-	-	51.86
	2nd year (AVT-1) 2017-18	2	55.82(S)	8.80(R)	81.77(S)	-	-	68.12 (S)
	3rd year (AVT)	2	34.37	25(L.1)	74.11(L550)	23.80	-	59.99

Conclusions

PDKV-Kanak variety found higher yield, tall and semi erect plant growth habit (Avg. 54 cm),Medium bold (23.68 g per 100 seed) grain,Early and synchronous maturity (109 days),Resistant to *Fusarium wilt* in wilt sick plot and fruiting zone starting at about 33.40 cm from the ground considered suitable option for mechanical for commercial cultivation to the farmers of Western Central Zone (Maharashtra, Gujarat and Western Madhya Pradesh) due to it's special character.

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Effect of Biotic and Abiotic Factors on the Incidence of Aphid (*Aphis craccivora* Koch) on Cowpea

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Abstract

Investigations were conducted on the "Effect of Biotic and Abiotic Factors on the Incidence of Aphid, *Aphis craccivora* Koch on Cowpea". at Agronomy farm, of S.K.N. College of agriculture, Jobner (Rajasthan) during *kharif*, 2016. The aphid population commenced in the first week of August (31st SMW) and the first observation was recorded on 2nd August. Initially, population of aphid was (16.20 aphids/ three leaves). The population gradually increased and reached its peak in 34th SMW (108.13 aphids/ three leaves) when the minimum temperature, maximum temperature, mean relative humidity and rainfall was 24.4^{0}C, 30.5^{0}C, 84 per cent and 17.4 mm and gradually declined thereafter. The population of both the predators *C. septempunctata* and *M. sexmaculatus* were positively correlated (r = 0.82 and r = 0.72, respectively) with aphid population. The population of predators increased with the increase in aphid population. The correlation between population of *C. septempunctata* and *M. sexmaculatus* with abiotic factors *viz*., maximum and minimum temperature, mean relative humidity and rainfall had non significant correlation.

Key words : *Cowpea, Aphis craccivora, biotic and abiotic factors.*

Introduction

Cowpea (*Vigna unguiculata* Linn.) is one of the most important legume crop also known as lobia, belongs to family Leguminaceae. It is used as green legume, fodder, vegetable as well as green manure crop. The seeds of cowpea contain 23.4 per cent protein, 18 per cent fat, 60.3 per cent carbohydrate and also a rich source of lysine and tryptophane (Singh, 1983)[14]. Like other legumes, cowpea has important beneficial effects in increasing soil fertility status because of their ability to fix atmospheric nitrogen. This is of paramount importance of Indian agriculture when we consider this in light of inadequate availability and increased cost of fertilizers.

In India, the pulses occupy nearly 25.26 lakh hectare area with a production of 16.47 million tonnes during the year 2015-16 (Anonymous 2016) [2]. In Rajasthan, cowpea is of great important because of its short duration, high yielding and quick growing capacity along with important because of its short duration, high yielding and quick growing capacity along with high protein content. The crop is also known to provide quick cover on the ground and this help in conservation of soil. The area under cowpea cultivation in Rajasthan was 66.32 lakh hectare with the production of 30.68 million tonnes (Anonymous 2016) [3]. In Rajasthan the Major cowpea growing districts are Jaipur, Sikar, Jhunjhunu and Nagaur.

As many as 21 insect pests of different groups are recorded damaging the cowpea crop from germination to maturity (Sardhana and Verma, 1986)[12]. The important insect species attacking to cowpea crop are aphid, *Aphis craccivora* Koch; jassid, *Empoasca fabae* (Harris)*;* thrips, *Megaleurothrips distalis* Karny; army worm, *Mythimna separata* (Walker); semilooper, *Thysanoplusia orichalcea* (Fab.); Leafminer, *Phytomyza horticola* Meigen and pod borer, *Helicoverpa armigera* (Hubner) resulting in heavy yield losses (Prasad *et al.,* 1983 and Satpathy *et al*., 2009)[11,13]. Among these, cowpea aphid, *Aphis craccivora* Koch is the most serious pest of this crop and occurs in different parts of India (Ganguli and Raychaudhuri, 1984) [5], causes 20-40 per cent yield loss (Singh and Allen, 1980) [15]. The cowpea aphid, *A. craccivora* belongs to the family Aphididae of order Hemiptera, suborder Homoptera. Both nymph and adult cause damage by sucking cell sap from leaves, petioles, tender stems, inflorescence and pods. Due to their fast multiplication within few days, aphids usually cover the entire surface of apical shoots and with the result of continuo seeding, by such a large population yellowing, curling and subsequent drying of leaves take place, which ultimately leads to the formation of weak pods and undersized grain in the pods and decreased yield. David and Kumaraswami (1982) [4] observed that the cowpea aphid also act as vector of several viral diseases like cowpea mosaic and papaya mosaic. The role of natural enemies like coccinellid and syrphid predators are known to be associated with the control of cowpea aphid (Singh and Jackai, 1985) [16]. Due to variation in the agro climatic conditions of different regions insects show varying trends in their incidence,

Table-1 : Effect of biotic and abiotic factors on the incidence of cowpea aphid, *Aphis craccivora* Koch in *Kharif*, 2016.

S. No.	Date of observation	Standard Meteorological Week (SMW)	Mean aphid population per three leaves	Mean *coccinella septempunctata* population	Mean *Menochilus sexmaculatus* population	Meteorological conditions			
						Average temperature (^{0}C)		Relative humidity (%)	Rainfall (mm)
						Maximum	Minimum		
1.	02.08.2016	31	16.20	0.00	0.00	31.40	24.50	82.00	70.00
2.	09.08.2016	32	66.06	2.70	0.80	31.90	24.90	82.00	41.00
3.	16.08.2016	33	83.26	3.28	1.80	31.90	24.20	77.00	3.80
4.	23.08.2016	34	108.13	3.99	3.60	30.50	24.40	84.00	17.40
5.	30.08.2016	35	91.26	5.26	4.30	32.70	24.40	80.00	16.60
6.	06.09.2016	36	51.06	3.50	3.00	32.30	22.50	65.00	0.00
7.	13.09.2016	37	32.20	3.20	2.20	34.90	22.40	59.00	0.00
8.	20.09.2016	38	22.13	2.10	1.60	37.90	23.30	56.00	0.00
9.	27.09.2016	39	8.26	0.70	0.60	37.10	22.70	59.00	0.00
Correlation coefficient with mean aphid population (r)				0.818*	0.719*	-0.680*	0.547	0.673*	-0.051
Correlation coefficient with *C. septumpunctata* population (r)				-	-	-0.331	0.115	0.236	-0.409
Correlation coefficient with *menochilus sexmaculatus* (r)				-	-	-0.264	-0.028	0.147	-0.439

nature and extent of damage to the crop. Suitable understanding of the population dynamics of aphid pests is important due to variation in the weather condition and changing pest status. The study would give an idea about their peak period of pests activity which may be helpful in developing pest management strategy against them.

Materials and Methods

The materials used and methodologies adopted during the course of investigation on effect of biotic and abiotic factors on the seasonal incidence of Aphid, *Aphis craccivora* Koch on Cowpea, as envisaged in the plan of work has been described in detail hereunder. To study the effect of biotic and abiotic factors on the incidence of insect pests of cowpea, the variety RC-19 was sown on 16th July 2016 in plots of 3 m x 4 m keeping row to row and plant to plant distance of 30 cm and 10 cm, respectively.

Observations : The crop was left for natural infestation. The observations of aphid population were recorded from three leaves *viz.,* upper, middle and lower on each of five tagged plants at weekly interval from the first appearance of aphid till harvesting of the crop. When the aphid population appeared, the observations on aphid population were recorded early in the morning by visual counting method. The predator population was recorded on five randomly selected and tagged plants in each plot at weekly interval. The data recorded on aphid, predator populations and meteorological parameters were used for statistical analysis.

Interpretation of data : To interpret the results of seasonal incidence of aphid, *A. craccivora* on cowpea for analysis of variance test was applied and the simple correlation was computed between aphid population and abiotic factors (maximum and minimum temperature, relative humidity and rainfall) and between aphid population and biotic factors (predators).

Results and Discussion

The population of aphid, *A. craccivora* recorded during the crop season *Kharif,* 2016 on variety RC-19 has been presented in table 1 along with abiotic factor, *viz.*, minimum and maximum temperature, relative humidity and rainfall. The data revealed that the aphid population commenced in the first week of August (31st standard meteorological week, SMW) and the first observation was recorded on 2nd August. Initially, population of aphid was (16.20 aphids/ three leaves). The population gradually increased and reached its peak in 34th SMW (108.13 aphids/ three leaves). A gradual decline in the pest population was evident thereafter. The population was8.26 aphids/ three leaves in the 39th SMW and observed in traces thereafter. The population was 8.26 aphids/ three leaves in the 35 SMW and observed in traces thereafter. Srikanth and Lakkundi (1990)[17] observed that the population of *A. craccivora* on cowpea increased rapidly with crop growth and peaked at pod formation in *Kharif* (August-October), partially corroborates with the present findings. Angayarkanni and Nadarajan (2008) [1] studied the biology and seasonal activity of *A. craccivora* in cowpea ecosystem. It was revealed that the aphid remained active throughout the year.

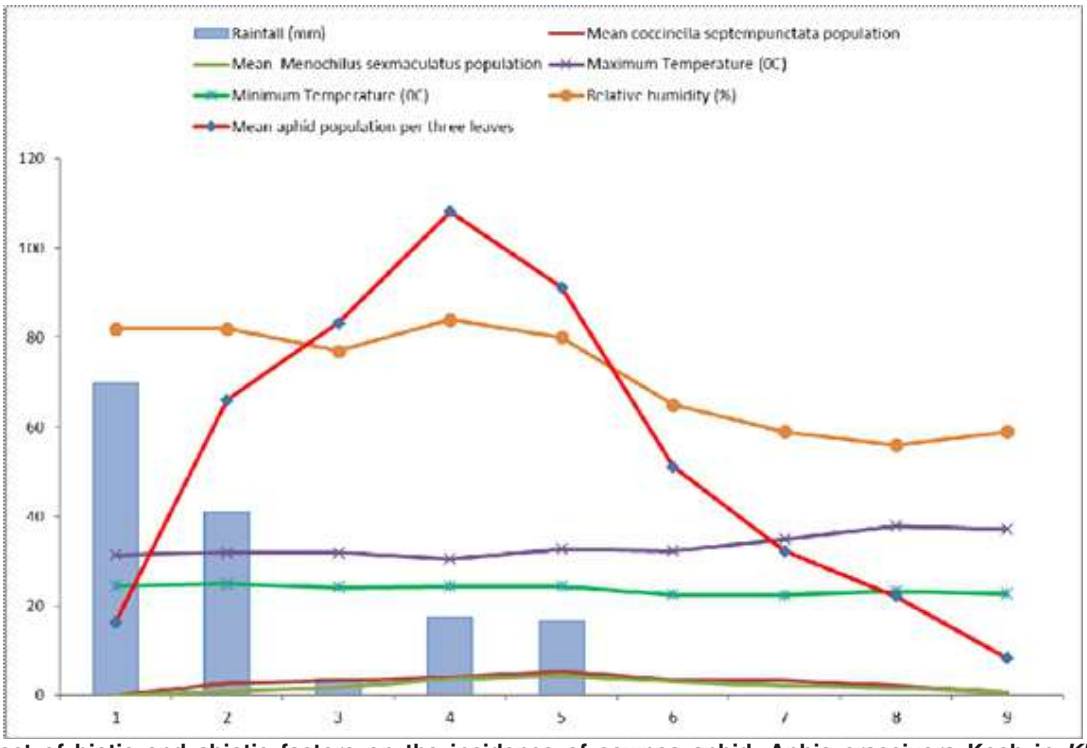
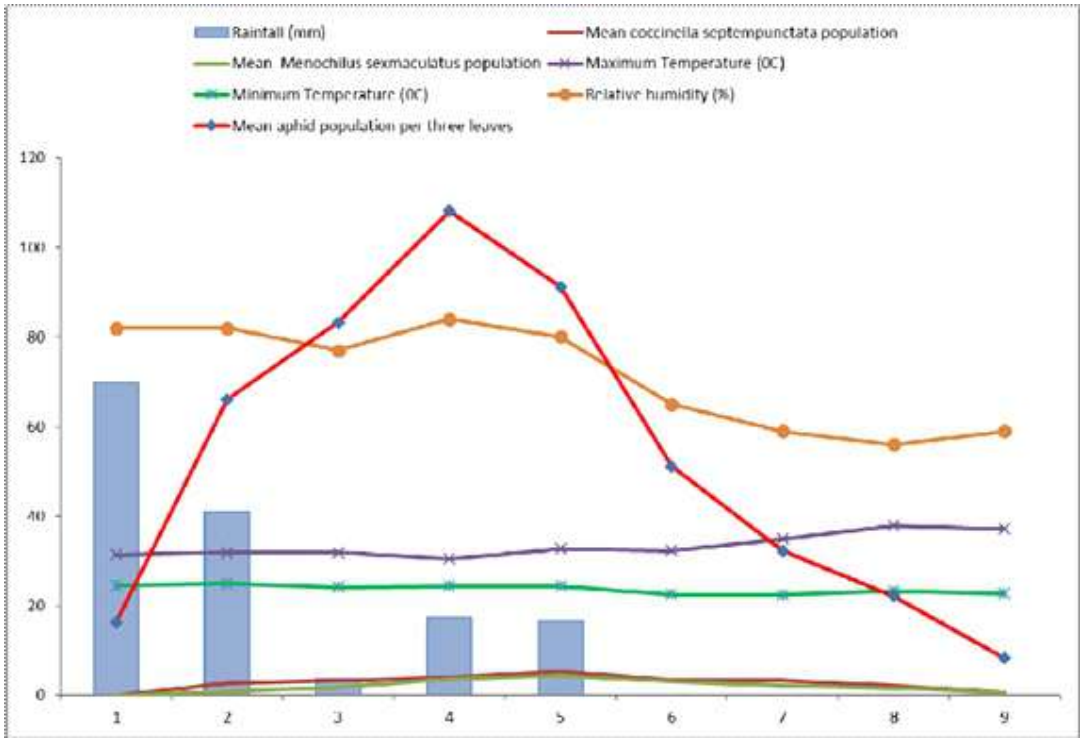


Fig.-1 : Effect of biotic and abiotic factors on the incidence of cowpea aphid, Aphis craccivora Koch in *Kharif*, 2016.



The maximum temperature was in the range of 30.50 to 37.90 ^{0}C in different weeks of the crop season. The maximum temperature was lowest on 23 August, *i.e.* 34th SMW (30.50) and highest in the 38th SMW (37.90 ^{0}C). The minimum temperature was observed in the range of 22.40 to 24.90 ^{0}C, the minimum being in the 37th SMW and maximum in the 32nd SMW. The relative humidity during the crop season was in the range of 56 to 84 per cent, the minimum in the 38th SMW and received maximum in the 34th SMW. The rainfall during crop season was in the range of 0.00 to 70.00 mm. The rainfall was not received during 36-39th SMW and maximum in the 31st SMW. The highest aphid population, *viz.*, 108.13 aphids/ three leaves was observed at 24.40 ^{0}C minimum

temperature, 30.50 ^{0}C maximum temperature, 84 per cent relative humidity and 17.40 mm rainfall. Data presented in table 1 and Fig. 1 depicted that the maximum temperature were significant negatively correlated (r = -0.68) whereas, relative humidity showed significant positive correlation (r = 0.67) with aphid population. The results exhibit a non significant relationship of cowpea aphid, *A. craccivora* with minimum temperature and rainfall. The results exhibit a non significant relationship of cowpea aphid, *A. craccivora* with minimum temperature and rainfall. The results are agreement with those of Kumar and Kumar (2014) [9] who also reported that the population of aphids influenced positively by relative humidity and significant negative correlation between aphid population and maximum temperature.

Effect of biotic factors : The data presented in table-1 revealed that the population of *C. septempunctata* and *M. sexmaculatus* were appeared in the second week of August and remained throughout the crop period in more or less numbers. The population of predators increased with the increase in aphid population. In the first observation (9th August, 2016) the population of *C. septempunctata* and *M. sexmaculatus* was 2.70 and 0.80 predators per five plant, respectively with aphid population of66.06 per three leaves when there was 31.90^{0}C maximum and 24.90^{0}C minimum temperature, 82 per cent relative humidity and 41 mm rainfall. The population of *C. septempunctata* and *M. sexmaculatus* were increased gradually and reached to its peak (5.26 and 4.30 per five plant, respectively) were recorded at 32.70^{0}C maximum and 24.40^{0}C minimum temperature, 80 per cent relative humidity and 16.6 rainfall in the fourth week of August (35th SMW), with aphid population of 91.26 per three leaves. Thereafter, the population of the both the predator decreased with decrease in aphid population at crop reaching to maturity stage. In the 39th SMW (27nd September, 2016) the population of *C. septempunctata* and *M. sexmaculatus* were 0.70 and 0.60 per plant, respectively, withaphid population of 8.26 per three leaves. The present findings are in fully agreement with that of Gauns *et al.* (2014) [6] who reported that the population of lady bird beetle was initially noticed in the second week of August. The present investigations are also in inconformity with that of Jangu *et.al*. (2014) [7], who also observed that the population of *C. septempunctata* and *M. sexmaculatus* were appeared in the fourth week of August and reached to its peak in the 1st week of September These results are in partially agreement with that of Srikanth and Lakkundi (1990) [17] who reported that the predatory coccinellid, *M. sexmaculatus* constituted 77-78 and 83-85 per cent of the total predatory population in the summer and *Kharif* crop seasons, respectively.

The population of both the predator were positively correlated(r = 0.82 and r = 0.72, respectively) with aphid population. The correlation between population of *C. septempunctata* with maximum temperature and rainfall were negatively correlate (r = -0.33 and r = -0.40 respectively) and minimum temperature and relative humidity had positively correlation (r= 0.11 and r = 0.23). Whereas, both maximum and minimum temperature and rainfall were negatively correlated r = -0.26, r = -0.02 and r = -0.43 for *M. sexmaculatus,* respectively. However, the relative humidity was positively correlated (r = 0.14) for *M. sexmaculatus.*

The present result confirm with the findings of Gauns *et al.* (2014)[6] who reported the positive correlation between weekly aphid and predator populations. The present results are also in agreement with that of Jat (2004) [8] who reported the positive correlation between predator and aphid population. No work is available on correlation between climatic factors and predator populations, however, the present findings are partially corroborates with that of Mathew *et al.* (1972) [10] who reported positive correlation between predators and climatic factors.

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To Survey the Infestation of Diamondback Moth of Cabbage in Major Cabbage Growing District of Rajasthan

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Abstract

This research paper presents a comprehensive survey conducted to assess the infestation of Diamondback Moth (*Plutella xylostella*) in the districts of Jaipur and Ajmer, Rajasthan. The study focused on specific tehsils within these districts, namely Chomu, Jhotwara, Viratnagar, Amer in Jaipur, and Nasirabaad, Beawar, Pushkar, Pisangan in Ajmer. The survey revealed intriguing insights, with Chomu tehsil in Jaipur showcasing the highest infestation levels of Diamondback Moth. Meanwhile, in Ajmer district, Beawar tehsil exhibited the most significant infestation. The findings not only contribute to the understanding of regional pest dynamics but also highlight specific areas that may require targeted pest management strategies. This research underscores the importance of localized surveys in developing targeted interventions for pest control, especially considering the impact of Diamondback Moth on cruciferous crops in the region.

Key words : Diamondbcak moth, survey, infastation.

Introduction

Cabbage is the second most important cole crop, which originated in Europe and in the Mediterranean region after cauliflower. Cabbage is one of the most popular winter vegetables grown in India. The botanical name of cabbage is *Brassica oleracea var capitata* L, Family Crucifera, and Chromosome number: 2n=18. The English name cabbage comes from the French caboche, meaning head referring to its round form. Cabbage has widespread use in traditional medicine, in the alleviation of symptoms associated with Gastrointestinal Disorders (gastritis, peptic and duodenal ulcers, irritable bowel syndrome) as well as in the treatment of Minor cuts and wounds and Mastitis.

"Cabbage has an anti-cancer property, it protects against bowel cancer due to the presence of indole-3-carbinol. It is known to possess medicinal properties and its enlarged terminal buds is a rich source of Ca, P, Na, K, S, Vitamin A, Vitamin C, and Dietary fiber. 100 gm of cabbage contains 25g of calories, 0 gm of Fat, 18mg of Sodium, Cholesterol 0 mg, 170 gm of Potassium, 6g of Carbohydrate, 1.3 gm of Protein, Vitamin A 1%, Vitamin C 60%, Calcium 4%, Iron 2%, Vitamin B6 5%, mg 3%" (source: USDA nutrient database).

"Plutella xylostella was first recorded in 1746 and probably from European origin. About 128 countries or regions reported infestation by this insect pest in 1972. The level of infestation varies from place to place for example the infestation is serious in South and Southern Asian countries and moderate in other Asian regions than the Mediterranean region. *Plutella xylostella* L. is a foreign pest".

In India, diamondback moth (DBM) was first recorded in 1914 (Fletcher, 1914) on cruciferous vegetables. "This species distributed Haryana, Uttar Pradesh, Orissa, Bihar, West Bengal, Assam, Karnataka, Maharashtra, Madhya Pradesh and Tamil Nadu. DBM has national importance on cabbage as it causes 50-80% annual loss in the marketable yield" (Devjani and Singh, 1999).

"Frequent use of chemical insecticides at higher dose results in plundering of natural enemies" and "development of insecticide resistance in *Plutella xyllostella* against a range of insecticide in different parts of India" (Talekar *et al.,* 1990).

Materials and Methods

Surveys were carried out in different cabbage growing areas of Jaipur (26.9 ºN and 75.8ºE) and Ajmer (26.44ºN and 74.63ºE) districts during 2021-2023 to investigate the occurrence and diversity of major insect pests and their natural enemies. The survey was conducted in Chomu, Jhotwara Viratnagar and Amer tehsil of Jaipur and also survey was conducted in Pushkar, Pisangan, Beawar and Nasirabad of district. Farmers' fields having at least 0.5 acre area was selected and the field was divided into five plots (P1, P2, P3, P4 and P5) and in each plot 10 plants were selected at random for counting the pests population and observations were taken in zigzag rows (Raja *et al.,* 2014). The following formula were used to find out the Pest infestation of DBM on cabbage.

Table-1 : Survey the infestation of diamond back moth of cabbage in major cabbage growers in Jaipur district Rajasthan during Rabi, 2021-22.

S. No.	Tehsil	Village	Percent Plant Damage		Average
			At 35-40 DAT	At 50-60 DAT	
1.	Chomu	Khorashyamdas	10.5	18	
		Chitwadi	12.5	20.5	19.375
		Bilochi	12.5	21.5	
		Ishrwala	10.5	17.5	
2.	Amer	Jalsu	10.5	17.5	
		Dader	11.5	16.5	18.125
		Berna	12.5	19.5	
		Gudhaserjan	11	19	
3.	Jhotwara	Kalwar	12.5	15	
		Pachar	13.5	18.5	16.625
		Kanwar Ka Bas	14.5	16	
		Derjania	13.5	17	
4.	Viratnagar	Bhaid	9.5	16.5	
		Viratnagar	10.5	15.5	17.125
		Sujapur	11.5	17.5	
		Tori	11	19	

Table-2 : Survey the infestation of diamond back moth of cabbage in major cabbage growers in Ajmer district Rajasthan during *Rabi,* 2021-22.

S. No.	Tehsil	Village	Percent Plant Damage		Average
			At 35-40 DAT	At 50-60 DAT	
1.	Pushkar	Nand	12	30.5	
		Swaipur	16.5	27.5	
		Kisanpura	14	23.5	25.75
		Chawandia	14.5	21.5	
2.	Pisangan	Budhwara	15.5	24.5	
		Bhanwta	13	26.5	
		Dantra	16.5	25.5	26.5
		Govindgarh	17	29.5	
3.	Beawar	Kharwa	16	27	
		Beawarkhas	15.5	28	
		Gola	16.5	30	28.37
		Makreda	15.5	28.5	
4.	Nasirabad	Bhimpura	16.5	27	
		Rajgarh	15.5	23	26.25
		Bhawani khera	16.5	28.5	
		Ratangarh	15.5	26.5	

$$\text{Plant percent infestation} = \frac{\text{No. of infected plant}}{\text{Total no. of plant}} \quad 100$$

Results and Discussion

The data presented in table-1 during *Rabi,* 20221-22 showed that the average DBM infestation in Cabbage crop at different locations of Jaipur and Ajmer district was varied from 9.5 to 14.5 per cent and 12.0 to 17.0 per cent plant damage at 35-40 DAT and 15 to 21.5 per cent and 21.5 to 30.5 per cent at 50-60 DAT respectively. The maximum DBM damage per cent 19.375 was recorded in Chomu tehsil followed by Amer 18.125, viratnagar 17.125 and minimum was in Jhotwara 16.625 of jaipur district and in Ajmer the maximum DBM damage per cent 28.375 was recorded in Beawar tehsil followed by pisangan 26.5 and nasirabad 26.25 and minimum was in pushkar 25.75.

The data recorded confirms that the overall mean incidence of DBM damage of cabbage crop in Jaipur district was 17.81 per cent and 26.71 per cent in Ajmer.

The data presented in table-1 during *Rabi,* 20222-23 showed that the average DBM infestation in Cabbage crop at different locations of Jaipur and Ajmer district was

Table-3 : Survey the infestation of diamond back moth of cabbage in major cabbage growers in Jaipur district Rajasthan during *Rabi,* 2022-23.

S. No.	Tehsil	Village	Percent Plant Damage		Average
			At 35-40 DAT	At 50-60 DAT	
1.	Chomu	Khorashyamdas	15.5	22.5	
		Chitwadi	13.5	23.5	22.50
		Bilochi	14.5	19.5	
		Ishrwala	14.0	24.5	
2.	Amer	Jalsu	12.0	18.0	
		Dader	13.5	19.0	18.62
		Berna	11.5	17.0	
		Gudhaserjan	16.5	20.5	
3.	Jhotwara	Kalwar	10.5	15.5	
		Pachar	9.0	14.5	16.00
		Kanwar Ka Bas	11.0	16.5	
		Derjania	12.5	17.5	
4.	Viratnagar	Bhaid	11.5	15.5	
		Viratnagar	12.5	16.5	17.13
		Sujapur	10.5	17.5	
		Tori	12.5	19.0	

Table-4 : Survey the infestation of diamond back moth of cabbage in major cabbage growers in Ajmer district Rajasthan during *Rabi*, 2022-23.

S. No.	Tehsil	Village	Percent Plant Damage		Average
			At 35-40 DAT	At 50-60 DAT	
1.	Pushkar	Nand	13.00	29.50	
		Swaipur	16.50	24.50	26.25
		Kisanpura	14.50	27.50	
		Chawandia	15.00	23.50	
2.	Pisangan	Budhwara	16.00	25.50	
		Bhanwta	17.50	27.00	26.75
		Dantra	15.50	28.00	
		Govindgarh	16.00	26.50	
3.	Beawar	Kharwa	13.50	28.50	
		Beawarkhas	14.00	26.00	27.50
		Gola	15.00	27.00	
		Makreda	18.50	28.50	
4.	Nasirabad	Bhimpura	12.50	22.50	
		Rajgarh	11.50	26.50	26.63
		Bhawani khera	15.50	29.00	
		Ratangarh	12.50	28.50	

varied from 9 to 16.5 per cent and 12.5 to 18.5 per cent plant damage at 35-40 DAT and 15.5 to 24.5 per cent and 22.5 to 29.5 per cent at 50-60 DAT respectively. The maximum DBM damage per cent 22.5 was recorded in chomu tehsil followed by Amer 18.625, viratnagar 17.125 and minimum was in jhotwara 16.0 of jaipur district and in Ajmer the maximum DBM damage per cent 27.5 was recorded in Beawar tehsil followed by pisangan 26.75 and nasirabad 26.625 and minimum was in pushkar 26.25.

The data recorded confirms that the overall mean incidence of DBM damage of cabbage crop in Jaipur district was 18.56 per cent and 26.84 per cent in Ajmer.

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Influence of Phosphate and Zinc Solubilizing Bacteria on Growth Yield and Nutrient Content of Paddy

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Abstract

The present investigation was carried out to study the combined effect of phosphate and zinc solubilizing bacteria on growth and yield of paddy under field condition. In this study, Use of two efficient phosphate-solubilizing bacteria *Pseudomonas sp.* and *Bacillus sp.* along with zinc solubilizing bacteria as inoculants has improved growth and yield of paddy. The study consisted of 8 treatments with three replications each. Treatment with combine inoculation of dual phosphate solubilizing bacteria isolates with zinc solubilizing bacteria and 75% recommended dose of fertilizer has significantly increased the plant height, number of tillers per hill, panicle length and grain yield of paddy over other treatments.

Key words : *Pseudomonas sp., Bacillus sp. phosphate solubilizing bacteria, zinc solubilizing bacteria.*

Introduction

Rice (*Oryza sativa* L) belongs to Poaceae family. It is a major part of balanced diet, and a rich source of energy and carbohydrates. Phosphorous is a major component in ATP, molecule that provides energy to the plants for such processes photosynthesis, protein synthesis, nutrient translocation, nutrient uptake and respiration. In addition, phosphorous has been observed to increase the root growth, influence early maturity, straw strength, crop quality and disease resistance (Deepak kumar, 2011). From total amount of applied phosphate, the considerable amount get fixed by cations *viz.* Al, Fe and Ca. Under such conditions phosphate solubilizing bacteria plays major role in conversion of insoluble phosphate into soluble form. Phosphate solubilization occurs by production and release of organic acids by PSB isolates and decreases pH. The organic acids solubilize insoluble P either by decreasing the pH or by making complexes with cations bound to phosphorous.

A rise in phosphorous uptake to the plants and the concomitant increase in the growth and yield of rice plants under field condition have been reported (Son *et al.* 2007; Panhwar *et al.* 2011; Vahed *et al.* 2012). The aim of this study was to evaluate the performance of two efficient phosphate solubilizing bacteria i.e., *Pseudomonas sp.* and *Bacillus sp.* along with zinc solubilizing bacteria on the growth and yield of rice alone and in combination under field conditions.

Materials and Methods

Forty phosphate solubilizing bacteria were isolated from 40 rhizosphere soil samples of paddy collected from Raichur and Koppal district of Karnataka. The isolates were characterized and identified. Based on the in vitro experiments performance, among ten, two efficient phosphate solubilising bacteria were chosen to evaluate the efficacy on plant growth promotion under field condition. The experiment was carried out in a Random complete bock design. Growth parameters were recorded at 30, 60, 90 days and at harvest. Growth and yield parameters were statistically analyzed and tabulated.

Estimation of Phosphorous content from plant sample : The plant samples collected after harvesting were oven dried properly and grind to fine powder was used for estimation of phosphorous content following the standard Vanadomolybdate phosphoric yellow method of Jackson (1973).

Results and Discussion

In vitro screening analysis was carried out to test the PGPR activities of PSB isolates *viz.*, phosphate solubilization efficiency, release of phosphate, change in pH, phosphatase activity and titrable acidity along with beneficial traits IAA production and siderophore production. Two efficient isolates were chosen and evaluated *viz.*, for the growth promotion activities under field condition. The effect of two isolates of phosphate solubilizing bacteria *viz.,* PPSB 21 and PPSB 5 along with zinc solubilizing bacteria were used alone and in combination with different levels of RDF was assessed under paddy field conditions. The results and discussion were mentioned below.

Plant height : The data on plant height at obtained at 30^{th}, 60^{th}, 90^{th} DAT and during harvest were presented in the

Table-1 : Plant height and number of tillers per hill of transplanted rice as influenced by the application of microbial inoculants.

Treatments	Plant height (cm)				Number of tillers/hill		
	30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT
T_1-Control	21.2	46.2	70.2	73.2	5.00	6.56	7.24
T_2-100% RDF	31.5	58.2	83.5	86.2	6.25	9.51	10.21
T_3-75% RDF + ZSB	24.5	49.5	73.3	76.5	5.01	7.01	7.00
T_4-75% RDF + PPSB 5	28.6	56.1	82.5	84.5	6.05	9.02	9.12
T_5-75% RDF + PPSB 21	29.5	57.3	83.2	85.1	6.21	9.12	9.25
T_6-75% RDF + PPSB 5 + PPSB 21 + ZSB	32.2	61.2	86.2	88.2	7.12	10.25	12.2
T_7-75% RDF + Reference PSB	25.3	50.2	74.2	77.2	5.21	7.12	7.12
T_8-75% RDF + Reference ZSB	26.1	51.2	75.3	78.2	5.25	7.25	7.35
SEm±	0.27	1.09	0.97	0.80	0.30	0.28	0.67
C.D. at 5%	0.82	3.28	2.92	2.42	0.91	0.84	2.05

Note : Mean values are average of three replications
DAT : Days After Transplanting

Table-2 : Yield parameters of transplanted rice as influenced by the application of bacterial inoculants.

Treatments	Panicle length (cm)	No. of seeds/panicle	Grain yield (kg/ha)
T_1-Control	15.7	170	3315
T_2-RDF (100% NPK)	20.9	230	5632
T_3-75 % RDF + ZSB	17.5	193	4485
T_4-75 % RDF + PPSB 5	19.6	230	5253
T_5-75 % RDF + PPSB 21	19.7	235	5365
T_6-75 % RDF + PPSB 5 + PPSB 21 + ZSB	21.9	250	5745
T_7-75 % RDF + Reference PSB	17.7	198	4525
T_8-75 % RDF + Reference ZSB	17.9	200	4625
SEm ±	0.44	7.06	39.3
C.D. at 5%	1.32	21.2	118

Note : Mean values are average of three replication.

Table-3 : Available P content in shoot and grain of transplanted rice as influenced by the application of microbial inoculants.

Treatments	Available P content (%)	
	Shoot	Grain
T_1-Control	0.13	0.65
T_2-RDF (100% NPK)	0.72	1.93
T_3-75% RDF + ZSB	0.34	1.10
T_4-75% RDF + PPSB 5	0.61	1.58
T_5-75 % RDF + PPSB 21	0.69	1.64
T_6-75% RDF + PPSB 5 + PPSB 21 + ZSB	0.85	2.10
T_7-75% RDF + Reference PSB	0.41	1.28
T_8-75% RDF + Reference ZSB	0.49	1.37
SEm±	0.016	0.10
C.D. at 5%	0.50	0.30

Note : Mean values are average of three replication.

table 1. Treatment T_6 (75 % RDF + PPSB 5 + PPSB 21 + ZSB) with combined inoculants continued to exert increased growth attributes over all other treatments with plant height of 88.2 cm. Plant height was increased upto significantly upto 90th DAT after there was a slight increase in the plant height at harvest in all treatments. The increased growth promotion might be due to the root colonization of phosphate solubilizing bacterial inoculants enhanced the availability of accumulated phosphates for growth by solubilization.

Similar results were obtained in the experiments of Rima and Dulley (2013), conducted study on application of phosphate solubilizing bacteria and its ecological effect on growth and yield of winter maize, observed that the

values of all growth parameters like plant height, green leaves, leaf area, recorded higher due to PSB inoculation and the values remained lower under control (Panwar *et al.* 2011.

Total number of tillers per hill : Effect of different individual and combined inoculation of isolates along with different dose of fertilizer application on the number of tillers per hill of rice were studied at 30th, 60th, 90th DAT and represented in the table (Table-1).

On 90th DAT, treatment with combine application of inoculants along with fertilizer T_6 (75 % RDF + PPSB 5 + PPSB 21 + ZSB) was superior over other treatments with 12.2 tillers per hill. The data showed that there was a significant difference between combined applications of inoculants with RDF when compared to treatments with individual inoculants and RDF alone inoculation. The minimum number tillers per hill were recorded by the treatment with control over other treatments. Similar trend was continued on 30th, 60th, 90thand during harvest stage.

The enhanced plant growth parameters might be due to the activity of PSB in Phosphate solubilization as well as better scavenging activity of the soluble phosphorous and also the increased availability of plant growth promoting substances and other trace elements.

Similar results were obtained in experiments of Bakhshandeh *et al.* (2015) evaluated the efficiency of four phosphate solubilizing bacteria strains were *Rahnella aquatillis*, *Enterobacter sp.*, *Pseudomonas fluorescens* and *Pseudomonas putida* under pot and field condition. Increased grain yield, biological yield, total number of stems per hill, number of panicles per hill and plant height were observed due to single PSB inoculations in field trials.

Yield parameters : The results pertaining to the yield parameters *i.e.* panicle length and grain yield were presented in the table-2.

Panicle length : The treatment with combine inoculation of dual culture with RDF T_6 (75 % RDF + PPSB 5 + PPSB 21+ ZSB) showed the maximum panicle length (29.1cm) over other treatments. But the control recorded the minimum panicle length (15.7 cm) compare to all treatments. Similar results were obtained on 30th, 60th, 90th DAT successively. The growth promotion activity of plant might be due to the mechanisms used by inoculated PSBs are related to their ability to release metabolites directly such as P solubilization and the availability of essential minerals or modulating plant hormone levels like IAA, and indirectly decreasing the inhibitory effects of various pathogens on plant growth such as siderophores and hydrogen cyanate production in the forms of bio control agents.

Similar results were reported by Joseph *et al.* (2015) isolated PSB isolates namely *Gluconacetobacter sp.* and *Burkholderia sp.* and were examined for their growth enhancement potential of rice. Positive results have been noticed in their nutrient uptake, yield plant growth promotion activity due to synergistic interaction between strains of *Gluconacetobacter sp.* and *Burkholderia sp.*

Total number of seeds per panicle : After harvest, the total number of grains per panicle of rice for the field experiment was collected as per the treatment (Table1). Significantly minimum number of seeds per panicle (170) was obtained in control (T_1) compare to other treatment. The significantly maximum number of seeds per panicle (250) was registered with treatment T_6 (75 % RDF + PPSB 5 + PPSB 21 + ZSB) over all treatments but it was not significant with T_2 (100%RDF). The increased plant growth promotion in terms of seed number was recorded. It might be due to the ability of isolates to release P from insoluble sources and significant uptake of total P from plant and the other plant growth promoting substances produced by the organism.

Similar results were reported by, Bakhshandeh *et al.* (2015) evaluated the efficiency of four PSB strains were *Rahnella aquatillis*, *Enterobacter sp.*, *Pseudomonas fluorescens* and *Pseudomonas putida*. Increased grain yield, biological yield, total number of stems hill^{-1}, number of panicles hill^{-1} and plant height were observed due to PSB inoculations in field trials compared to the control.

Grain yield : After harvest, the grain yield of rice for the field experiment was analysed with respect to the treatment and represented in the table-3. Treatment with multiple inoculants along with fertilizer T_6 (75 % RDF + PPSB 5 + PPSB 21 + ZSB) received the significantly maximum number of grain yield (5745kg/ha) compare to other treatments.

Similar results were obtained by Viruel *et al.* (2014) reported the PSB, conducted *Pseudomonas tolaasii* strain stimulated seedling emergence (8%), shoot length (19%), grain yield (44%), 1000-grain weight (18%), total dry biomass (32%) and P content (56%) compared to the un inoculated control. Similarly, Tariq *et al.* (2007), where, an increase of 65% in grain yield was observed due to inoculation with plant root associated PGPR in rice.

Estimation of Phosphorous content from plant sample : The P content in shoot and grain of paddy were analysed after harvesting of the crop and tabulated in table-3. The results revealed that there was increased content of P in all the treatments except control whereas, the highest percent of P content in both shoot and grain (0.85% and 2.10% respectively) were seen in the treatment T_6 with combined inoculation of efficient PSB, ZSB and 75% RDF.

Based on these results it may be concluded that, the PSB contributed from unavailable to available form of soil phosphorous and stimulated the available form of applied phosphatic fertilizer as a result increased nutrient uptake. The addition of P solubilizers to the soil enhanced the P uptake by the plants.

Similar outcomes were found by Vikram and Hamzehzarghani (2008) and Viruel *et al.* (2014) conducted pot culture experiment to investigate the effects of seven previously isolated PSB on early development of maize. Plants treated with *Pseudomonas tolaasii* IEXb results a significant increment in plant height (45%), shoot dry weight (40%), while *Pseudomonas korensis* SP28 has remarkably increased the P content compared to the uninoculated control.

Conclusions

The high phosphate solubilization activity of the introduced phosphate solubilizing bacteria lead to the higher available P content in soil which in turn resulted in increased nutrient uptake by plants and reflected on the growth and yield of rice crops. The plant growth promotion of PSM have been reported to be a combination of several other factors, such as nitrogen fixation, production of plant growth promoting substances, siderophores. All the tested parameters showed paramount performance in mixed inocula compared to individual application. The results proves the superiority of the isolates to the standard PGPR strain used in this study thereby prospecting the PSBs *Pseudomonas sp.* (PPSB-21) and *Bacillus sp*. (PPSB-5) as potential bacterial inoculants for production of biofertilizers due to multiple plant growth promoting attributes.

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Effect of Supplementation of *Moringa oleifera* Leaf Meal on Growth Performance of Madgyal Lambs

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Abstract

These experimental animals were fed dry roughages and greens in addition to the concentrate mixture during stall feeding. The feeding regimens of the experimental growing lambs in the control and treatment groups were equivalent, with the exception of *Moringaoleifera* supplementation in the treatment groups. The trial was for the period of 90 days and the treatments wereT_0 (Control), stall feeding with dry and green fodder + concentration mixture as per usual feeding practice (ICAR,2013), T_1 (Treatment), stall feeding with dry and green fodder + concentrate mixture (15% concentrate mixture replaced with *Moringa oleifera* leaf meal) (on DMB).andT_2 (Treatment), Stall feeding with dry and green fodder + concentration mixture (25% concentrate mixture was replaced by *Moringa oleifera* leaf meal) on (DMB). Supplementation of *Moringa oleifera* leaf meal in the diet of Madgyal lambs had no significant effect on fortnightly body weights of experimental Madgyal lambs.

Key words : *Chemical composition, growth performance, Moringa oleifera,*

Introduction

India is an agriculture dominated nation and small marginal farmers account for roughly 80% of the overall agricultural population in India (Gautam *et al.,* 2016). Additionally, India has the highest livestock population in world demanding a huge supply of fodder. In developing countries like India, there is a big imbalance between supply and demand for livestock feeds and fodder. Currently the country has a green fodder deficit of 11.24 percent, a dry fodder deficit of 23.49 percent, and a concentrate feed deficit of 28.9 percent (IGFRI, 2019). Replacing costlier protein supplements with readily available, inexpensive, and high-quality feed allows farmers to increase income along with maintaining animal health. Increasing livestock rearing techniques among farmers necessitates the use of nutrient-dense, low-cost feed supplements in order to reduce feed costs and boost animal production efficiency.The “Madgyal sheep” are much superior in respect of body gain, prolificacy, early maturity and adult weight in comparison to Deccani, a sheep breed from the same breeding tract. Madgyal rams are becoming increasingly popular for upgradation of local flocks. On the other hand, Madgyal was found to be more susceptible to diseases and less capable of coping with the stresses. The Madgyal has also been found more prone to diseases like orchitis in male breeding rams (Arora *et al.,* 2010). *‘Moringa oleifera’* belongs to the *Moringaceae* family and is a leguminous, versatile, fast-growing, and drought-resistant tree. *Moringa oleifera* (MO) is an evergreen multipurpose tree of high economic importance and nutritional values (Padayachee and Baijnath, 2020). Leaves of *Moringa oleifera*, the most nutritious and utilized part of the plant, are a rich source of proteins, amino acids, minerals, and vitamins (Abbas *et al.,* 2018).

Materials and Methods

The present research work was carried out at the “Madgyal Sheep Unit” at Punyashlok Ahilyadevi Sheep Goat Development Corporation, Dahiwadi, Dist.-Satara. (M.S), for a period of 90 days, For the present study, 18 healthy Madgyal lambs which were of 4 to 6 months of age of either sex with uniform body size and weight were selected. They were randomly divided into three (03) groups (T_0), (T_1), and (T_2) as treatments involving six lambs in each group. (T_o) was the control group, and (T_1) and (T_2) were the treatment groups Feed was given daily in the early morning and evening time. All the feeders were cleaned before feeding. The feed was offered after calculating the minimum amount of feed from the previous day. The feeding of concentrates and roughages was followed separately throughout the experiment. Clean fresh drinking water was made available for 24 hrs. All lambs were divided equally into three groups with six animals per treatment. Three experimental treatment groups i.e., (T_0) 100 % concentrate + 0% MOLM, (T_1) 85% concentrate + 15% MOLM, and (T_2) 75 % concentrate + 25% MOLM. Mixed feed was offered twice daily. Green fodder were made available *ad.lib*. to the sheep at the feeding place. The duration of the experiment was 90 days. The present study was fully based on feeding *(Moringaoleifera)* leaf meal to assess the growth performance of Madgyal lambs. The data obtained with

Fortnight	Treatment Groups				Significance
	T_0	T_1	T_2	P-value	
0 Day	14.02±0.74	14.06±0.72	14.16±0.56	0.989	NS
1	15.36±0.75	15.41±0.70	15.54±0.56	0.982	NS
2	17.11±0.79	17.19±0.79	17.34±0.51	0.975	NS
3	18.89±0.77	18.99±0.82	19.19±0.63	0.959	NS
4	20.96±0.76	21.16±0.90	21.56±0.73	0.869	NS
5	23.29±0.78	23.70±0.95	24.18±0.83	0.765	NS
6	25.83±0.80	26.38±1.00	26.97±0.91	0.683	NS
Mean±SE	19.35±0.67	19.56±0.71	19.85±0.71	0.881	NS

P-value : Probability value, (P=0.05) NS : Non-Significant.

regard to the parameters under study was subject to statistical analysis using Correlation analysis as per Snedecor and Cochran, (1994)

Results and Discussion

The body weight of the experimental lambs was measured at fort night intervals on electronic weighing balance. (Mean±SE) values shown in Table-2 and graphically depicted in Fi Fortnightly body weight (kg) of experimental Madgyal lambs.

The body weight of all three groups of lamb increased with age/average body weight. The initial weights of experimental animal's groups T_0, $T_1$and T_2 were 14.02±0.74, 14.06±0.72, and 14.16±0.56 (kg), respectively. The average weight of the experimental lambs over the last week was 25.83±0.80, 26.38±1.00, and 26.97±0.91 (kg), respectively for T_0, T_1 and T_2. The overall mean weight for all six fortnight intervals of experimental groups T_0, T_1 and T_2 was 19.35±0.67, 19.56±0.71, and 19.85±0.71(kg), respectively. Body weight was non-significantly differ between treatment groups at all fortnights.

The results of this study are consistent with Redekar *et al*. (2019) observation that, feeding growing lambs varying doses of moringa did not significantly alter their weight gain. According to Sarwatt *et al.* (2002) and Damor *et al.* (2017), statistical analysis revealed that, the integration of various quantities of *Moringaoleifera* leaves had no effect on the body weight increase in goats (P>0.05). Syed Ali, (2017),Yusuf *et al.* (2018) discovered non significant effect of giving commercial supplement with *Moringaoleifera* leaf meal on nutritional status and growth performance in West African Dwarf goats. Bhokre *et al*.(2020) also reported Deccani lamb's non-significant fortnightly weight gain, which was consistent with our findings.

The results of the current study, do not support the claims made by Babeker and Abdalbagi, (2015) observed that, goats fed a 20% meal of *Moringaoleifera* leaves had higher growth performance. Moyo*et al.* (2012) found that, goats fed *Moringaoleifera* leaf gained considerably more body weight than those who were not fed *Moringaoleifera* based diet.Similarly, Fadiyimu*et al.* (2010) discovered that, feeding West African Dwarf sheep a *Moringaoleifera* multinutrient block resulted in considerably increased body weight gain.Bushara *et al.,* 2017 discovered that, meals including a blend of range plants + *Moringaoleifera* pods, stems, and leaves provided superior growth performance in fattening rams.Gebregiorgis *et al.* (2011),Asaulo *et al*.(2012) Tono *et al*.(2014) and Sultana *et al*.(2015) observed considerable increase in body weight of goats fed diets containing varying levels of *Moringaoleifera* leaves.

However, in the current study, we discovered that replacing 25% (T_2) + 15% (T_1) *Moringaoleifera* leaf meal replacement with concentrate promotes body weight gain faster than the (T_0) control group, indicating that it may meet sheep protein needs.

Conclusions

Supplementation of *Moringa oleifera* leaf meal in the diet of Madgyal lambs had no significant effect on fortnightly body weights of experimental Madgyal lambs. The average daily gain in body weight of experimental Madgyal lambs fed *Moringaoleifera*had no significant effect in all the groups.The dry matter intake from roughages and concentrates and total dry matter intake showed non-significant effect in Madgyal lambs in all groups fed *Moringa oleifera* leaf meal.

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Influence of Secondary Nutrients and Biofertilizers on Nutrient Status and Soil Microbial Population in Chilli (*Capsicum annuum* L.)

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Abstract

A field experiment was conducted on influence of secondary nutrients and biofertilizers on nutrient status and soil microbial population in chilli at College of Horticulture, Mudigere. The major nutrient availability in soil, nutrient content in chilli leaf and fruits and soil microbial properties after the harvest of chilli was studied. The highest availability of major major nutrients in soil in soil N (305.65 kg/ha), P (45.67 kg/ha), K (117.56 kg/ha), Ca (146.06 g/kg) and Mg (109.69 g/kg) and the highest nutrient content in chilli leaf N (2.76 %), P (0.42 %) and K (2.99 %), Ca (2.37 %) and Mg (1.23 %) in leaves, Ca (0.124 %) and Mg (0.052 %) in fruits were noticed with the application of 75 % RDNPK+$CaNO_3$ @ 0.5 %+ $MgSO_4$ @ 0.4 % +*Azospirillum* +PSB + KSB (T_{11}). Similarly the soil microbial population include were recorded maximum in the treatment T_{11}. Thus combined use of organic amendments (biofertilizers, FYM) along with chemical fertilizers not only produced highest and sustainable crop yield but also enhanced the efficiency of added fertilizers as well as fertility status of the soil.

Key words *: Secondary nutrients, nutrient availability, soil microbial population.*

Introduction

Chilli (*Capsicum annuum* L.) is one of the important commercial crops of India. It is a crop of tropical and sub-tropical regions and requires a warm humid climate. Though, chilli can be grown in many types of soils, well-drained loamy soils rich in organic matter are the best suited for its cultivation. There is an almost need to produce more crop yield which has led to the tendency of using more and more chemical fertilizers. Due to this it has resulted in to deterioration of productive soil. Stated that mineral fertilizers decrease both the biological activities in the soil and aggregate stability. The intensive use of chemical inputs has not only polluted the soil, water and environment causing their slow degradation but also affected the life of human being. Thus, the importance of organic manure in present agriculture is increasing day by day, because of its utility not only improving the physical, chemical and biological properties of soil but also maintaining the soil health without pollution.

From nutrients point of view, the role of organic matter is very limited. However its value lies more in its action as a soil ameliorant corrective for physical, chemical condition and biological activity to enhance the productivity. The nutritional demand of chilli crop is partially fulfilled by slow release of nutrients from organic manure but its alone use is not sufficient. Therefore, there is a need to supplement with chemical nutrients. The supplementary and complementary use of organic manures along with inorganic fertilizers augment the efficiency of both the substances to maintain high level of soil productivity.

The beneficial impact of combined application of chemical fertilizers along with organic manures *viz*., farmyard manure, biofertilizers and many more of such are known. Application of organic manures in general improves availability of other nutrients like zinc, iron, manganese and copper. A balanced application of both organic, inorganics (NPK) and biofertilizers along with Ca and Mg appear to be an ideal proposition to meet nutrient requirements of crops rather than single application. In view of this, the present investigation was undertaken to assess the influence of organic and inorganic sources of nutrients on the soil nutritional status and microbial population in chilli crop.

Materials and Methods

To study the effect of secondary nutrients and biofertilizers on growth, yield and quality of chilli (*Capsicum annuum* L.) under hill zone of Karnataka. The field experiment was conducted at College of Horticulture, Mudigere during *Summer* season 2022-2023. The experiment was laid out in a Randomised Complete Block Design (RCBD) with eleven treatments and three replications. The seedlings were sown in ridge and furrow method at a distance of 60

cm between row to row and 45 cm between plants. All the recommended cultural operations were followed and observations were recorded in five randomly selected plants per replication of all the treatments.

The treatment details as follows :

T_1-RDF

T_2-RDF + $CaNO_3$@ 0.5 %

T_3-RDF + $MgSO_4$ @ 0.4 %

T_4-RDF + $CaNO_3$ @ 0.5 % + $MgSO_4$ @ 0.4 %

T_5-RDPK + 75 % N + $CaNO_3$ @ 0.5 % + *Azospirillum*

T_6-RDPK + 75 % N +$MgSO_4$ @ 0.4 % + *Azospirillum*

T_7-RDNK + 75 % P + $CaNO_3$ @ 0.5 % + PSB

T_8-RDNK + 75 % P + $MgSO_4$ @ 0.4 % + PSB

T_9-RDNP +75 % K + $CaNO_3$ @ 0.5 % + KSB

T_{10}-RDNP + 75 % K + $MgSO_4$ @ 0.4 %+KSB

T_{11}-75% RDNPK + $CaNO_3$@ 0.5 % + $MgSO_4$ @ 0.4 % +*Azospirillum* + PSB + KSB

The soil physical and chemical properties of experimental site was recorded and presented in (Table 1). Well decomposed FYM @ 25 tonnes per hectare was applied at the time of land preparation. The recommended dose 150:75:75 kg NPK/ha) was applied in the form of urea, single super phosphate and muriate of potash, respectively. One week after transplanting drenching of biofertilizers was done and two weeks after transplanting secondary nutrients were sprayed twice in 15 days interval and at the same time observations on growth, yield and quality parameters were recorded.

Soil samples were collected to a depth of 0-15 cm treatment wise after final picking of chilli (120 DAT). The collected samples and shade dried for five days ground in wooden pestle and mortar, sieved by passing through 2 mm sieve were mixed thoroughly and partitioned by quartering technique to get composite working sample for the analysis. Nitrogen was estimated by Alkaline potassium permanganate ($KMnO_4$), phosphorus by Olsen's method, potassium by Flame photometer method, calcium and magnesium by titration process, and for plant analysis tagged plants were collected randomly from each treatment at final picking stage. The plant samples after digestion were analysed for nutrients content by following standard procedure and nutrient availability was computed. Nitrogen was estimated by Kjeldahl's digestion and distillation method, phosphorus by Vanadomolybdate method, potassium by Flame photometer method, calcium and magnesium by titration process, respectively. Whereas microbial population in respect to bacteria, fungi and actinomycetes were assessed after harvest by serial dilution technique. Specific media used for enumeration of soil microorganisms such as Nutrient agar (NA) for bacteria, Martin's Rose Bengal Agar (MRBA) for fungi and Kuster's Agar (KA) for Actinomycetes.

Results and Discussion

The nutrient status of nitrogen, phosphorus, potassium, calcium and magnesium in both soil and plants were significantly influenced by the effect of secondary nutrients and biofertilizers in chilli (Table-2 and 3). Significantly the lowest nitrogen in the soil (305.65 kg/ha) was recorded with the treatment T_{11} -75 % RDNPK + $CaNO_3$@ 0.5 % + $MgSO_4$ @ 0.4 % +*Azospirillum* + PSB + KSB which was followed by T_6 and T_5 (337.89 and 348.67 kg/ha, respectively). However highest nitrogen (416.65 kg/ha) was recorded in RDF. Application of 75 % RDNPK + $CaNO_3$@ 0.5 % + $MgSO_4$ @ 0.4 % +*Azospirillum* + PSB + KSB (T_{11}) recorded lowest phosphorus in the soil (45.67 kg/ha) which was followed by T_8 and T_7 (56.89 and 60.18 kg/ha, respectively). However highest phosphorus (129.76 kg/ha) was recorded in RDF. Similarly the lowest potassium in soil (117.56 kg/ha) was reported with the application of 75 % RDNPK + $CaNO_3$@ 0.5 % + $MgSO_4$ @ 0.4 % +*Azospirillum* + PSB + KSB which was followed by T_{10} and T_9 (132.34 and 143.34 kg/ha, respectively). However highest potassium (216.64 kg/ha) was recorded in RDF. However the lowest calcium content of (146.06 mg/kg) was recorded in (T_{11}) which was followed by (T_9) and (T_7). However highest calcium (263.89 kg/ha) was recorded in RDF. Magnesium content of (109.69 mg/kg) which was recorded in (T_{11}) which was followed by (T_{10}) and (T_8). However highest magnesium (189.73 kg/ha) was recorded in RDF. The decreased nitrogen, phosphorus, potassium, calcium and magnesium status of soil might be due to the higher plant uptake and utilisation of available nutrients for better growth and increased yield was observed under (T_{11}). Similar findings were also reported by Samsangheile and Kanaujia (2014) in chilli, Yogaraju *et al.* (2017) in chilli and Chatterjee and Bandyopadhyay (2014) in tomato. With respect to nutrient content in plants, significantly results were found among different treatments, the application of 75 % RDNPK + $CaNO_3$@ 0.5 % + $MgSO_4$ @ 0.4 % +*Azospirillum* + PSB + KSB (T_{11}) received maximum nitrogen content (2.76 %), phosphorus content (0.42 %), potassium content (2.99 %), calcium content (2.37 %) and magnesium content (1.23 %) in leaves, calcium content (0.124 %) and magnesium content (0.052 %) in fruits. Whereas RDF recorded minimum nitrogen content (2.13 %), phosphorus content (0.25 %), potassium content (1.78 %), calcium content (1.48 %) and magnesium content (0.87 %) in leaves, calcium content (0.072 %) and magnesium content (0.029 %) in fruits, respectively. The probable reason for

Table-1 : Physical, Chemical and fertility status of experimental site.

Physical parameters						
Particulars	**Sand (%)**	**Clay (%)**	**Silt (%)**		**Texture**	
Values	48.3	28	23		Sandy loam	
Chemical parameters						
Particulars	Soil pH	Electrical conductivity	Organic carbon	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
Values	6.07	0.447	0.72	270	25.20	109

Table-2 : Influence of secondary nutrients and biofertilizers on available NPK status in soil and leaf NPK content (%) in chilli.

Treatments	Available NPK status in soil			Leaf NPK content (%) in chilli		
	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	N (%)	P (%)	K (%)
T_1	416.65	129.76	216.64	2.13	0.25	1.78
T_2	359.87	109.50	211.87	2.18	0.26	1.99
T_3	367.87	103.60	187.76	2.28	0.27	2.02
T_4	362.45	126.43	178.55	2.30	0.30	2.13
T_5	348.67	121.05	165.37	2.48	0.34	2.18
T_6	337.89	106.07	158.58	2.52	0.36	2.30
T_7	376.15	60.18	156.11	2.43	0.38	2.40
T_8	387.04	56.89	152.78	2.37	0.39	2.65
T_9	379.78	101.45	143.87	2.33	0.32	2.80
T_{10}	356.29	93.87	132.34	2.46	0.35	2.87
T_{11}	305.65	45.67	117.56	2.76	0.42	2.99
Mean	365.74	94.18	165.92	2.39	0.33	2.39
S. Em±	3.86	1.06	1.18	0.02	0.02	0.02
CD @ (5%)	11.11	3.04	3.40	0.07	0.01	0.06

recording higher nutrient content in chilli leaves and fruits might be due to the synergetic effect of organic and inorganic fertilizers had ensured higher efficiency of macronutrients and secondary nutrients also enhanced better root, shoot growth and while plants enhanced its ability to absorb the nutrients from increased supply in greater synthesis of photosynthates, leading to the accumulation of more nutrients during the crop growth period. Similar results were reported by Suja *et al*. (2011), Vimera *et al*. (2012) and Rakesh kumar *et al.* (2014). Similar results were reported with respect to microbial population in soil, The higher bacterial population (225.06 and 193.94 cfu/g soil, respectively) was observed under 75 % RDNPK + $CaNO_3$ @ 0.5 %+ $MgSO_4$ @ 0.4 % + *Azospirillum* + PSB + KSB (T_{11}) at 10^{-5} and 10^{-6} dilution, respectively. While minimum was recorded in RDF (31.58 and 22.11 cfu/g soil, respectively) 10^{-5} and 10^{-6} dilution. With regard to fungal population in soil, at 10^{-3} and 10^{-4} dilution the higher fungi biomass of (51.35 and 46.95 cfu/g soil, respectively) was noticed with inoculation of 75 % RDNPK + $CaNO_3$ @ 0.5 %+ $MgSO_4$ @ 0.4 % + *Azospirillum* + PSB + KSB (T_{11}). Whereas RDF recorded least number of fungal colonies (18.41 and 12.97 cfu/g soil, respectively) at 10^{-3} and 10^{-4} dilution. Similarly the higher actinomycetes biomass of 40.01 and 30.83 cfu/g soil at 10^{-2} and 10^{-3} dilution, respectively was reported with application of 75% RDNPK + $CaNO_3$ @ 0.5 %+ $MgSO_4$ @ 0.4 % + *Azospirillum* + PSB + KSB (T_{11}). However RDF recorded lowest number of colonies 16.60 and 9.37 cfu/g soil at 10^{-2} and 10^{-3}, respectively. The increase in microbial biomass under this treatment might be due to increased microbial activity and multiplication as it was inoculated with microbial consortium along with FYM. The production of root exudates due to exuberant growth of the crop as reflected by higher dry matter production resulted in higher microbial population. The results are confirmed with the findings of Yogaraju *et al.* (2017) and Deshpande *et al.* (2010). Therefore present investigation concluded that application of 75 % RDNPK + $CaNO_3$ @ 0.5 %+ $MgSO_4$ @ 0.4 % + *Azospirillum* + PSB + KSB has more beneficial effects with respect to soil health and nutrient status of soil as well as the plants and at the same time microbial population also improved as compared to RDF under field conditions.

Table-3 : Influence of secondary nutrients and biofertilizers on available calcium and magnesium status in soil and calcium and magnesium content (%) in leaves and fruits.

Treatments	Available Ca and Mg status in soil		Ca and Mg content (%) in leaves and fruits			
	Available Ca (mg/kg of soil)	Available Mg (mg/kg of soil)	Ca (%)	Mg (%)	Ca (%)	Mg (%)
T_1	263.89	189.73	1.48	0.87	0.072	0.029
T_2	246.89	111.01	1.78	0.96	0.100	0.032
T_3	142.55	184.95	1.49	1.07	0.079	0.037
T_4	224.44	175.94	1.88	1.09	0.104	0.040
T_5	215.71	113.97	1.94	0.95	0.109	0.036
T_6	149.38	167.89	1.66	1.15	0.087	0.043
T_7	199.12	110.47	2.05	0.93	0.114	0.035
T_8	148.30	157.21	1.83	1.12	0.094	0.046
T_9	188.57	112.12	2.02	0.98	0.119	0.032
T_{10}	147.06	147.41	1.68	1.14	0.093	0.049
T_{11}	146.06	109.69	2.37	1.23	0.124	0.052
Mean	175.31	143.85	1.84	1.04	0.100	0.004
S. Em±	1.49	1.44	0.02	0.01	0.002	0.001
CD @ (5%)	4.29	4.14	0.07	0.03	0.004	0.002

Table-4 : Influence of secondary nutrients and biofertilizers on bacteria, fungi and actinomycetes population (CFU g^{-1} soil) in soil.

Treatments	Bacteria (CFU g^{-1} soil)		Fungi (CFU g^{-1} soil)		Actinomycetes (10^{-3} CFU g^{-1} soil)	
	10^{-5}	10^{-6}	10^{-3}	10^{-4}	10^{-2}	10^{-3}
T_1	31.58	22.11	18.41	12.97	16.60	9.37
T_2	51.87	55.72	19.25	16.93	21.05	10.45
T_3	68.45	62.01	25.60	17.73	22.05	11.64
T_4	99.03	115.29	28.74	18.58	25.32	14.83
T_5	121.71	132.56	33.23	26.94	26.73	17.85
T_6	120.86	139.04	31.57	28.70	28.49	18.64
T_7	133.23	154.47	36.49	29.51	30.24	19.77
T_8	155.18	170.06	39.34	32.23	32.62	22.77
T_9	180.08	175.00	40.81	36.10	38.34	27.18
T_{10}	211.37	181.51	44.75	38.74	40.01	28.18
T_{11}	225.06	193.94	51.35	46.95	41.81	30.83
Mean	126.95	127.43	33.59	27.76	29.39	19.23
S. Em±	1.05	1.20	0.39	0.26	0.39	0.12
CD @ (5%)	3.02	3.46	1.13	0.76	1.11	0.33

Conclusions

It can be concluded that combined application of 75 % RDNPK + $CaNO_3$ @ 0.5 %+ $MgSO_4$ @ 0.4 % + *Azospirillum* + PSB +KSB (T_{11}) showed the significant variation in available nitrogen, phosphorus and potassium in soil as well as plants and also noticed higher microbial population in the same treatment.

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Estimation of Crop Water Requirement (CWR) for Wheat (*Triticum Aestivum* L.) in Arid Region

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Abstract

The estimation of crop water requirements (CWR) for wheat (*Triticum aestivum* L.) cultivation in arid regions is a challenging task due to the lack of accurate and reliable data. This paper focuses on the estimation of CWR specifically for wheat cultivation in the Jaipur region of Rajasthan, India. The study aims to provide valuable insights into irrigation planning and water resource management in regions facing water scarcity challenges. By implementing a systematic methodology, including wheat crop production practices, data collection, estimation of reference evapotranspiration (ET0), determination of crop coefficients (Kc), and calculation of crop water requirement (ETc), the study aimed to provide useful insights into optimizing irrigation practices and promoting sustainable agriculture in the region. The review concludes by emphasizing the need to draw insights from the current status of water resources in Rajasthan and recommends measures such as sustainable groundwater management, awareness campaigns promoting water conservation, and the establishment of effective water governance mechanisms. The findings of this study offer practical guidance for irrigation planners and farmers, facilitating precise irrigation scheduling to optimize water usage and enhance crop quality and yield. The analysis of collected data from VGU Farm highlights the suitability of CROPWAT software in assessing irrigation water requirements for agricultural crops.

Key words : *Crop water requirement, crop coefficient, irrigation water requirement, wheat.*

Introduction

Water is a vital natural resource that supports biodiversity, human health, social welfare, and economic development. Agriculture, a significant consumer of water resources, relies heavily on irrigation for 70-90% of its water dependency. Efficient water utilization in both irrigated and rainfed agricultural areas are crucial for optimal crop production. Irrigation requires considering factors such as crop typegrowth stage, climate conditions, soil characteristics, and evapotranspiration rates. Traditional methods like empirical formulas and crop coefficients are often insufficient due to their lack of precision and failure to consider site-specific conditions. Advancements in technology have revolutionized irrigation management, providing real-time data and insights for farmers. Effective water management strategies involve water-saving techniques like drip irrigation, precision sprinklers, and soil moisture-based irrigation systems. These methods minimize water losses due to evaporation, runoff, and deep percolation; ensuring water is delivered directly to the root zone of plants. Mulching, cover crops, and conservation tillage practices can also help reduce water evaporation, improve soil moisture retention, and enhance overall water-use efficiency. Promoting awareness and education among farmers about water conservation and efficient irrigation practices is crucial for sustainable water resource management. Governments, policymakers, and agricultural extension services should play an active role in providing training, technical support, and incentives to encourage the adoption of water-efficient technologies and practices within the realm of agricultural water management, accurately estimating the Crop Water Requirement (CWR) assumes paramount importance. CWR refers to the amount of water that crops need during their various growth stages to meet their physiological needs and achieve optimal yields. However, determining CWR is a complex task that requires considering multiple factors, including climate conditions, soil properties, crop characteristics, and agronomic practices. The interplay between these intricate factors must be comprehensively analysed to develop accurate and site-specific estimations of CWR. Over the years, traditional methods have been used to estimate CWR, such as pan evaporation and water balance approaches. These methods have provided valuable insights into crop water requirements. However, they often lack precision and fail to account for the specific requirements of different crop varieties and local environmental conditions. This limitation becomes particularly significant in arid regions, where water scarcity poses substantial challenges to agricultural productivity. In such regions, it is crucial to develop more advanced and tailored approaches to estimate CWR effectively. To enhance the accuracy of CWR estimations, it is essential to integrate climate data into the analysis. Climate variables such as temperature, humidity, solar radiation, and wind speed significantly influence evapotranspiration rates, which directly impact

crop water needs. Collecting and analysing long-term climate data is crucial for developing reliable models that can predict CWR accurately. Additionally, climate forecasting tools and remote sensing technologies can provide real-time data on weather conditions, allowing farmers to adjust irrigation practices accordingly.

Soil properties play a crucial role in determining CWR as well. Factors such as soil texture, structure, and water-holding capacity affect the availability of water to crops. Conducting soil surveys and analysing soil samples help in characterizing soil properties accurately. Moreover, advanced techniques like soil moisture sensors can provide real-time data on soil moisture levels, enabling farmers to make informed decisions about irrigation scheduling and water application. Understanding the specific characteristics and requirements of different crop varieties is vital for estimating CWR accurately. Each crop has distinct physiological stages, such as germination, vegetative growth, flowering, and fruit development, with varying water needs at each stage. Crop coefficients, which represent the ratio of crop water use to reference evapotranspiration, are commonly used to estimate CWR for different crops. These coefficients can be determined through field experiments and observations, considering local conditions and crop-specific factors. Agronomic practices, such as planting density, crop spacing, and mulching, also influence CWR. Implementing practices that enhance water-use efficiency, such as drip irrigation, precision sprinklers, and conservation tillage, can significantly reduce CWR without compromising crop yields. Additionally, adopting crop management techniques like crop rotation, intercropping, and agroforestry can optimize water use and enhance overall agricultural sustainability.

This thesis is dedicated to the estimation of Crop Water Requirement (CWR) for wheat (Triticum aestivum L.) cultivation in arid regions. Wheat is a vital staple crop grown extensively worldwide, serving as a key source of nutrition and livelihood for millions of people. However, the water requirements of wheat plants undergo significant variations during different growth stages, emphasizing the need for accurate determination of water needs at each developmental phase. This precise estimation is essential to achieve optimal wheat yields while simultaneously conserving water resources. By focusing on CWR estimation for wheat in arid regions, this thesis aims to contribute to sustainable agricultural practices and effective water management strategies in regions facing water scarcity challenges.

Research Objectives : The objective of this thesis is to assess water resource management for wheat cultivation in the arid region. The primary goals of the study include :

Estimation of ET_0 (Reference evapotranspiration) by using FAO-Penman Monteith Method based on local data.

Estimation of ET_c (Crop water requirement), IWR (Irrigation water requirement) for wheat crop.

Irrigation scheduling based on crop water requirement.

Develop crop coefficient for wheat crop.

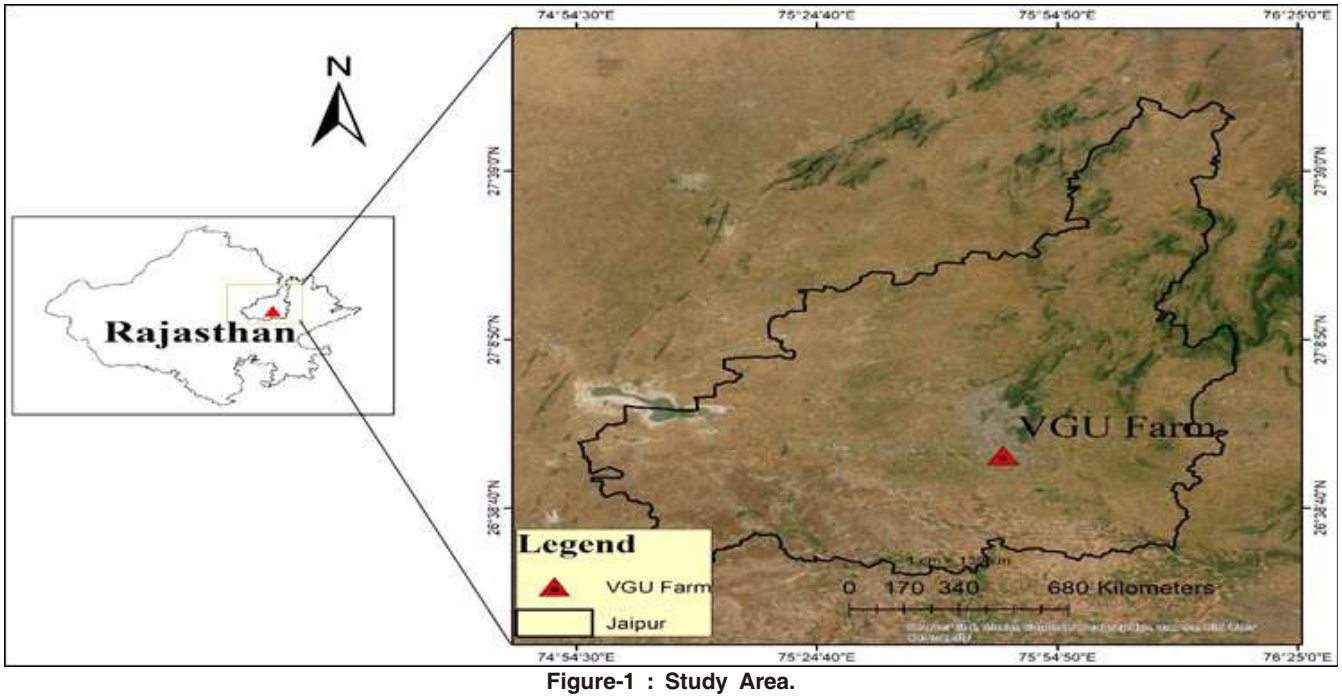

Figure-1 : Study Area.

Table-1 : Reference Evapotranspiration (ETo).

Month	ETo (mm/day)
January	3
February	4
March	5.27
April	7.07
May	8.9
June	8.19
July	5.03
August	4.03
September	4.79
October	5.08
November	3.55
December	2.78
Average	5.14

Methods and Materials

Study area : Jaipur is the capital city of the state of Rajasthan, situated in the northwestern part of India. It is located at approximately 26.9124° N latitude and 75.7873° E longitude. The city covers an area of about 484.64 square km and has a population of around 3.1 million people, making it one of the largest cities in Rajasthan.

Geographically, Jaipur is situated on the eastern edge of the Thar Desert, also known as the Great Indian Desert. It is surrounded by the Aravalli Range, which runs through the state of Rajasthan. The city falls under the semi-arid climatic zone, characterized by hot summers and relatively mild winters. The climate of Jaipur experiences extreme temperatures, with the summer months (April to June) being extremely hot, with maximum temperatures reaching around 45°C. The winter months (December to February) are comparatively cooler, with minimum temperatures dropping to around 5°C. The monsoon season, from July to September, brings some relief from the heat, with moderate rainfall. In terms of soil types, Jaipur predominantly consists of alluvial and sandy soils, which are typical of arid and semi-arid regions. These soils have low water-holding capacity and require careful irrigation management to ensure efficient water usage for agricultural purposes. Jaipur presents a challenging environment for agriculture due to its arid climate, limited water resources, and specific soil conditions. Understanding the crop water requirement for wheat cultivation in this region is essential for optimizing irrigation practices and promoting sustainable agriculture. The study area is shown in Figure-1.

Data collection : Monthly meteorological data were recorded throughout the study period, capturing essential variables such as maximum and minimum temperature, solar radiation, sunshine hours, and wind speed. These meteorological parameters play a significant role in determining crop water requirements as they directly influence the evapotranspiration process. By monitoring these variables, a comprehensive understanding of the climate patterns and their impact on wheat water needs was obtained.

Soil information was collected from representative locations within the study area. This included important parameters such as soil type, texture, and moisture content. Soil type and texture influence water-holding capacity and drainage characteristics, which significantly impact the availability of water to the wheat crop. By collecting soil data from multiple locations, variations in soil properties within the study area were captured, allowing for a more accurate estimation of CWR.

Rainfall data, obtained from reliable sources, provided insights into the precipitation patterns during the wheat crop season. Rainfall is a crucial water source for crops, especially in arid regions where water scarcity is a significant challenge. Analysing the timing, amount, and distribution of rainfall events helped in understanding the natural water inputs and their contribution to meeting the water requirements of the wheat crop. Effective rainfall is determined by the “USDA S.C. Method”.

Crop data is captured at different growth stages of the wheat crop, capturing important variables related to plant height, root depth, and overall crop health. These observations were carried out on representative plots within the study area, providing valuable insights into the growth and development of the wheat crop under specific environmental conditions. Monitoring plant height and root depth allowed for an assessment of the crop’s water uptake capacity and its ability to access water from deeper soil layers.

Estimation of reference evapotranspiration (ET_0) : To determine the irrigation water demand for plant growth, the estimation of reference evapotranspiration (ET_0) was conducted. In this study, the FAO-Penman Monteith method, recommended by the Food and Agriculture Organization (FAO), was employed to estimate ET_0 using monthly climate data. The FAO-Penman Monteith method is a widely accepted and robust approach for calculating ET_0, as it takes into account various meteorological parameters such as temperature, solar radiation, wind speed, and humidity.

The estimation of ET_0 using the FAO-Penman Monteith method involves the application of the following equation (1) :

$$ET_0 \quad \frac{0.408\ (R_n \quad G) \quad \frac{900}{T \quad 273}\ u_2\ (e_s \quad e_a)}{(1 \quad 0.34\ u_2)} \quad \text{...Eq. (1)}$$

Where:

ET_0 = Reference evapotranspiration (mm/day)

= Slope of the vapor pressure curve (kPa/°C)

R_n = Net radiation at the crop surface (MJ/m²/day)

G = Soil heat flux density (MJ/m²/day)

= Psychometric constant (kPa/°C)

T = Mean daily air temperature (°C)

u_2 = Wind speed at 2 meters height (m/s)

e_s = Saturation vapor pressure (kPa)

e_a = Actual vapor pressure (kPa)

By utilizing this equation and the monthly climate data, including temperature, net radiation, soil heat flux density, wind speed, and vapor pressure, the reference evapotranspiration (ET_0) was estimated. This provided a valuable parameter for determining the water requirements of the wheat crop in the study area.

Determination of crop coefficient (Kc) : The determination of the crop coefficient (Kc) for wheat involved dividing the crop into four distinct growth stages: initial, developmental, mid-season, and late-season. For each stage, specific Kc values were utilized as provided in the FAO-56 guidelines. These standardized Kc values served as reference values for estimating the water requirements of the wheat crop at different stages of growth.

By assigning the appropriate Kc values to each growth stage, the study ensured accurate estimation of the crop water requirement and efficient irrigation management. The use of standardized Kc values from the FAO-56 guidelines allowed for consistency and comparability across different studies and regions. These Kc values served as important parameters in determining the optimal irrigation schedule and water supply for the wheat crop during each growth stage.

Crop water requirement (ETc) : To determine the crop water requirement (ETc) for wheat, the daily reference evapotranspiration was multiplied by the corresponding crop coefficient (Kc) value. The ETc represents the amount of water needed by the crop on daily basis to meet its evapotranspiration needs. The equation (2) used for calculating ETc is as follows :

$$ETc = Kc \times ET_0 \quad \text{...Eq. (2)}$$

By multiplying the Kc value for each growth stage of the wheat crop with the daily ET_0, the study obtained an estimation of the crop's daily water requirement. This approach allowed for precise irrigation scheduling and optimal water management throughout the different growth stages of the wheat crop. The ETc values served as a valuable guide for determining the amount of irrigation water necessary to sustain optimal crop growth and yield.

Results and Discussion

Reference evapotranspiration (ETo) :

Among the months, May month exhibits the highest average value of ETo at 8.9 mm/day, indicating a significant demand for water due to increased evaporation and plant transpiration (Table 1). This likely corresponds to warmer temperatures and higher solar radiation during that period, leading to greater water loss from soil and plants. Conversely, December displays the lowest average ETo of 2.78 mm/day, suggesting minimal water loss due to reduced temperatures and limited plant activity . This aligns with the colder weather conditions typical of the winter season, which slows down the overall evaporation and transpiration processes.

Crop coefficients (Kc) :

The planting date of the crop was on December 1, 2022, marking the beginning of its growth cycle. The cultivation date, which occurred on April 29, 2023, represents the endpoint of the crop's growth period. The time between these two dates encompasses the entire cultivation duration, during which the crop underwent its various growth stages, development, and maturation processes. The crop coefficient values for different growth stages of wheat provide insights into its water requirements (Figure 3). In the initial stage, which spans around 30 days, the crop coefficient is at 0.30. This indicates that young wheat plants have relatively low water demand as they establish their root systems. During the transition from initial to development, lasting another 30 days, the crop coefficient gradually rises from 0.30 to 1.15. This signifies a significant increase in water needs as the wheat plants enter a crucial growth phase, demanding more resources for optimal development. The mid-season stage, encompassing around 40 days, maintains a constant crop coefficient of 1.15. This signifies the peak water requirement period, corresponding to the plant's active growth and reproductive stages. As the late season unfolds, spanning approximately 50 days, the crop coefficient remains decreases from 1.15 to 0.30. This trend underscores the diminishing water requirements of the wheat crop as it approaches the end of its growth cycle. The reduction in the crop coefficient reflects the reduced metabolic activity and growth rate of the plants during this late stage.

Crop water requirement (ETc) :

The Table-2 presents a comprehensive overview of crop

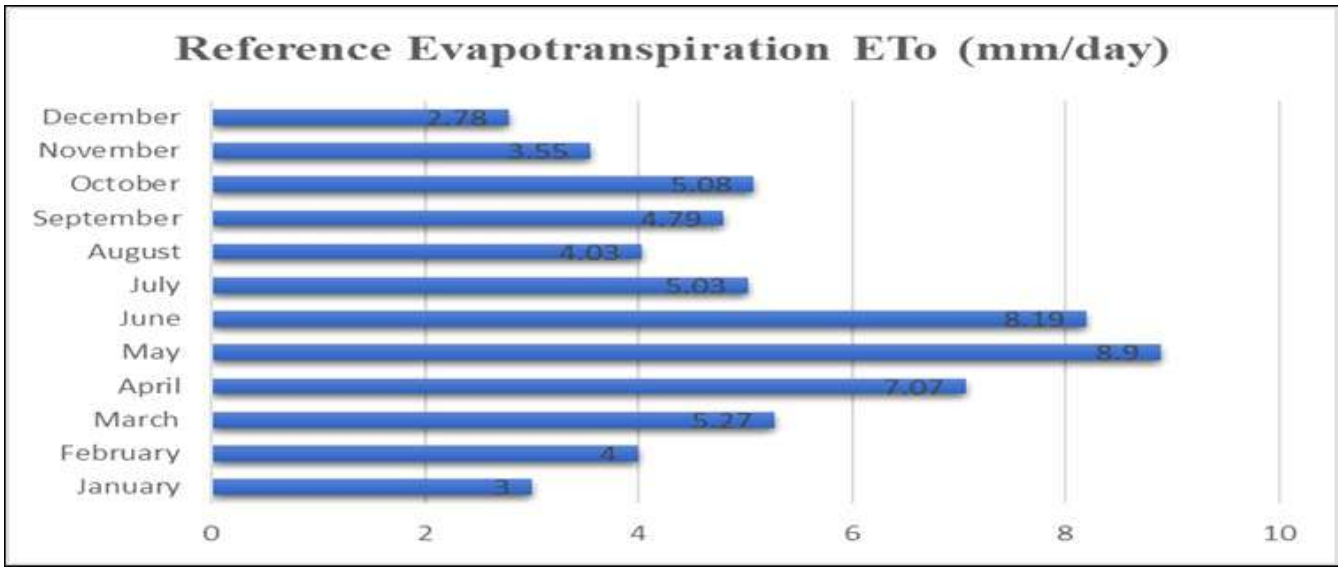

Figure-2 : Reference Evapotranspiration Bar Chart.

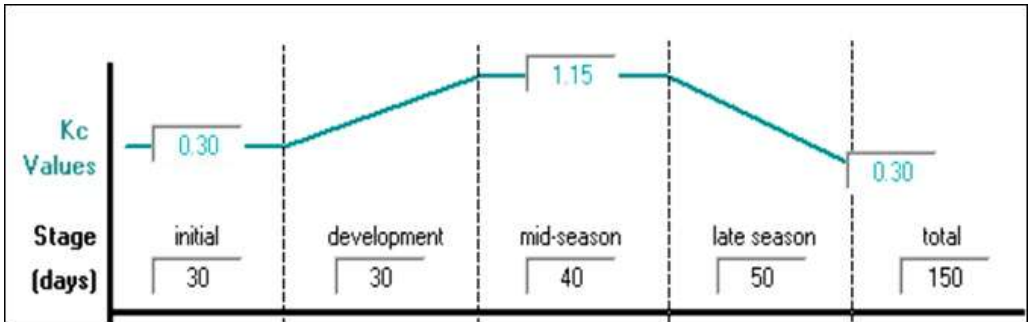

Figure-3 : Crop coefficients (Kc).

growth, water requirements, and irrigation considerations over different months and growth stages. As evident from the results, the crop's water demands vary significantly throughout its growth cycle. In the initial stages of December, the crop coefficient remains low at 0.3, reflecting limited water needs. However, as the crop transitions into the development stage in January, the Kc increases, resulting in higher ETc values due to enhanced growth and transpiration. The mid-season stages in January and February witness the greatest water demand, as indicated by the substantial ETc values, reaching up to 56.6 mm/decade. This corresponds to the peak growth phase when the crop's transpiration and water uptake are at their highest. Towards the late season in March and April, the crop coefficient decreases, resulting in lower ETc values and subsequently reduced irrigation requirements (Figure-4). The overall irrigation requirement for the cultivation period adds up to 484.2 mm/decade, demonstrating the necessity of efficient water management strategies to meet the crop's evolving needs while minimizing water wastage.

Crop irrigation schedule : The results (shown in Figure-5) obtained from the recorded data provide valuable insights into the irrigation management and water utilization for the wheat cultivation in the given period. As depicted by the data, the chosen irrigation strategy effectively catered to the crop's water needs during its growth stages. The soil moisture depletion (Depl) values ranged from 55% to 66%, reflecting a well-maintained balance between irrigation and crop water requirements. The net irrigation values, ranging from 119.1 mm to 143.1 mm, demonstrate the amount of water applied to the field to supplement the crop's water needs. Notably, the absence of irrigation deficit (Deficit) and loss further underscores the precision of the irrigation scheduling and its effectiveness in meeting the crop's demands. The gross irrigation values (Gr. Irr) of 170.1 mm to 204.4 mm represent the total water applied, combining both irrigation and any potential losses. The flow rates (Flow) of 0.29 l/s/ha to 0.88 l/s/ha indicate the rate of water application per unit area, reflecting the efficiency of water distribution.

The graph (Figure-6) depicts the soil water retention characteristics over the course of the crop's growth period, showcasing the changes in readily available moisture (RAM) and Total available moisture (TAM) depletion. The

Table-2 : Crop water requirement and Irrigation requirement.

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			Coeff.	mm/day	mm/dec	mm/dec	mm/dec
Dec	1	Initial	0.3	0.89	8.9	1.2	7.7
Dec	2	Initial	0.3	0.8	8	1.3	6.7
Dec	3	Development	0.3	0.84	9.3	1.3	8
Jan	1	Development	0.49	1.43	14.3	1.1	13.2
Jan	2	Development	0.78	2.34	23.4	0.9	22.4
Jan	3	Mid	1.07	3.58	39.4	2	37.3
Feb	1	Mid	1.17	4.28	42.8	3.8	39
Feb	2	Mid	1.17	4.67	46.7	5	41.7
Feb	3	Mid	1.17	5.17	41.3	3.9	37.4
Mar	1	Mid	1.17	5.66	56.6	2.3	54.3
Mar	2	Late	1.07	5.66	56.6	1.4	55.2
Mar	3	Late	0.89	5.23	57.5	1.3	56.2
Apr	1	Late	0.71	4.58	45.8	1	44.8
Apr	2	Late	0.53	3.78	37.8	0.7	37
Apr	3	Late	0.37	2.84	25.5	2.1	23.2
				Total	513.8	29.4	484.2

x-axis represents the days after planting, ranging from 0 to 150 days, while the y-axis indicates the soil water retention in mm.

For the RAM, the graph reveals that within the initial 60 days after planting, the soil water retention ranges from 30 mm to 120 mm. This interval signifies the dynamic soil moisture availability during the early stages of the crop's growth, where the moisture content gradually decreases due to plant uptake and evaporation. Between 60 and 100 days, the RAM value stabilizes at 120 mm, suggesting that the soil reaches a certain equilibrium in moisture availability. Moving forward, from 100 to 150 days, the RAM value increases from 120 mm to 170 mm. This period might indicate additional moisture replenishment due to external factors such as rainfall or irrigation, leading to an augmented soil water retention value.

Similarly, when focusing on TAM, the graph shows that within the initial 60 days, the soil water retention ranges from 60 mm to 215 mm. This wider range compared to RAM highlights the higher initial water availability in the soil profile, contributing to the crop's establishment and early growth. Subsequently, between 60 and 150 days, the TAM value stabilizes at 215 mm, reflecting the maintained soil moisture content during the later stages of crop development.

Conclusions

The analysis of collected data from VGU Farm in Jaipur highlights the suitability of CROPWAT software in assessing irrigation water requirements for agricultural crops. Among the months, May emerges as a critical period with the highest average ETo of 8.9 mm/day, indicating its suitability for high water availability. Conversely, December's lowest average ETo of 2.78 mm/day suggests it as a period with minimal water loss due to lower temperatures and reduced plant activity. The planting and cultivation dates demarcate the wheat crop's growth cycle, capturing the entire span of growth stages, development, and maturation. Crop coefficient values provide insights into water requirements, where the initial stage witnesses a low coefficient of 0.30, indicating modest water demand. The transition from initial to development stages sees the crop coefficient gradually rising to 1.15, reflecting heightened water needs for critical growth phases. The consistent crop coefficient of 1.15 during the mid-season stage signifies peak water demand, corresponding to active growth and reproductive phases. The late-season decline in the crop coefficient from 1.15 to 0.30 underscores the diminishing water requirements as the crop approaches maturity. The comprehensive overview of crop growth, water needs, and irrigation in different months and stages underlines the dynamic nature of water demand. December's initial stage demonstrates low crop coefficient and irrigation requirement, indicating minimal water needs during the early growth phase. Transitioning into January's development stage, higher crop coefficient and ETc values reflect increased water demand for optimal growth. The peak of water demand occurs during January and February's mid-season stages, aligning with substantial ETc values attributed to active growth. The late-season stages of March and April witness reduced irrigation requirements, coinciding with lower crop coefficients and ETc values. The cumulative irrigation requirement for the cultivation period of 484.2 mm showcases the necessity of

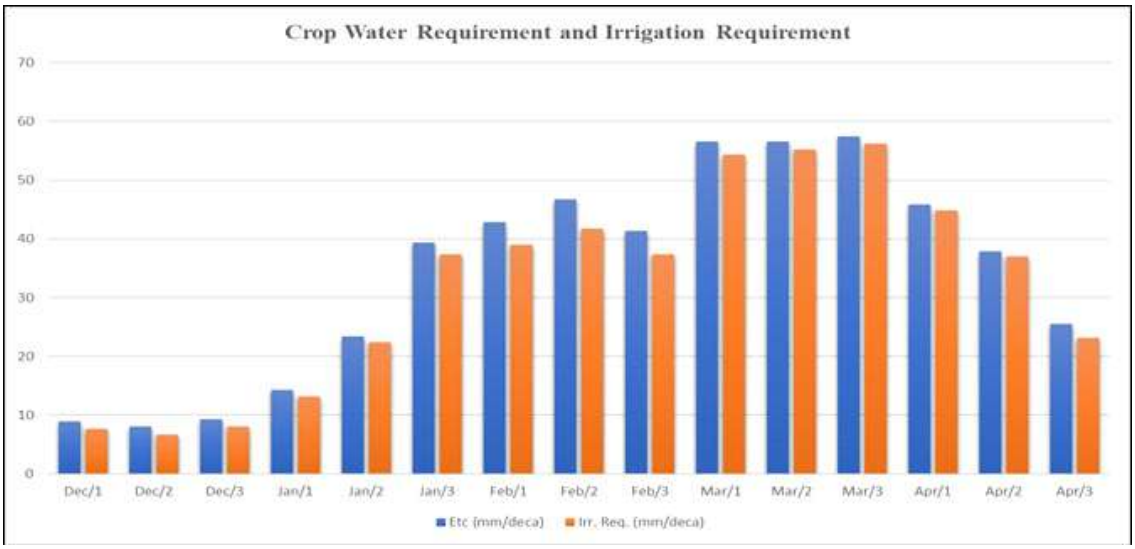

Figure-4 : Crop water requirement and Irrigation requirement Chart.

Table format
Irrigation schedule
Daily soil moisture balance

Timing: Irrigate at critical depletion
Application: Refill soil to field capacity
Field eff. 70 %

Date	Day	Stage	Rain	Ks	Eta	Depl	Net Irr	Deficit	Loss	Gr. Irr	Flow
			mm	fract.	%	%	mm	mm	mm	mm	l/s/ha
6 Feb	68	Mid	0.0	1.00	100	55	119.1	0.0	0.0	170.1	0.29
5 Mar	95	Mid	0.0	1.00	100	57	123.2	0.0	0.0	176.1	0.75
1 Apr	122	End	0.0	1.00	100	66	143.1	0.0	0.0	204.4	0.88
29 Apr	End	End	0.0	1.00	0	45					

Totals

Total gross irrigation	550.5	mm	Total rainfall	29.9	mm
Total net irrigation	385.4	mm	Effective rainfall	28.0	mm
Total irrigation losses	0.0	mm	Total rain loss	1.9	mm
Actual water use by crop	511.0	mm	Moist deficit at harvest	97.6	mm
Potential water use by crop	511.0	mm	Actual irrigation requirement	483.0	mm
Efficiency irrigation schedule	100.0	%	Efficiency rain	93.6	%
Deficiency irrigation schedule	0.0	%			

Figure-5 : Crop Irrigation Schedule.

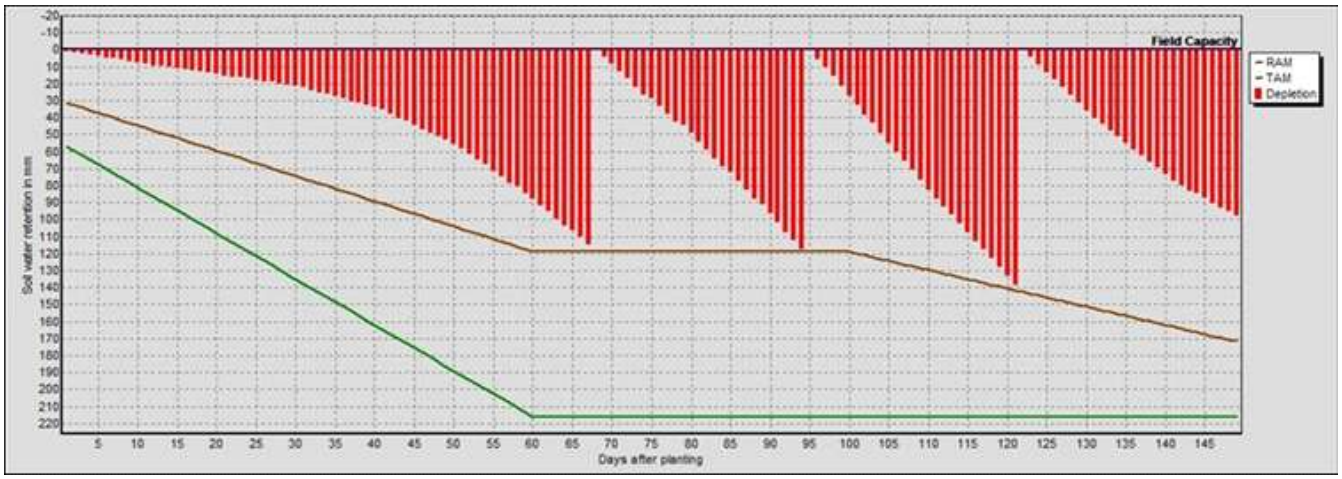

Figure-6 : Soil water retention curve.

efficient water management strategies. The recorded data validates the irrigation strategy's effectiveness, maintaining a balanced soil moisture depletion between 55% and 66%. The net irrigation values ranging from 119.1 mm to 143.1 mm demonstrate water application to meet the crop's water requirements. Absence of irrigation deficit and loss underscores the precision of irrigation scheduling, ensuring optimal water utilization. The graph depicting soil water retention over time underscores the changing Readily Available Moisture (RAM) and Total Available Moisture (TAM) dynamics. The congruence between observed data and model-derived estimates strengthens the reliability of irrigation planning and management strategies at VGU Farm**.**

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Management of Red Pumpkin Beetle (*Aulacophora foveicollis* Lucas) through Biorational Approaches on Bottle Gourd (*Lagenaria siceraria* M.)

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Abstract

Bottle gourd (*Lagenaria siceraria*) is one of the most important cucurbitaceous vegetable crop in India grown in both summer and rainy seasons. Numerous insect pests cause the damage to the crop from nursery till maturity stage. Among all the infesting pest, red pumpkin beetle *Aulacophora foveicollis* Lucas causes major damage to the crop. The study was done at Vegetable Research and Demonstration Block during *Zaid* season, 2023 to study its management through biorational approaches on bottle gourd. Management of the pest was done by taking nine treatments. The effectiveness of each treatment was determined based on the population of red pumpkin beetle recorded pre-treatment observations. While post treatment observations were taken on 3rd, 5th and 7th day of the application of the treatment after 1st and 2nd spray. Amongst all these treatments Spinosad 45SC (1ml/L) showed the best results after first 54.42% PROC and second spray 60.13% PROC (Per cent reduction over control) while after first spray Ginger rhizome extract (5%) resulted least efficient to control the population of the beetle 17.40% PROC whereas after second spray cow dung (1:5 w/v) showed least reduction in population of the beetle with 17.89% PROC. The highest estimated yield was found maximum from the plot treated with Spinosad 45SC which was 135.00 q/ha with yield over control (%) of 65.66%.

Key words : *Bottle gourd, Red pumpkin beetle, biorational, management, spinosad 45SC.*

Introduction

Bottle gourd belongs to the Cucurbitaceae family which is commonly known as the gourd, melon or pumpkin family. The plants of the cucurbitaceae family provide the major contribution for economically important domesticated species and are cultivated for medicinal and nutritional value (Rahaman *et al.,* 2003). It is anti-cancerous, cardio protective, diuretic, aphrodisiac and also antidote to certain poisons and scorpion stings, alternative purgative and also have cooling effects (Badmanaban and Patel, 2010). It can also be used to cure pain, ulcers and fever and is used for pectoral cough, asthma and other bronchial disorders using prepared syrup from the tender fruits (Upaganlawar and Balaraman, 2010). The gourd is used as curative plant for mental health disorders.

The total area under bottle gourd in India is 1, 16,939 ha and total production is 14, 28,296 tonnes and productivity being 12.21 t/ ha. Productivity of bottle gourd is very low which needs immediate attention to increase (Anonymous, 2022). In India it is grown in Bihar, Uttar Pradesh, Uttarakhand, Chhattisgarh, Madhya Pradesh, Orrisa, Telangana, Assam, Tripura etc. where Bihar is the leading state. Among all the main insect pests of cucurbit vegetables, red pumpkin beetle, *Aulacophora foveicollis* (Lucas.), (Coleoptera: Chrysomelidae) is widespread. It is widely disseminated all the way through the world. It is a polyphagous pest of cucurbit crops). The roots and underground parts of cucurbitaceous plants, as well as fruits that touch the soil, are consumed by the grubs. The adults feed on both the surfaces of leaves. When the adult feed on the middle of the leaf, they produce a characteristic circular ring like injury. Young seedlings are particularly susceptible to damage as small numbers of beetles can cause total defoliation. The adult beetle causes damage by biting holes in the cotyledons, flowers and foliage. Fruits that have been infected become unfit for human eating. When plants are in the seedling stage, the beetles can consume up to 35-75 percent of the leaves, flower buds, and flowers. The losses caused by this insect have been estimated to be between 30 and 100 percent in some circumstances (Rashid *et al*., 2014). During spring, the beetles feed on the cucurbit seedlings to such a limit that re sowing may be required 3-4 times (Dash *et al*., 2021). Adults feeding on flowers usually make them sterile. The pest has a regular occurrence and cause serious damage at seedling stage (Roy and Pande, 1991; Pradhan *et al.,* 2020).

The red pumpkin beetle has only been managed using chemical insecticides. Aside from harming the ecosystem, repeated exposure to them has created insects resistant to them. Additionally, pesticides are used

carelessly, creating pesticide waste and endangering consumers and non-target animals. The current study examined the bio efficacy of more recent insecticides and natural remedies to combat the red pumpkin beetle infestation on bottle gourd. In general, biorational pest management entails the use of substances or procedures that have negligible or no negative effects on the environment and non-target organisms (humans, beneficial fauna and flora etc.), but have lethal, suppressive or behaviour-altering effects on a target organism and strengthen the targeted control system.

Materials and Methods

To evaluate the efficacy of different biorational approaches against Red pumpkin beetle (*Aulacophora foveicollis* Lucas) a study was made at Vegetable Research and Demonstration Block, College of Horticulture, VCSG UUHF, Bharsar (Pauri Garhwal) during *Zaid* season, 2023 by taking ten treatment (9 treatments + control) and three replications in RCBD (Randomized Complete Block Design). Treatments were given according to the doses mentioned and were applied during the morning hours and on sunny days. They were applied two times during the whole cropping season. Pest monitoring was done on the daily basis to monitor the pest population and to record its ETL level for the treatment application. For the purpose of recording the observations, four plants were randomly selected from each net plot. Observations on red pumpkin beetle were recorded prior as well as on 3rd, 5th and 7th day after each spray. The hand sprayer fitted with hollow cone nozzle was used for the spraying purpose. Plant materials were collected from the nearby places of Bharsar. Extract was prepared by crushing the plant material with the help of mortar and pestle. Separation of the extract was done with the help of muslin cloth and it was filtered by filter paper. Extracts of bulb, rhizome and plant leaves were prepared separately and kept in a conical flask. Animal product was collected from nearby places and was mixed with water in appropriate amount before the application. Red chili powder was also mixed with water before its application.

Following formulae were used :

Flemming and Retnakaran, 1985 gave the following formula for the per cent reduction of insect over per count :

$$\text{PROC \%} = 1 \frac{Ta \quad Cb}{Tb \quad Ca} \quad 100$$

Total yield (q/ha) :

$$\text{Total yield} = \frac{\text{Yield per plot}}{\text{Plot size}} \quad \frac{10{,}000}{100}$$

Following formula was given by Purwar and Srivastava (2003) :

$$\text{\% yield loss} = \frac{\text{Yield in treated plot} - \text{Yield in untreated plot}}{\text{Yield in untreated plot}} \quad 100$$

Results and Discussion

First spray : The investigation revealed that Spinosad 45SC (1mL/l) showed the most effective result amongst all the treatments by having least number of beetle count and had the maximum per cent reduction over control *i.e.* 54.42% which was followed by Neem leaf extract (10%) having 47.48% PROC, Neem oil (20mL/l) with 43.90% PROC and *Pongamia pinnata* oil (20mL/l) with 38.71% PROC, Garlic bulb extract (5%) with PROC 31.37%, *Beauveria bassiana* (0.5mL/l) with 30.94% PROC while cow dung (1:5w/v) and red chili powder (1:10w/v) showed 22.05 % and 24.20% PROC, respectively. The least effective treatment was Ginger rhizome extract with PROC 17.40 %. The research conducted by Dangi *et al*. (2006) supported the research since he tested the effectiveness of Spinosad 45SC in treating *Aulacophora foveicollis* on ridge gourd and revealed that it was significantly effective in controlling the population of the beetle. The present findings are also corroborate with Yadav *et al*. (2017) who reported the highest mean per cent reduction in the population of red pumpkin beetle on bottle gourd with Spinosad 45 SC and minimum with parthenium leaf extract. Supporting the current findings Neupane and Shrestha (2016) and Zahid *et al*. (2017) reported that neem products are effective against the red pumpkin beetle.

Second spray : At the time of 2nd spraying which was given after 10 days of first spray, effective results were shown by the treatment Spinosad 45SC (1mL/l) with PROC 60.13% followed by *Pongamia pinnata* oil (20mL/l) with PROC of 51.19 % and Neem oil (20mL/l) with PROC of 50.96%. While, the least effective treatment amongst all was Cow dung with PROC 17.89%. Under the current experiment, none of the evaluated insecticidal treatments resulted in any phototoxic effects on the bottle gourd plants and all were found significantly effective when compared with control. The study was supported by investigation carried out by Koirala *et al*., 2021 who resulted that Imidachloropid and Spinosad recorded the lowest number of red pumpkin beetles (RPB), lowest leaf infestation percentage and lowest leaf damage severity percentage per plant, respectively, followed by Azadirachtin and Jholmol. Lady bird beetles, honeybees, wasps and other beneficial insects were shown to be least undertreated by Imidachloropid, whereas Spinosad, Azadirachtin and Jholmol (a botanical insecticide) appeared to be relatively safer options.

Fruit yield : The highest estimated yield was from the plot

Table-1 : Treatment details of the treatments which were used for testing the effectiveness against red pumpkin beetle under field conditions.

Treatment details	Treatments	Doses used
T_1	Control	—
T_2	*Azadirachta indica* oil	20 mL /l
T_3	*Pongamia pinnata* (L.) oil	20 mL/l
T_4	Spinosad 45SC	1 mL/l
T_5	Cow dung	(1:5 w/v)
T_6	Red chili powder	(1:10 w/v)
T_7	Garlic Bulb Extract	5%
T_8	Ginger Rhizome Extract	5%
T_9	*Beauveria bassiana*	0.5mL/l
T_{10}	Neem leaf extract	10%

Table-2 : Effect of different Biorational approaches against beetle (*Aulacophora foveicollis* Lucas) population on bottle gourd after 1st spray.

Treatments	Dose used	Number of beetles/plant at indicated period				Mean population
		Pre-count	3 DAS	5 DAS	7 DAS	
Control	-	2.96	3.01±0.01	3.18±0.04	3.23±0.02	3.14
Neem oil	20mL/l	2.59	1.52*±0.02	1.54*±0.04	2.24*±0.06	1.76
Pongamia pinnata oil	20mL/l	2.68	1.65*±0.01	1.82*±0.07	2.32*±0.05	1.93
Spinosad 45SC	1mL/l	2.73	1.45*±0.01	1.32*±0.09	1.52*±0.10	1.43
Cow dung	(1:5w/v)	2.87	2.10*±0.12	2.52*±0.01	2.74*±0.02	2.45
Red chili powder	(1:10w/v)	2.78	2.31*±0.02	2.32*±0.02	2.51*±0.01	2.38
Garlic Bulb Extract	5%	2.65	2.15*±0.03	2.01*±0.02	2.00*±0.03	2.05
Ginger Rhizome Extract	5%	2.82	2.81*±0.01	2.42*±0.02	2.53*±0.03	2.59
Beauveria bassiana	0.5mL/l	2.60	2.58*±0.02	2.16*±0.02	1.73*±0.15	2.16
Neem leaf extract	10%	2.82	1.74*±0.03	1.42*±0.01	1.78*±0.06	1.65
$SE_{(d)}$	-		**0.06**	**0.06**	0.09	-
$C.D._{(0.05)}$	-		**0.13**	**0.13**	**0.19**	-

*Significant at 5% level of significance as compared with control, DAS= Days After Spray.

Table-3 : Mean per cent reduction in Red Pumpkin Beetle (*Aulacophora foveicollis* Lucas) population over control after 1st spray.

Treatments	Dose used	Number of beetle/plant at indicated period				Mean per cent Reduction over control
		Pre-count	Reduction over control in per cent 3 DAS	Reduction over control in per cent 5 DAS	Reduction over control in per cent 7 DAS	
Neem oil	20mL/l	2.59	49.50	51.57	30.65	43.90
Pongamia pinnata oil	20mL/l	2.68	45.18	42.77	28.17	38.71
Spinosad 45 SC	1mL/l	2.73	51.83	58.49	52.94	54.42
Cow dung	(1:5w/v)	2.87	30.23	20.75	15.17	22.05
Red chili powder	(1:10w/v)	2.78	23.26	27.04	22.29	24.20
Garlic Bulb Extract	5%	2.65	29.23	36.79	38.08	31.37
Ginger Rhizome Extract	5%	2.82	6.64	23.90	21.67	17.40
Beauveria bassiana	0.5mL/l	2.60	14.29	32.08	46.44	30.94
Neem leaf extract	10%	2.82	42.19	55.35	44.89	47.48

treated with Spinosad 45SC which was 135.00 q/ha since there was less infestation of the pest which was followed by Neem oil 131 q/ha, *Pongammia pinnata* oil 127.00 q/ha, Neem leaf extract 121.00 q/ha, Garlic bulb extract 113.00 q/ha, *Beauveria bassiana* 108.00 q/ha and Ginger rhizome extract 102.00 q/ha. Whereas, the lowest estimated yield was seen in plot treated with Cow dung that was 88.00 q/ha and Red chili powder with estimated yield of 85.33 q/ha. The chronology of increase in yield over control (%) was Spinosad 45SC 65.66% > Neem oil 60.74 % > *Pongammia pinnata* oil 55.83% > Neem leaf extract 48.57 % > Garlic bulb extract 38.65 % > *Beauveria*

Table-4 : Effect of botanicals against red pumpkin beetle (*Aulacophora foveicollis* Lucas*)* populations on bottle gourd after 2nd spray.

Treatments	Dose used	Number of beetle/plant at indicated period				Mean population
		Pre-count	3 DAS	5 DAS	7 DAS	
Control	-	3.28	3.30±0.01	3.45±0.02	3.52±0.01	3.42
Neem oil	20mL/l	2.63	1.72*±0.10	1.67*±0.02	1.64*±0.07	1.68
Pongamia pinnata oil	20mL/l	2.41	1.65*±0.11	1.69*±0.03	1.67*±0.13	1.67
Spinosad 45 SC	1mL/l	2.32	1.52*±0.01	1.40*±0.01	1.16*±0.01	1.36
Cow dung	(1:5w/v)	2.72	2.60*±0.03	2.84*±0.01	3.00*±0.06	2.81
Red chili powder	(1:10w/v)	2.59	2.46*±0.02	2.36*0.02	2.57*±0.09	2.46
Garlic Bulb Extract	5%	2.09	1.95*±0.03	1.77*±0.01	1.62*±0.01	1.78
Ginger Rhizome Extract	5%	2.34	2.27*±0.03	2.24*±0.02	2.00*±0.07	2.17
Beauveria bassiana	0.5mL/l	2.16	2.09*±0.04	1.87*±0.02	1.61*±0.12	1.86
Neem leaf extract	10%	2.12	1.90*±0.01	1.79*±0.02	1.62*±0.02	1.77
SE(d)	-		0.07	0.02	0.09	-
C.D. (0.05)	-		0.14	0.05	0.19	-

*Significant at 5% level of significance as compared with control, DAS= Days After Spray.

Table-5 : Mean per cent reduction in red pumpkin beetle (*Aulacophora foveicollis* Lucas*)* population over control after 2nd spray.

Treatments	Dose used	Number of beetle/plant at indicated period				Mean per cent Reduction over control
		Pre-count	Reduction over control in per cent 3 DAS	Reduction over control in per cent 5 DAS	Reduction over control in per cent 7 DAS	
Neem oil	20mL/l	2.63	47.88	51.59	53.41	50.96
Pongamia pinnata oil	20mL/l	2.41	50.00	51.01	52.56	51.19
Spinosad 45 SC	1mL/l	2.32	53.94	59.42	67.05	60.13
Cow dung	(1:5 w/v)	2.72	21.21	17.68	14.77	17.89
Red chili powder	(1:10w/v)	2.59	25.45	31.59	26.99	28.01
Garlic Bulb Extract	5%	2.09	40.91	48.70	53.98	47.86
Ginger Rhizome Extract	5%	2.34	31.21	35.07	43.18	36.49
Beauveria bassiana	0.5 mL/l	2.16	36.67	45.80	54.26	45.58
Neem leaf extract	10%	2.12	42.42	48.12	53.98	48.17

bassiana 32.52%, Ginger rhizome extract 25.15% >Cow dung 7.98% > Red chili powder 4.29%. The current findings are corroborated by reports from Babu *et al*. (2002), Kumar *et al*. (2013) and Yadav *et al*. (2017) regarding the efficacy of these pesticides against red pumpkin beetle on various crops and also the yield was obtained maximum from the plots treated with Spinosad 45SC since it had least number of damaged flowers and fruits in comparison to other treatments which were taken under study.

Conclusions

In India and other parts of the world, the red pumpkin beetle (*A. foveicollis*) is the main pest of cucurbitaceous crops. Since insects can inflict up to 100% of the damage in a given area, timing is crucial for management. The study revealed that the population of red pumpkin beetle can be decreased by using different biorational approaches as a management practise which is eco-friendly and cost effective too. Among all the treatments Spinosad 45SC (1mL/l) was the most effective insecticide tested against the red pumpkin beetle on bottle gourd, causing the greatest reduction in red pumpkin beetle population on the third, fifth, and seventh day of first spray (54.42% PROC). Even at the time of 2nd spraying the effective results was again shown by the treatment Spinosad 45SC (1mL/l) with PROC 60.13% whereas, the least effective treatments were Ginger rhizome extract with PROC 17.40 % during 1st spray and Cow dung with PROC 17.89% during 2nd spray.

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Mechanization of Khoa and Khoa Based Sweets – A Review

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Introduction

Khoa is an indigenous milk product which has been evolved over ages utilizing locally available equipment, utensils and procedures. It is estimated that about 50 - 55 per cent of total milk produced in Bihar is converted into different indigenous traditional milk products by unorganized and organized sectors. Conversion of surplus milk into khoa around production areas in villages is highly profitable because it helps in effectively managing the cost of transaction, processing, transportation etc. like a cash crop for earning of local small-scale entrepreneurs/vendors. It is to be noted that the processed liquid milk supply requires huge capital investment on civil work, equipment and other infrastructure, however, the indigenous milk products like khoa and khoa based sweets have brought a balancing role in the business of dairying because most of the milk can be converted into value added products such as burfi, peda, kalakand, gulabjamun, milk - cake etc. Apart from this, skilled manpower is available to produce indigenous milk products at cottage scale, which brings mass appeal to consumers, lower production costs and high profit margins but the hygiene of production and quality and safety of products are lower due to low infrastructure and operational overhead expenses made in village level manufacturing installations. There exists a scope of demand profile consumption pattern of these products and it allows a significant R & D development for value addition and growth compared to other products if quality and shelf-life criteria are to be given priority. It is necessary to exploit some of the technological innovations for processing, preservation and packaging as a combination to enhance the shelf-life of the product manufactured.

The research works in technology and design of batch and continuous processing equipments for these indigenous products have undergone changes but the pace of development remained slows and adoption and exploitation for industrial production are meager. Recently few organized dairy sectors have started the hygienic production of khoa and khoa based sweets. Despite, the various technologies have been developed utilizing scraped surface heat exchangers (SSHEs) for viscous and particulate food products in different national institutes and universities in the country, the organized sector has so far not been able to tap most of their technologies and new developments in equipments and machineries to adopt at industry level. Legal standards for these products must be met which should be considered as challenge for example to provide minimum legal standards in khoa. The minimum fat content of 4.4% in cow milk and 5.5% in buffalo milk should be maintained. The buffalo milk is preferred for the manufacture of khoa as it has larger proportion of butyric acid-containing triglycerides, and there is more release of free fat responsible for smooth and mellow texture which are desirable (Sindhu,1996). The minimum level of fat desired in buffalo milk should be 5.5 % while in cow milk it should be 4% to meet the regulatory provision for khoa productions. Khoa made from cow milk has moist surface, salty taste and sticky and sandy texture which are considered undesirable for the preparation of sweetmeats. The chemical quality of khoa as per Food Safety and Standard Regulations 2011, the milk fat content shall not be less than 30 percent on dry weight basis of finished product. It may contain citric acid not more than 0.1 percent by weight. It shall be free from added starch, added sugar and added colouring matter. The khoa has been classified as pindi, danedar and dhap with and average moisture content of about 31-33%,35-40% and 37-44%, respectively. The mechanization of khoa and khoa based sweets and their development in packaging have been summarized.

Mechanization of Khoa and Khoa based sweets : The traditional process of khoa making have several limitation such as batch to batch variation, poor hygienic conditions, labour intensive process and poor shelf life of the product. To overcome this deficiencies, the present mechanization system, involves following batch and continuous principles-

Batch method :

(i) The body of the kettle is stationary with mechanically operated agitator and scraping blade assembly.

(ii) Instead of rotating the agitator assembly the body of the kettle is rotated.

Continuous method : Several types of continuous method using horizontal and inclined thin film scrapped surface heat exchangers have been used by several

researchers in the country (Patel *et al*., 2007; Dodeja *et al*.,, 1992). It has overcome the draw backs of batch methods in which final thickened and pasty khoa was removed manually with some burning particles and non uniform texture of the products.

Depending upon the volume of production, the equipments used at cottage level will be enlarged to industrial level and it is necessary to promote R & D of value-added quality khoa products. The technical awareness for the research completed should be available to industries.. Several research works have been completed on development of batch type khoa making machine having either SS kettle with built in stirrer or conical process vat type with agitator by Agrawala *et al.* (1987) and More (1987). Recently, the works have been done to manufacture indigenous milk products like basundi, khoa, rabri, burfi and peda etc in continuous process in scraped surface heat exchangers (SSHEs).

An inclined scraped surface heat exchanger for continuous khoa making was developed by Punjarath et al., (1990). A scraper assembly was so built as to combine the functions of scraping and conveying. The inclined SSHE had three jackets which may be opera at 1.0, 1.5 and 1.0 kg/cm^2 respectively. It has SSHE in inclined configuration (0-30°). Milk was previously pre-concentrated under vacuum to 40 - 55% T.S. and fed at the rate of 60-80 lit/hr with feed temperatures between 10 – 80°C. Rotor speed used was 40 to 80 rpm. By increasing rotor speed, there was significant increase in the heat transfer rate.Variation in steam pressure in separate sections of steam jacket resulted in change of heat transfer rate, colour and texture of khoa due to change in the temperature to which the milk constituents were subjected to different stages of khoa making. The rotor is driven by a variable speed drive and the design of rotor is key factor in this innovation. The process has been successfully employed at the Sugam Dairy Vadodara for commercial production of khoa.

Christie and Shah (1992) designed and developed a continuous khoa making machine with three stage concentration. It utilized three horizontal jacketed TFSSHEs in a cascade arrangement with a mechanism of providing inclination and slope in the direction of longitudinal movement of the contents in heat exchanger. The unit was provided with variable pulley drive to adjust the speed of the scraper assembly in SSHEs.The machine had three jacketed cylinders placed in a cascade arrangement. This facilitates easy transfer of milk from one cylinder into the other. The scrapper speeds were 40, 55 and 69 rpm for the first, 2nd & 3rd stage respectively. The operating steam pressures used were 2.0, 1.7 & 1.5 kg/cm^2 in respective stages. One roller was used in the last stage in place of scraper blade which kneaded the khoa to improve its body and texture. The first stage raised the milk solids level from initial 15 to 25 percent, the second stage to 50 percent and the third stage to 65-70 percent. The machine converted 50 kg of milk into khoa per hour at the operating pressures. However, the capacity depends on the milk flow rate, steam pressure, total solid concentration of feed and final moisture required in the product. It is claimed that use of concentrated milk improves the capacity of the machine.

Dodeja *et al.* (1992) developed a continuous khoa making system which consisted of two SSHE equipped with scraper assembly. Two TFSSHE are arranged in a cascade fashion the rotor of first SSHE is provided with four variables clearance blades operated at 200rpm, however the rotor of second TFSSHE has two variable clearance blades and two helical blade, which operates at speed of 150rpm. The concentrated milk from the first SSHE inters into the second SSHE by gravity and the rotor of the second SSHE scrapped as well as conveys the concentrated mass of khoa to the outlet of second SSHE. It can produced about 50kg khoa/hr from raw/pasteurized milk. It is adaptable to automation and clean- in –place (CIP) with hygienic condition and low low physical strain on the operator.

Dodeja (2008) designed and developed three stage TFSSHE integrated system to manufacture khoa from low fat milk of 2%, 3%, 4 % and 6% fat in good consistent quality. The capacity of the system was evaluated to be 50 kg khoa per hour using 6% fat buffalo milk and it can be enhanced to 120 kg khoa per hour, if feed of preconcentrated buffalo milk to 30% concentration is fed to plant. This equipment consisted of three identical thin film SSHEs with similar rotor in first two SSHEs and a unique rotor design in third stage SSHE. All rotors were having independent mechanism of varying rotor speed to control the texture of final product. A precise feed control mechanism and various steam pressure controllers in each stem inlet lines were incorporated to control consistency in production. This system offers fully automation, hygienic, sanitation, uniform quality and colour of product with any fat level of buffalo as well as cow milk.

Bhadania (1998) had developed three stage continuous khoa making machine based on principle of scraped surface heat exchanger and had studied heat transfer performance of the machine.

Attempts were made to prepare khoa on Contherm-Convap system which was developed by Alfa-Laval. This unit consists of two parts, a Contherm for heating the feed to about 95 ºC and Convap for concentrating milk to desired milk solids level.

Concentrated milk with 35-40% T.S. at the rate of 300-350 kg per hour can be fed to the machine. The steam pressures employed were 3 kg /cm^2 in Contherm and 4 kg/cm^2 in Convap. Contherm types and Vertical Convap type SSHEs were made of alpha Laval and Kelsream SSHEs. The Contherm with maximum six arm rotating assembly are used for highly viscous products. The Convap evaporators were normally operated under vacuum with a vapour separator to separate water vapour from top and concentrated product from bottom. It can concentrate to extremely high total solids prior to final drying. Similar work for forewarming of milk under pressure in a horizontal votator with holding tubes and back pressure needle valve, followed by evaporation of milk under vacuum was studied by Badshah and Kohli (1999) in horizontal Thin film SSHE along with vapour separator having fristam pump with seal water for discharge of concentrate, direct contact condenser and vane type mechanical vacuum pump for maintaining desired vacuum and removing vapours. Before evaporation, milk was forewarmed under pressure in a horizontal liquid full scraped surface heat exchanger with pressure seal, a holding tube fitted with a needle valve at the entry of thin film SSHE to maintain a back pressure in the horizontal votator for forewarming at 121°C in votator and evaporating under vacuum in TFSSHE. Such facility is an intense need for concentrating heat sensitive products like milk concentrates and fruit purees etc.

A mechanized scraped surface heat exchanger with a conical vat process was developed for the production of khoa. Forty kg concentrated or 80 kg whole milk can be taken per batch which takes about 14 min and 50 min respectively. Steam pressure used was 1.5 kg/cm^2. Product losses were high in this machine. In this model, the steam jacket was subdivided into three parts to reduce the amount of heating as the product moves. The scraper speed was 40 rpm and the steam pressure maintained was 3 kg/cm^2 in the first compartment which was step wise reduced to 1.5 kg/cm^2 in the last compartment. The machine can convert 50 kg of milk into khoa per hour per batch. RO process for pre-concentration of milk 2.5- fold for cow milk and 1.5- fold for buffalo milk) followed by desiccation in steam jacketed open pan was utilized for manufacture of khoa by Pal and Cheryan (1987) for cow milk and Kumar and Pal (1994) for buffalo milk. It was recommended to replace jacketed kettle from SSHE system to make the process continuous, which needs to be standardized.

Kumar *et. al*., 2014 have made systematic efforts to standardize the In-line production system by integrating scraped surface heat exchanger (SSHE) and conical process vat (CPV) with agitator through suitable piping, pumps and intermediate balance tank. The system was designed to manufacture multiple Indian dairy products like khoa, burfi, basundi, rabri and ghee. Operational parameters of the equipments were optimized by Response surface methodology (RSM). The mechanical parameters considered were SSHE rpm (50-200), SSHE steam pressure (2-5 kgf/sq.cm.) and CPV steam pressure (1-3.5 kgf/sq.cm.).

A mechanized system for continuous cooling has been developed that could be integrated through In-line production system to replace the slow cooling in open trays. This system was fabricated using food grade stainless steel with the angle adjustments viz. 0.5 to 10° inclination and variable rpm viz. 3, 6, 9 of screw shaft rotating in fully enclosed jacketed tubular screw conveyor (Gurjar and Sawhney, 2009).

Khoa based sweets : The three-stage thin film SSHEs system developed by dodeja et. al. (2008) is claimed to be used for khoa, burfi, basundi and rabri (Minz and Dodeja, 2014). Kumar and Dodeja (2004) developed a continuous method of making burfi using non-integrated three stages TFSSHEs. It consisted of two stage TFSSHE khoa making system and a burfi making unit with sugar dosing mechanism. Rahjoria (1995) stated that roller drier can be used for preparing khoa by adjusting process variables such as steam pressure, roller speed, concentration and ?ow rate of milk and by changing the distance between the rollers and scrapper blades. Vacuum concentrated milk with 50 % total solids preheated to 74°C for 10 min was found suitable for khoa -making on roller driers at 25–30 psi. A kneader is placed at the outlet of roller drier to make homogenous mass of khoa.

Rabri : Efforts have been made to develop a commercial method for manufacture of Rabri employing SSHE for concentration of buffalo milk (Gayen and Pal, 1991). Pal, *et al.,* (2005) successfully developed a technology for the large scale production of Rabri using thin film scraped surface heat exchanger (TSSHE). Dodeja and Saroj (2008) has developed large scale method of rabri manufacture using concentration in TFSSHE upto 56% TS from buffalo milk of 6% fat and 9% SNF. The flaky texture, which is an integral and desirable attribute of rabri is produced by adding malai.

Burfi : The burfi is manufactured mainly in non organized sector on cottage scale in small batches. Palit and Pal (2005) developed a mechanized method of manufacture of burfi. They have adopted a combination of double stage SSHE and Stephen processing kettle using sugar @30% in the kettle for proper blending and kneading of khoa with sugar. After addition of preservatives like potassium sorbate and cardamom @0.1% of khoa (w/w), the burfi was hot- filled at about 60° into already clean and sterilized polystyrene containers and wash covered.

Peda/Kalakand/Milk cake, Gulabjamun and Kunda : Sugam Dairy Baroda has adopted a method developed by NDDB for converting khoa into peda which has used a planetary mixer for admixing sugar @30% of the khoa having about 72% TS.

Kalakand has more granular mass, cooked flavor, brown colour and pleasant caramel flavor. On first boiling of standardized buffalo milk (min.5% fat and 9% SNF), 0.01% citric acid is added to the milk to form the characterized granular mass, if acidity upto 0.18% is not developed. In preparation of kalakand the starting material is taken by danedar khoa in a kettle and heated to 70° and sugar is added @ 30% of khoa and mixed with the desired additives using mixer. It is prepared on small scale adopting batch method by the milk confectioners. Desiccation of milk is done in a karahi to 50%TS and it is continued to bring dough like consistency and 6% sugar is added at 80-85°C. It is then transfer to lubricated aluminum trays with ghee. Generally, kunda is prepared by dhap khoa having 40% moisture content which was prepared using buffalo milk. This high mixture khoa is mixed with crystalline sugar @20-25% and desiccated over low flame in a shallow pan for 90-120min. to developed pleasant caramel flavor (Singh, 2014).

A mechanized semi continuous system was adopted for the manufacture of gulabjamun which involved mixing of khoa (60-70%TS) with 19-22% maida and 0.5% baking powder in a planetary method (Banergee, 1997).

Status of adoption of development in mechanization in India : With the innovation of Scraped Surface Heat Exchanger (SSHE), the traditional sweetmeat products can be easily manufactured by the Indian dairy industry. About 15 plants in India have initiated industrial production of khoa with daily output of 1-4 tonnes using continuous khoa making machine. Upadhyay *et al*., (1993) studied the production of khoa based sweets using batch type stainless steel version of scraped surface heat exchangers (SSHEs). Banerjee, 1997 developed a semi-continuous system for the manufacture of gulabjamun from khoa at Sugam Dairy, Baroda.SMC College of Dairy Science, Anand Agricultural University, Anand has designed and developed several equipments for mechanized production of value added Traditional Indian Dairy Products (TIDP), like Basundi, Kulfi mix, Kheer, Khoa, Peda, Thabdi, Burfi, Gajar Halwa, Dudhi Halwa, Halwasan etc. with better hygienic, rheological qualities and improved shelf-life at lower cost of processing.

Packaging of Khoa and khoa based Sweets : The production, packaging and labeling should be innovative and should be monitored to compete with global competition and standard for similar products to enhance international marketing. With the innovation of mechanized systems using SSHEs, the hopes have emerged to export the good quality indigenous dairy products. Wide variations exist in chemical quality of cow and buffalo milk khoa. Apart from this limited shelf life from less than 24 hours to about one week during storage is one of the factors. Boiling in sugar syrups or storage at low temperature enhances the shelf life. The khoa has a shelf life of about 5 days at room temperature and about 10 weeks at the refrigeration temperature (5 -10°C). Hence, it is also one of the challenges to take all cares during manufactures and storage to enhance the keeping quality of indigenous milk products. The shelf life of khoa can be increased up to 13 days at 30°C with the use of four- ply laminated pouches and tin containers, and 75 days under refrigerated storage. Vacuum packaging of khoa could enhance the shelf life up to 120 days under refrigerated storage (Rajorhia *et al.,* 1984).

To improve the shelf life of khoa, the proper packaging systems must be followed by the producers of khoa before marketing, which is not been observed in most of the market. Hot filling of khoa in rigid polypropylene containers with lids at 85°C is useful in extending the shelf life of khoa. The shelf life can be improved up to 14 days at room temperature and 75 days under refrigerated temperatures. Further with the ambition of protecting khoa against the bacterial growth in khoa, packaging of khoa in aluminium cans and steaming them for 15 to 20 min will prevent the spoilage for few weeks. By U.V. rays irradiation method, the khoa can be preserved up to 25 days. However, the oxidation changes are caused by U.V. radiation, which affects the flavor of khoa. Another method is deep freezing of khoa and storing at -10 to -20°C, which will extend the shelf life for considerably long periods. However, at this temperature of storage, the lactose which is in super saturated state in khoa gets crystallized and will gives rise to sandiness defect. Some attempts have been made to improve the shelf life of khoa by adding mould inhibitors, nisin and antioxidants. Antifungal agents like sorbic acid, propionic acid and their salts can be used to preserve khoa. Addition of 0.2 % sorbic acid by weight of khoa during the last stage of its manufacture will enhance the shelf life up to 20 days at 30°C and 125 days in cold storage. The mould inhibitors can be sprayed on to the surface of the product or alternatively the packaging material can be treated with the chemical agent. Addition of Nisin (Nisaplin) will improve the shelf life of *khoa* by 10-11 days at 30°C.

Conclusions

India's traditional dairy sector is poised for rapid expansion with the applications of modern technologies in

the production of Indigenous/Traditional dairy products. Fast change in socio-economic environments will drive the pace in research and developments of mechanization in production, adoption and automation of packaging technology. The roles of FSSAI and Agricultural Universities in the fields of Dairy and Food Technology has become important in surveying of locally manufactured products and assigning the standards for uniformity and superior quality in regard of shelf life and sensory and rheological profiles. The development in mechanization in Indigenous dairy products have certainly taken place but their adoption is a phase phenomenon in due course of time.

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Residual Effect of Organic Manures and Phosphorus on Available Soil N, P and K in Rabi Blackgram

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Abstract

A field experiment was conducted to study the residual effect of organic manures and phosphorus on available soil N, P and K in succeeding blackgram under rice-blackgram cropping sequence during *rabi* seasons of 2018 and 2019 at Agricultural College Farm, Bapatla. Results of two years (2018-2019) experimentation revealed that at both flowering and harvest stages of blackgram, significantly highest available nitrogen, phosphorus and potassium in soil were recorded with application of RDNK+*Dhaincha* @ 10t ha^{-1}(M_3) and this was on par with RDNK+ Sunhemp @ 10t ha^{-1}(M_2), whereas lowest was recorded in RDNK (M_0) alone in both the seasons of study. Among the P levels the available nutrient status (N, P and K) were increased with the increasing level of P from 0 (P_1) to 120 kg P_2O_5 (P_5) ha^{-1}. Significantly highest was recorded in P_5 (120 kg P_2O_5 ha^{-1}) and this was on par with P_4 (90 kg P_2O_5 ha^{-1}), whereas the lowest was recorded in treatment P_1 that received 0 kg P_2O_5 ha^{-1}.

Key words : *Organic manures, phosphorus fertilizer, soil fertility status, rabi blackgram.*

Introduction

Rice based cropping systems are the major production systems contributing to food production. Current crop production systems are characterized by inadequate and imbalanced uses of fertilizers *e.g.,* blanket fertilizer recommendations over large domains with least regard to the variability in soil fertility and productivity. Future gains in productivity and input use efficiency require soil and crop management technologies that are tailored to specific characteristics of individual farms or fields.

To meet the food requirement of the growing population, the rice and pulse production has to be enhanced with good management practices with shrinking availability of land and water resources condition. Rice-pulse is the predominant cropping system of major rice growing areas of Andhra Pradesh. The cropping sequence of rice-pulse is practically feasible, viable, economical, eco-friendly, water saving technology for sustaining soil fertility and rice productivity. Increased use of inorganic fertilizers in crop production deteriorates soil health, causes health hazard and insecurity of quality food. Energy crisis, higher fertilizer cost, sustainability in agri-production system and ecological stability are the important issues which renewed the interest of farmers and research workers in non-chemical sources of plant nutrients like biofertilizers, farmyard manure, green manure, composts etc. Awareness about crop quality and soil health increased the attention of people towards organic farming (Sharma *et al*., 2020). Balanced use of nutrients through organic sources like farmyard manure, vermicompost, green manuring, neem cake and biofertilizers are prerequisites to sustain soil fertility, to produce maximum crop yield with optimum input level (Dahiphale *et al*., 2013). The organic manures leave behind sufficient residual effect for the sequence crops (Singh *et al*., 2010). In view of the above facts, field experiment on "Influence of organic manures and phosphorus on blackgram in rice-blackgram cropping sequence" was conducted with the following objective. 1) To study the influence of organic manures and phosphorus on available macro nutrient status on succeeding blackgram.

Materials and Methods

The present experiment in rice based cropping system *viz.,* rice - blackgram was started at Agricultural College Farm, Bapatla (15^0 54' N latitude, 80^0 25' E longitude, 5.49 meters above the mean sea level) during June, 2017-19. During normal years, the annual rainfall is 1200 mm of which around 70 % is received during September to October (South East monsoon). The climate of the experimental site is sub tropical monsoon type. During *rabi* blackgram sowing in December and harvest in March were grown under irrigated conditions. The soil of the experimental site is clay loam texture. Here, we are discussing the results of two consecutive years. The initial

analytical data of the available N (156.60 kg ha^{-1}), phosphorus (35.20 kg ha^{-1}) and potassium (385.23 kg ha^{-1}). The Experiment was laid out in a split plot design with 20 treatments and three replications. Nitrogen was applied in three equal splits for *kharif* rice (transplanting, tillering and panicle initiation) and for *rabi* blackgram (residual effect of preceeding rice crop), while phosphorus was applied entirely as basal and potassium in two equal splits (as basal and at panicle initiation stage). The fertilizers used were urea, single super phosphate, muriate of potash. For treatments of organic manures (M_2 and M_3), sunhemp (2.43 % N, 0.48 % P and 1.96% K and 2.51 % N, 0.53 % P and 2.03% K), *dhaincha* (3.20 % N, 0.57 % P and 1.70 % K and 3.40 % N, 0.65 % P and 1.91 % K) was incorporated @ 10 t ha^{-1} and FYM (0.70 % N, 0.27 % P and 0.56% K and 0.76 % N, 0.29 % P and 0.59% K) @ 5 t ha^{-1} (M_1) in both 2017-18, 2018-19 on dry weight basis, respectively.) was incorporated as main plots and five phosphorus levels of 0 kg P_2O_5 ha^{-1} (P_1), 30 kg P_2O_5 ha^{-1} (P_2) and 60 kg P_2O_5 ha^{-1} (P_3), 90 kg P_2O_5 ha^{-1} (P_4) and 120 kg P_2O_5 ha^{-1} (P_5) as sub- plot treatments for *kharif* rice. The *rabi* experiment was continued on the same site without disturbing the soil for succeeding blackgram crop to study residual effect of organic manures and P levels applied to preceeding rice crop. Need based plant protection measures were taken up against pest and diseases. The chemical properties of soil *viz.,* available nitrogen, phosphorus and potassium was analysed by different chemical methods as described below.

Available nitrogen : Available nitrogen was estimated by alkaline permanganate method by using macro Kjeldahl distillation unit (Subbiah and Asija, 1956).

Available phosphorus : Available phosphorus in the soil samples was extracted with 0.5 M $NaHCO_3$ buffered at pH 8.5 and the phosphorus in the extract was estimated by ascorbic acid method using spectrophotometer at 660 nm (Watanabe and Olsen, 1965).

Available potassium : It was extracted with neutral normal ammonium acetate and estimated with the help of flame photometer (Jackson, 1973).

Results and Discussion

Available NPK status of soil was significantly influenced by different organic manures along with inorganic fertilizers and also by inorganic phosphorus fertilizer levels during both the years of the study. However, the interaction effect was not significant.

Nitrogen : Data pertaining to available nitrogen as influenced by different organic manures and P levels were presented in tables-1 and 2. It was evident from the data presented in the above tables that available nitrogen was significantly influenced due to different treatments. At flowering and harvest, among the different sources of organic manures, the significantly highest soil available nitrogen was observed with the RDNK+ *Dhaincha* 10 t ha^{-1} (M_3-212.85, 205.05, 221.68 and 213.21 kg ha^{-1}) which was on par with the application of RDNK+sunhemp 10 t ha^{-1} (M_2-209.53, 198.97, 218.03 and 206.80 kg ha^{-1}) and found significantly superior over application of RDNK (M_0-190.05, 181.24, 194.48, and 185.00 kg ha^{-1}) during 2018 and 2019 at flowering and harvest, respectively). However the treatment M_2 was on par with M_1, while M_1 was remain on par with M_0 in both the years of study, respectively. The per cent increase was ranged from 11.9 to 13.1 % during 2018 and 13.9 to 15.2 % during 2019 was achieved in M_3 over M_0 treatment. This might be due to fixation of atmospheric nitrogen by legumes in their nodules by *rhizobium* through symbiotic N-fixation process. Ali *et al*., (2022) reported that legumes were potentially important to diversify cereal based mono cropping into cereal-legume sequences which had nutrient cycling advantages. Bhargavi *et al.* (2017) also concluded soil available nitrogen was more with greenmanure/greengram haulms incorporated in rice-rice system than other systems.

Among the P levels, the treatment P_5 (210.09, 200.60 in 2018 and 217.27, 207.11 kg ha^{-1} in 2019) recorded significantly highest available nitrogen and it was on par with P_4 (208.08, 198.60 in 2018 and 215.19, 205.05 kg ha^{-1} in 2019), P_3 (205.01, 195.30 in 2018 and 212.04, 201.67 kg ha^{-1} in 2019) and P_2 (200.99, 191.08 in 2018 and 207.96, 197.38 kg ha^{-1} in 2019), while significantly superior over P_1 (193.56, 184.68 in 2018 and 200.44, 190.89 kg ha^{-1} in 2019) at flowering and harvest, respectively. However, the significantly lowest available nitrogen was recorded in P_1. Interaction between organic manures and P levels was not significant. Even though, it was not significant, the highest nitrogen content in M_3P_5 and lowest was registered in M_0P_0 during both the years of study. Phosphorus application might have encouraged the buildup of available nitrogen due to enhanced activity of microbes and increased the formation of root nodules and thereby fixing atmospheric nitrogen in root nodules (Singaram and Kothandaraman, 2015).

Phosphorus : Data pertaining to available phosphorus was presented in tables-3 and 4 and revealed among the different sources of organic manures to preceeding rice crop, the highest soil available P was registered with the RDNK+ *Dhaincha* 10 t ha^{-1} (M_3-55.54, 52.39, 64.47 and 60.75 kg P_2O_5 ha^{-1}) which was on par with the application of RDNK+sunhemp 10 t ha^{-1} (M_2-53.97, 51.04, 62.56 and 59.07 kg P_2O_5 ha^{-1}), found significantly superior over application of RDNK+FYM (M_1-47.90, 44.78, 54.40 and 50.71 kg P_2O_5 ha^{-1}) and RDNK (M_0-40.06, 33.12, 44.59

Table-1 : Residual effect of organic manures and inorganic P fertilizer on available nitrogen content (kg ha^{-1}) of succeeding blackgram at flowering stage in rice based cropping sequence.

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1–0	180.84	191.42	199.94	202.05	193.56	185.06	197.68	208.28	210.74	200.44
P_2–30	187.39	199.31	207.21	210.05	200.99	191.75	205.63	215.62	218.84	207.96
P_3–60	191.65	203.36	210.46	214.55	205.01	196.07	209.73	218.95	223.41	212.04
P_4–90	194.16	206.35	214.01	217.78	208.08	198.69	212.81	222.59	226.66	215.19
P_5–120	196.19	208.30	216.04	219.82	210.09	200.80	214.86	224.69	228.73	217.27
Mean	190.05	201.75	209.53	212.85		194.48	208.14	218.03	221.68	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	4.63		16.03		8.8	4.52		15.65		8.3
P	4.92		14.18		8.4	4.97		14.30		8.2
M at P	9.84		NS			9.93		NS		
P at M	9.95		NS			9.97		NS		

M_0-No Organic manure, M_1-RDNK+FYM 5 t ha^{-1}, M_2-RDNK+Sunhemp 10 t ha^{-1}, M_3-RDNK+Dhaincha 10 t ha^{-1}.

Table-2 : Residual effect of organic manures and inorganic P fertilizer on available nitrogen content (kg ha^{-1}) of succeeding blackgram at harvest in rice based cropping sequence.

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1–0	172.16	181.86	189.39	195.29	184.68	175.71	187.45	197.07	203.31	190.89
P_2–30	178.16	187.86	196.22	202.09	191.08	181.86	193.51	203.96	210.21	197.38
P_3–60	182.25	192.47	200.39	206.08	195.30	186.00	198.18	208.21	214.27	201.67
P_4–90	185.83	195.21	203.43	209.93	198.60	189.69	201.01	211.34	218.14	205.05
P_5–120	187.79	197.30	205.42	211.87	200.60	191.73	203.20	213.40	220.12	207.11
Mean	181.24	190.94	198.97	205.05		185.00	196.67	206.80	213.21	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	4.00		13.83		8.0	3.87		13.41		7.5
P	4.50		12.97		8.0	4.54		13.09		7.9
M at P	9.00		NS			9.09		NS		
P at M	8.99		NS			9.00		NS		

M_0-No Organic manure, M_1-RDNK+FYM 5 t ha^{-1}, M_2-RDNK+Sunhemp 10 t ha^{-1}, M_3-RDNK+Dhaincha 10 t ha^{-1}

Table-3 : Residual effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P_2O_5 ha^{-1}) of succeeding blackgram at flowering stage in rice based cropping sequence.

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1–0	36.33	44.63	49.71	51.77	45.61	40.65	50.98	58.15	60.56	52.58
P_2–30	37.50	46.23	52.59	53.62	47.48	41.96	52.64	61.10	62.51	54.55
P_3–60	39.78	48.75	54.41	56.48	49.85	44.29	55.22	62.99	65.43	56.98
P_4–90	42.99	48.95	56.11	57.68	51.43	47.62	55.51	64.79	66.65	58.64
P_5–120	43.72	50.97	57.03	58.18	52.47	48.43	57.63	65.78	67.19	59.76
Mean	40.06	47.90	53.97	55.54		44.59	54.40	62.56	64.47	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	0.71		2.45		8.6	0.69		2.40		7.7
P	0.90		2.59		9.3	0.93		2.67		8.1
M at P	1.80		NS			1.85		NS		
P at M	1.76		NS			1.80		NS		

M_0-No Organic manure, M_1-RDNK+FYM 5 t ha^{-1}, M_2-RDNK+Sunhemp 10 t ha^{-1}, M_3-RDNK+Dhaincha 10 t ha^{-1}

Table-4 : Residual effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P_2O_5 ha^{-1}) of succeeding blackgram at harvest in rice based cropping sequence.

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1–0	29.38	40.31	47.17	48.12	41.25	33.13	46.10	55.05	56.35	47.66
P_2–30	30.72	41.54	49.47	50.27	43.00	34.62	47.39	57.42	58.60	49.51
P_3–60	32.21	45.79	50.82	53.32	45.54	36.16	51.70	58.84	61.71	52.10
P_4–90	35.69	47.00	53.07	54.47	47.56	39.76	53.00	61.19	62.88	54.21
P_5–120	37.59	49.24	54.67	55.77	49.32	41.73	55.34	62.86	64.22	56.04
Mean	33.12	44.78	51.04	52.39		37.08	50.71	59.07	60.75	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	0.82		2.84		7.0	0.79		2.73		5.9
P	0.94		2.71		7.2	0.96		2.75		6.4
M at P	1.88		NS			1.91		NS		
P at M	1.87		NS			1.88		NS		

M_0-No Organic manure, M_1-RDNK+FYM 5 t ha^{-1}, M_2-RDNK+Sunhemp 10 t ha^{-1}, M_3-RDNK+Dhaincha 10 t ha^{-1}

Table-5 : Residual effect of organic manures and inorganic P fertilizer on available potassium status (kg K_2O ha^{-1}) of succeeding blackgram at flowering stage in rice based cropping sequence.

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1–0	409.66	425.54	465.46	467.31	441.99	414.55	434.46	476.47	478.67	451.04
P_2–30	429.91	446.39	486.81	489.56	463.17	434.94	455.37	497.89	501.02	472.30
P_3–60	440.84	457.40	498.94	503.49	475.17	445.92	466.44	510.09	515.01	484.37
P_4–90	450.66	467.46	509.86	511.31	484.82	455.86	476.59	521.11	522.85	494.10
P_5–120	457.34	474.36	517.64	520.99	492.58	462.62	483.59	528.96	532.57	501.93
Mean	437.68	454.23	495.94	498.53		442.78	463.29	506.90	510.02	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	6.61		21.33		8.1	5.73		19.84		6.6
P	8.11		23.37		7.0	8.18		23.57		7.9
M at P	16.22		NS			16.36		NS		
P at M	15.77		NS			15.72		NS		

M_0-No Organic manure, M_1-RDNK+FYM 5 t ha^{-1}, M_2-RDNK+Sunhemp 10 t ha^{-1}, M_3-RDNK+Dhaincha 10 t ha^{-1}

Table-6 : Residual effect of organic manures and inorganic P fertilizer on available potassium status (kg K_2O ha^{-1}) of succeeding blackgram at harvest in rice based cropping sequence.

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1–0	402.72	414.45	451.78	454.80	430.94	406.94	422.71	462.12	465.49	439.32
P_2–30	423.07	435.03	473.03	476.15	451.82	427.43	443.35	483.44	486.94	460.29
P_3–60	434.10	446.26	484.96	488.18	463.38	438.52	454.64	495.45	499.03	471.91
P_4–90	445.02	456.33	495.78	499.10	474.06	449.55	464.80	506.36	509.98	482.67
P_5–120	451.80	463.21	503.46	506.88	481.34	456.41	471.77	514.11	517.79	490.02
Mean	431.34	443.06	481.80	485.02		435.77	451.45	492.30	495.85	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	8.02		27.77		6.8	7.59		26.28		6.3
P	9.34		26.90		7.0	9.37		27.00		6.9
M at P	18.67		NS			18.75		NS		
P at M	18.53		NS			18.41		NS		

M_0-No Organic manure, M_1-RDNK+FYM 5 t ha^{-1}, M_2-RDNK+Sunhemp 10 t ha^{-1}, M_3-RDNK+Dhaincha 10 t ha^{-1}

and 37.08 kg P_2O_5 ha^{-1}) alone at flowering and harvest during 2018 and 2019, respectively. The significantly lowest available phosphorus was recorded in M_0. However, the soil available phosphorus was decreased with advancement of crop stage during both the years and in all the treatments. This decrease in phosphorus might be attributed to absorption of P by the growing plants and/or due to refixation of solubilized phosphorus (Veeranagappa *et al*., 2022; Chikkaraju, 2022).

Bhargavi *et al*. (2017) reported that the highest available phosphorus was recorded with sunhemp-rice-rice and buildup of available phosphorus in soil was due to release of organic acids during microbial decomposition of greenmanure which helped in the solubility of native phosphorus in soil. As the phosphorus requirement of rice was meagre, organic and inorganic additions increased the soil phosphorus content. Dudhat *et al.* (2020) reported that the application of FYM alone or in combination with chemical fertilizer significantly increased the residual status of available phosphorus in soil. During decomposition of organic manures, various organic acids would be produced which solubilized phosphatase and other phosphate bearing minerals and thereby lowered the phosphate fixation and increased its availability (Meghadubey *et al*., 2015). Manna *et al*. (2021) reported that available phosphorus content was increased due to addition of farmyard manure over control. Mahala *et al.* (2018) also noticed the positive residual significant effect of farmyard manure on succeeding mustard crop in terms of the available phosphorus in soil.

Among the P levels, application of 120 kg P_2O_5 ha^{-1} (P_5 -52.47, 49.32, 59.76 and 56.04 kg P_2O_5 ha^{-1}) recorded significantly higher available phosphorus and this was on par with 90 kg P_2O_5 ha^{-1} (P_4-51.43, 47.56, 58.64 and 54.21 kg P_2O_5 ha^{-1}), while P_4 was on par with 60 kg P_2O_5 ha^{-1} (P_3-49.85, 45.54, 56.98 and 52.10 kg P_2O_5 ha^{-1}) at flowering and harvest in 2018 and 2019, respectively. However, these three treatments were significantly superior over 0 kg P_2O_5 ha^{-1} (P_1- 45.61, 41.25, 52.58 and 47.66 kg P_2O_5 ha^{-1}) during both the years of study. Significantly lowest nitrogen was recorded in P_1 during both the years of study. Whereas, the per cent increase in P_2O_5 content at flowering and harvest in both the years over control was 15.04, 19.56, 13.65 and 17.58%, respectively. However, interaction between organic manures and P levels were not significant. Even though, the highest available phosphorus was obtained in M_3P_5, followed by M_3P_4 and superior over M_3P_3, M_3P_2 and lowest was obtained in M_3P_1. Application of phosphorus in any form at any level could build up a higher level of residual phosphorus and higher doses of phosphorus application could account for higher residual values (Singaram and Kothandaraman, 2015).

Potassium : Data pertaining to soil available potassium (K_2O) at flowering and harvest of blackgram was presented in the tables-5 and 6 and revealed that available K in the soil did differ significantly due to organic manure treatments and levels of phosphorus to preceeding rice crop, but not by their interaction during both the years of study. Among the different sources of organic manures, significantly higher soil available K was recorded with the RDNK+ *Dhaincha* @ 10 t ha^{-1} (M_3-498.53, 485.02, 510.02 and 495.85 kg k_2O ha^{-1}), which was at par with the application of RDNK+Sunhemp 10 t ha^{-1} (M_2-495.94, 481.80, 506.90 and 492.30 kg k_2O ha^{-1}) and found significantly superior to application of RDNK+FYM (M_1-454.23, 443.06, 463.29 and 451.45 kg k_2O ha^{-1}) and RDNK (M_0-437.68, 431.34, 442.78 and 435.77 kg k_2O ha^{-1}) alone at flowering and harvest in 2018 and 2019, respectively. Whereas the treatment M_1 was on par with M_0. However, the significantly lowest available potassium was recorded in M_0 which received RDNK alone.

Among the P levels, the treatment P_5 (492.58, 481.34, 501.93 and 490.02 kg k_2O ha^{-1}) significantly recorded highest available potassium and lowest was recorded in P_1 (441.99, 430.94, 451.04 and 439.32 kg k_2O ha^{-1}) at flowering and harvest in 2018 and 2019, respectively. However the treatment P_5 was on par with P_4 (484.82, 474.06, 494.10 and 482.67 kg k_2O ha^{-1}) and P_3 (475.17, 463.38, 484.37 and 471.91kg k_2O ha^{-1}), while P_3 was on par with P_2, P_2 with P_1 during both the years of study. However, the interaction effect between organic manures and P levels were not significant. Dudhat *et al.* (2020) reported that application of FYM alone or in combination with chemical fertilizer significantly increased the residual status of available K in soil. When manure was applied to the soil, it had a longer lasting effect as indicated by positive response of the cowpea to previous season applied FYM (Rutunga and Neel, 2016).

Conclusions

Significantly highest available nitrogen, phosphorus and potassium in soil were recorded with application of RDNK+*Dhaincha* @ 10t ha^{-1}(M_3) and this was on par with RDNK+ Sunhemp @ 10t ha^{-1}(M_2), whereas lowest was recorded in RDNK (M_0) alone in both the seasons of study at both flowering and harvest stages of blackgram. Among the P levels the available nutrient status (N, P and K) were increased with the increasing level of P from 0 (P_1) to 120 kg P_2O_5 (P_5) ha^{-1}. Significantly highest was recorded in P_5 (120 kg P_2O_5 ha^{-1}) and this was on par with P_4 (90 kg P_2O_5 ha^{-1}), whereas the lowest was recorded in treatment P_1 that received 0 kg P_2O_5 ha^{-1}.

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Impact of Moisture Conserving Polymers and Crop Residues Mulching on Nutrient Contents and Quality Traits of Pearl millet (*Pennisetum glaucum* L.) under Rainfed Condition

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Abstract

A field experiment was conducted at Research Farm, Vivekananda Global University, Jaipur during *kharif* season of 2022. The experiment consisting of eight treatment combinations of pusa hydrogel and crop residue mulch *viz.,* control (T1), crop residue mulch @ 5.0 t/ha after 10-15 DAS (T2), Pusa Hydrogel soil application @ 2.5 kg/ha (T3), Pusa Hydrogel soil application @ 5.0 kg/ha (T4), Pusa Hydrogel soil application @ 7.5 kg/ha (T5), T3+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T6), T4+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T7), T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) were laid out in randomized block design with three replications. The results of one year study clearly showed that maximum nitrogen, phosphorus and potassium content and their uptake by grain and stover, protein content in grain and protein yield of pearl millet was obtained with T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) which was remained at par to T4+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T7) and T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T6) and significantly higher over all other remaining treatments for almost all the traits. The N, P and K content in grain and stover of pearl millet was remained unchanged due to application of pusa hydrogel and crop residue mulch combination. Therefore, application T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) was found most profitable as it gave highest nutrient uptake in grain as well stover of pearl millet.

Introduction

Pearl millet [*Pennisetum glaucum* (L)] is the most important cereal food crop after wheat, rice, and maize. Around the world, pearl millet is also known as bajara, cat tail millet and bulrush millet. It is said to have originated in West Africa. In terms of importance and production area, pearl millet ranks fourth in India behind rice, wheat, and maize as a viable cereal crop. In the state of Rajasthan, pearl millet cultivation is mainly confined to the arid and semi-arid regions. Rajasthan stand first in the country that produced 3.75 million tons of grains from 3.74 million ha area. The average productivity of state is 1004 kg/ha (Anonymous, 2022) which is much below than its production potential; vary greatly with rainfall intensity and its distribution. Hence, our research effort should be diverted to remove the constraints that are responsible for its poor yield.

A little amount of study has been conducted in India on the use of polymers in agriculture. Recently, several companies with various trade names have developed polymers in India with the intention of promoting them in dry-land agriculture to save water and nutrients. Depending on the kind of polymer, the application technique, the type of crop, etc., the dose of polymers ranges from 2.5 to 60 kg ha-1. Union Carbide, an American company, first introduced super absorbents to the market in the early 1960s (Dexter and Miyamoto, 1995). One of the most significant cultural practices for preserving moisture in a rainfed farming system is mulching. Mulch is said to lower soil warmth, reduce evaporation loss, protect soil from erosion, maintain soil moisture, and promote root development. Assuming that dry soil functions as a blanket, dust mulching reduces evaporation and also lowers the point of contact between soil particles because of loosening attraction between them. The temperature of the soil profile is moderated and water loss through evaporation is reduced when crop waste is applied as mulch to the soil surface (Ram *et al.*, 2012).

Crops may better withstand drought in rainfed conditions without moisture stress by using hydrogel. As irrigation water becomes more limited, water-efficient agriculture is becoming more and more popular. The threats to food security include rising food consumption and diminishing water supplies. With the aforementioned considerations in mind, the following research project, titled “Impact of moisture conserving polymers and crop residues mulching on growth and productivity of pearl millet (*Pennisetum glaucum* L.) under rain fed condition," will be conducted at the Research Farm, Vivekananda Global University, Jaipur, during the Kharif of 2022.

Materials and Methods

The experiment consisting of 8 treatments was carried out in factorial randomized block design. The treatments

along with their symbols are given in Table-1**.** The seeds were line sown in furrows opened with the help of a wooden marker at a row spacing of 45 cm × 15 cm, using 4 kg seeds ha-1 and furrow were covered immediately after sowing. The gap filling was done after one week of sowing to ensure uniform plant stand. The required quantity of pusa hydrogel mixed with 20kg/ha of FYM and applied in furrows at the time of sowing. Residue of farm waste was used as mulch as per treatment.

Statistical analyses : Data obtained on various variables were analyzed by analysis of variance method (Panse and Sukhatme, 1967). The total variance (S^2) and degree of freedom (n-1) were partitioned into different possible sources. The variance due to various treatments of mulching were compared with error of variance to find out 'F' values and ultimately for testing the significance at p = 0.05. The standard errors for the treatment based on error variance were calculated. Whenever, the results were found to be significant, critical differences were also calculated for comparison of treatment means at 5 per cent level of significance (CD at P = 0.05).

Results and Discussion

Nitrogen content and uptake (%) : The data pertaining to nitrogen content are presented in Table 2. The data reveals that nitrogen content in grain and Stover was not significant but numerically treatment T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) i.e. 2.14 % was found maximum nitrogen content while lowest nitrogen content was recorded in treatment control (T1) i.e. 1.78 %. A critical examination of data (Table 2) showed that different treatments had significant influence on nitrogen uptake by grain and Stover of pearl millet. Among different treatment combinations, maximum nitrogen uptake by grain and Stover was recorded with T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) i.e. 85.62 kg/ha in grain and 33.92 kg/ha in Stover which was closely followed by T4+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T7) i.e. 83.82 kg/ha in grain and 33.02 kg/ha in Stover, T3+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T6) i.e. 80.92 kg/ha in grain and 31.32 kg/ha in Stover and Pusa Hydrogel soil application @ 7.5 kg/ha (T5) i.e. 78.02 kg/ha in grain and 30.42 kg/ha in Stover and significantly higher over remaining treatments.

Phosphorus content (%) : The data pertaining to phosphorus content are presented in Table 2. The data reveals that phosphorus content was not significant in grain and Stover but numerically treatment T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) i.e. 0.43 % was found maximum phosphorus content while lowest phosphorus content was recorded in treatment control (T1) i.e. 0.29 %. A critical examination of data (Table 2) showed that different treatments had significant influence on phosphorus uptake by grain and Stover of pearl millet. Among different treatment combinations, maximum phosphorus uptake by grain and Stover was recorded with T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) i.e. 14.47 kg/ha in grain and 11.07 kg/ha in Stover which was closely followed by T4+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T7) i.e. 14.17 kg/ha in grain and 10.57 kg/ha in Stover, T3+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T6) i.e. 13.37 kg/ha in grain and 9.37 kg/ha in Stover and Pusa Hydrogel soil application @ 7.5 kg/ha (T5) i.e. 12.47 kg/ha in grain and 9.17 kg/ha in Stover and significantly higher over remaining treatments i.e. T1, T2, T3 and T4.

Potassium and uptake (kg ha^{-1}) : The data pertaining to potassium content are presented in Table-2. The data reveals that potassium content was not significant in grain and Stover but numerically treatment T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) i.e. 0.69 % in grain and 1.67% in Stover was found maximum potassium content while lowest Potassium content was recorded in treatment control (T1) i.e. 0.38 % in grain and 1.25 % in Stover. A critical examination of data (Table 2) showed that different treatments had significant influence on potassium uptake by grain and Stover of pearl millet. Among different treatment combinations, maximum potassium uptake by grain and Stover was recorded with T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) i.e. 12.93 kg/ha in grain and 29.73 kg/ha in Stover which was closely followed by T4+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T7) i.e. 11.33 kg/ha in grain and 28.33 kg/ha in Stover and T3+ Crop residue mulch @ 5.0 t/ha after 10-15 DAS (T6) i.e. 11.53 kg/ha in grain and 24.33 kg/ha in Stover and significantly higher over remaining treatments i.e. T1, T2, T3, T4 and T5.

Crude protein content (%) : The data pertaining to crude protein content in grain of pearl millet as influenced by different treatment combinations are presented in table 3. The data clearly indicated that protein content in grain of pearl millet was found statistically significant among all the treatments. Among different treatment combinations, maximum crude protein content in grain of pearl millet was recorded with T5+ Crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) i.e. 11.73 kg/ha which was closely followed T4+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T7) i.e. 11.43 kg/ha , T3+ crop residue mulch @ 5.0 t/ha after 10-15 DAS i.e. 11.03 kg/ha and Pusa Hydrogel soil application @ 7.5 kg/ha (T5) i.e. 11.23 kg/ha and significantly higher over control (T1), crop residue mulch @ 5.0 t/ha after 10-15 DAS (T2), Pusa Hydrogel soil application @ 2.5 kg/ha (T3) and Pusa Hydrogel soil application @ 5.0 kg/ha (T4). However, the lowest protein content in grain of pearl millet was recorded in control treatment.

Table-1 : Treatments details with their symbols.

S. No.	Treatments	Symbols
1.	Control	T_1
2.	Crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_2
3.	Pusa Hydrogel soil application @ 2.5 kg/ha	T_3
4.	Pusa Hydrogel soil application @ 5.0 kg/ha	T_4
5.	Pusa Hydrogel soil application @ 7.5 kg/ha	T_5
6.	T_3 + Crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_6
7.	T_4 + Crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_7
8.	T_5 + Crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_8

Table-2 : Effect of pusa hydrogel and crop residue mulch on nitrogen content (%), Phosphorus content (%) and Potassium content (%) and their uptake in grain and stover of pearl millet.

Treatment	Symbol	Nitrogen content (%)		N uptake (kg/ha)		Phosphorus content (%)		P uptake (kg/ha)		Potassium content (%)		K uptake (kg/ha)	
		Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Control	T_1	1.78	0.55	42.32	15.82	0.29	0.17	8.57	6.37	0.38	1.25	8.53	17.53
Crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_2	1.86	0.61	68.32	26.52	0.31	0.21	9.47	7.57	0.47	1.62	9.23	16.43
Pusa Hydrogel soil application @ 2.5 kg/ha	T_3	1.88	0.63	73.02	27.72	0.32	0.23	10.47	8.77	0.47	1.63	9.43	20.73
Pusa Hydrogel soil application @ 5.0 kg/ha	T_4	1.89	0.63	74.82	29.12	0.32	0.23	10.67	8.97	0.50	1.66	10.43	22.33
Pusa Hydrogel soil application @ 7.5 kg/ha	T_5	1.94	0.66	78.02	30.42	0.36	0.25	12.47	9.17	0.51	1.65	10.73	22.53
T_3+ Crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_6	1.99	0.68	80.92	31.32	0.40	0.25	13.37	9.37	0.62	1.67	11.53	24.33
T_4+ Crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_7	2.04	0.70	83.82	33.02	0.41	0.28	14.17	10.57	0.64	1.71	11.33	28.33
T_5+ Crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_8	2.14	0.84	85.62	33.92	0.43	0.28	14.47	11.07	0.69	1.67	12.93	29.73
SEm±		0.18	0.09	3.55	1.97	0.05	0.06	0.75	0.57	0.06	0.8	0.72	1.52
CD (P=0.05)		NS	NS	10.57	5.83	NS	NS	2.19	1.67	NS	NS	2.16	4.56

Table-3 : Effect of pusa hydrogel and crop residue mulch on crude protein content (%) and protein yield (kg/ha) of pearl millet.

Treatment	Symbol	Crude protein content (%)	protein yield (kg/ha)
Control	T_1	9.83	312.73
Crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_2	10.43	369.53
Pusa Hydrogel soil application @ 2.5 kg/ha	T_3	10.63	398.43
Pusa Hydrogel soil application @ 5.0 kg/ha	T_4	10.83	414.63
Pusa Hydrogel soil application @ 7.5 kg/ha	T_5	11.23	432.63
T_3 + crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_6	11.03	453.03
T_4 + crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_7	11.43	463.83
T_5 + crop residue mulch @ 5.0 t/ha after 10-15 DAS	T_8	11.73	485.73
SEm±		0.33	11.36
CD (P=0.05)		1.06	34.02

Protein yield (kg ha^{-1}) : The data pertaining to crude protein content in grain of pearl millet as influenced by different treatment combinations are presented in table 3. The data clearly indicated that protein content in grain of pearl millet was found statistically significant among all the treatments. Among different treatment combinations, maximum protein content in grain of pearl millet was recorded with T5+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) i.e. 485.73 kg/ha which was closely followed T4+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T7) i.e. 463.83 kg/ha and T3+ crop residue mulch @ 5.0 t/ha after 10-15 DAS (T6) i.e. 453.03 kg/ha and significantly higher over control (T1), crop residue mulch @ 5.0 t/ha after 10-15 DAS (T2), Pusa Hydrogel soil application @ 2.5 kg/ha (T3), Pusa Hydrogel soil application @ 5.0 kg/ha (T4) and Pusa Hydrogel soil

application @ 7.5 kg/ha (T5). However, the lowest protein content in grain of pearl millet was recorded in control treatment.

The N, P and K uptake in grain and stover, crude protein content and protein yield of pearl millet were significantly improved due to application of pusa hydrogel and crop residue mulch. T5+ Crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) registered significantly higher values of N, P and K uptake. This might be due to improved nutritional environment in the rhizosphere as well as in the plant system due to decomposition of crop residue leading to enhanced translocation of N, P and K in plant parts. Among different treatment combinations, maximum crude protein content and protein yield of pearl millet was recorded with T5+ Crop residue mulch @ 5.0 t/ha after 10-15 DAS (T8) which was closely followed T4+ Crop residue mulch @ 5.0 t/ha after 10-15 DAS (T7), T3+ Crop residue mulch @ 5.0 t/ha after 10-15 DAS (T6). The improvement in protein content has been observed in the present investigation because of increased N uptake in seed which attributed to increased availability of nitrogen in the soil due to decomposition of crop residue. These results are in close conformity with the findings of Chaudhari *et al*. (2002), Dar and Ram (2017), Akhtar *et al*. (2018), Thakor *et al*. (2018), Albalasmeh *et al* (2022) and Painkra *et al*. (2022).

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Effect of *Moringa Oleifera* Leaves Powder Based Green Feed on Poultry Meat

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Abstract

Moringa Oleifera Leaves Power effects on Sensory Attribution of Giriraja Poultry Meat" was conducted at Poultry Unit, Department of Poultry Science, PGIVAS, MAFSU under Deptt. A.H. & D.S., Dr. P.D.K.V, Akola to evaluate the effect of supplementation of Moringa leaves powderin the diet of Giriraja poultry birds. For present study 240 day old chicks were divided in eight treatments having three replication, each replicates has ten birds. The treatments were (T1) control with no supplementation, (T2) standard ration plus 0.4% MOLP, (T3) standard ration plus 0.6% MOLP, (T4) standard ration plus 0.8% MOLP, (T5) standard ration plus scavenging, (T6) standard ration plus 0.4% MOLPwith scavenging, (T7) standard ration plus 0.6% MOLPwith scavenging, (T8) standard ration plus 0.8% MOLPwith scavenging. The highest net profit gain was noticed in treatment 0.4% inclusion of Moringa oleifera leaves powder with scavenging of Giriraja poultry birds.

Key words *: Poultry birds, Moringa oleifera leaves powder, poultry meat.*

Introduction

Background Information : The WHO recommended animal protein intake of 60 gm/day. Poultry production has been traditionally practiced in many developing countries for many generations as an important source of nutrition and sustainable income (Anderson, 2011). Chickens constitute one of the most commonly eaten animal species in developed countries as well as developing country. The production of eggs and broilers is continuously marked high as it has been rising at the rate of 8 to 10% /annum compare to 1.5% to 2% /annum crop production.From the status of commercial poultry farm to small scale backyard venture India poultry industry has made remarkable progress. In India backyard poultry farming plays significant role for the livelihood of many rural families particularly the rural women.

There is a huge gap between demand and availability of poultry feeds in general and energy feeds in particular and cost of the feed accounts about 65 to 70% for broiler production and is the major factor which affects the production cost (Pathak et al 2015; Srivastava et al 2015). India have developed few genetic stocks recently improved backyard varieties like Vanraja, Grampriya, Shrinidhi, Giriraja etc. developed mostly by public sector and a few by private sector like kroiler, Rainbow rooster are substantially contributing to the total chicken eggs and meat production of the country(Anonymous, 2015). They have given good results under traditional backyard and semi-intensive system of poultry production with an improved productivity, adoptability and disease resistance. Poultry can be housed under different systems depend on fectors like availability of land, cost of land, type of farming, climatic condition and labour availability. There are three type of housing system viz Intensive, semi-intensive and free range or extensive.In semi-intensive system as the name suggest birds were halfly way reared in house and half way on ground or range. The houses are with solid floor while runs are field only. The success of rearing depends on maintenance of condition of runs to reduce the combination. Runs can also be used on turn base the stoking density rate on an average per adult birds is 750/ha. This system is usually adopted for duck rearing. The feeding and watering facilities are provided in the pen. In this system there is more economical use of land compared to free range system birds protect from extreme climatic condition and control over scientific operation is some extent possible (Banerjee, 1998).Thus the backyard poultry production is less economical under present scenario. The meat from native fowls has significantly higher amino acids than meat from exotic birds and is widely preferred because of their plumage colour, pigmentation taste juiciness and suitability for special dishes and often fetches higher prices. Several high yielding germplasm suitable for backyard production have been developed as discussed earlier.

Importance and Need of Study : Supplimented feed is the key element that affect the net return from the poultry enterprise. The high cost of conventional feed ingredients in poultry diets has necessitated the investigation into

unconventional readily available feed stuff. The impact of indigenous chicken in improving the nutritional status, income, food security and livelihood of small holder is significant owing to their low cost of production (FAO, 1997).Indigenous chickens contribute to the overall well-being of the households through employment creation and income generating (Noreki et al 2010). Any attempt to improve commercial poultry production and increase its efficiency therefore needs to focus on searching alternative and better utilization of feed resources (Udedibie and Asoluka, 2008).

With the continuing increase in demand of raw feed materials that will suffice the needs of animal growers, a call for extensive search on utilization of the cheog and quality alternative feed source from indigenous plant species was formulated. The development of the potential indigenous plants as source of animal feed stuff might not only decrease dependency of the feed industry on expensive imported feed ingredients but relatively reduces the production cost leading to the animal growers economic efficiency. Food and Agriculture Organization (1996) the numerous uses of Moringa Oleifera as medicine, low cost water purifier, human food and animal feed, hedge, seed oil, fibre, its easy propagation and pan tropical cultivation justify more intensive research into its biological and economic possibilities particularly as useful feed ingredients and medicines.

There are about 13 species of Moringa trees in the family of Moringaceae. They are native of India. *Moringa oleifera* is the most widely known. The leaves are highly nutritious and contain significant quantities of vitamins (A, B and C), calcium, iron, copper, sulphur and protein furthermore, heavy metals such as mercury, arsenic and cadmium which are potentially toxic are absent. *Moringa oleifera* is a well-known cultivated species in the genus Moringa, Family Moringaceae) under the order Brassicales. The common name of *Moringa oleifera* include Moringa, drumstick tree, horseradish tree and ben oil tree or benzoil tree or miracle tree. The M. oleifera tree is native to South Asia, especially India, Sri Lanka, Pakistan, Bangladesh, Afghanistan: North Eastern and South Western Africa, Madagascar and Arabia. The Moringa seed and leaves have a broad use in the food industry and therapeutic issues. It is popular for its seeds, flowers and leaves in human food and as herbal medicine. The different parts of *M. oleifera* tree are used as a good source of human nutrition and in traditional diets in different countries of the world. Furthermore, the seed powder of *M. oleifera* contains polyelectrolytes, which are the most important active ingredients for water purification.

The Moringa plant has been expended by humans all over the century in various culinary ways. Virtually all fragments of the plant are used culturally for their nutritional value, ostensible medicinal properties as well as taste and flavour. The leaves of *Moringa oleifera* can be consumed fresh, boiled, or kept as a dried powder for countless months supposedly without any major damage of its nutritional value. Epidemiological studies have specified that *Moringa oleifera* leaves are a good source of nutrition and display anti-tumour, anti-inflammatory, anti-ulcer, anti-atherosclerotic and anti-convulsant activities. The leaves, seeds, flowers, fruit, bark and roots are all used as vegetable, and each part is exceptionally harvested and utilized. For example, fresh leaves are picked, shade dried, ground to a powder and then stored for later use as a food flavouring or additive. Dried or fresh leaves are also used in foods such as soups and porridges, curry gravy and in noodles, rice or wheat. Farmers have included the leaves to animal feed to support a healthy livestock, while exploiting the manure and vegetable compost for crop growth. The feeding value of Moringa has been recounted to be analogous to that of soybeans and rapeseed meal. With the leaves being rich in nutrients, pregnant women and lactating mothers use the powdered leaves to enhance their children's nourishment, principally in under developed countries where malnutrition is common.

Supplemented foods having high levels of protein (soybeans, groundnuts, sunflower seeds) and other feed supplements for poultry production are expensive to purchase while energy foods (e.g. Cereal such as maize, sorghum. Millets, wheat, rice, maize bran, wheat bran and rice bran by-products) are often plentiful and relatively cheap. This has obligated most poultry farmers to move away from this industry leading to low production of poultry meat and eggs and raised the price of poultry products due to high cost of importation. The energy in the diet necessary for production of poultry meat and eggs and for the maintenance of vital functions and body temperature, are largely in the form of carbohydrates, fats and amino acids which can be in the leaves of *Moringa oleifera*. The production of protein in the body tissue entails an adequate supply of about 20 different amino acids, 10 of which cannot be synthesized by poultry, and must therefore be provided in their diets. These essential amino acids are distributed in the leaves of *Moringa oleifera* all year round.

Moringa oleifera is very useful as a feed supplement for animals, as its leaves are highly nutritious part, being a significant source of vitamin B complex, vitamin C, pro-vitamin A as beta-carotene, vitamin K, manganese and protein among other essential nutrients. Moringa oleifera leaves have antimicrobial roles and are rich with fats, protein, vitamins and minerals. The extracts from

leaves of *Moringaoleifera* contain low amounts of polyphenols, which might have effects on blood lipid metabolism. Moringa can be used as a source of micronutrients and as a dietary supplement in poultry. In addition, *Moringa oleifera* leaf powder has anti-septic and detergent properties due to presence of different phytochemicals in the leaves. *Moringa oleifera* was reported to be an excellent source of vitamins and amino acids that reportedly boost immune systems. The seed extracts of Moringa are rich in polyunsaturated fatty acid. Moringa oleifera exhibits anti-oxidant properties that can supress formation of reactive oxygen species (ROS) and free radicals.

Moringa leaves have a relatively high protein content which varies from 25% to 32%. A high proportion of this protein is potentially available for digestion due to high proportion of pepsin soluble nitrogen (82-91 %) and low proportion (1-2 %) of acid detergent insoluble protein (Makkar and Becker, 1997). There has been an increased interest in the utilization of the Moringa oleifera, in improving of ruminants farming (Gadzirayi *et al.,* 2012) and poultry performances (Banjo. 2012: Portugaliza and Fernendez, 2012: Abbas and Ahmed 2012): as a protein source for livestock (Makkar and Becker, 1997" Sarwatt *et al.,* 2002): industrial and medicinal uses(Morton, 1991). Moringa oleifera leaves are widely used traditionally for its antimicrobial abilities and its pharmacological properties. However, trials were conducted to study the effect of these leaves meal on the growth performance of chicks (Melesse *et al,* 2011), on the productive performance of laying hens on broilers performance (Olugbemi *et al,* 2010 and Zanu *et al,* 2012), and on the growth, carcass and blood indices of weaned rabbits (Nuhu, 2011). The effect of Moringa leaves and seeds were also examined by researchers for increasing immunity response and improving physiological and productive performance (Kakengi et al, 2007) and has a positive effect on meat quality (Waskar *et al,* 2009) especially lipid peroxidation which is a major cause of meat quality deterioration, affecting colour, flavour, texture and nutritional value (Giannenas *et al* 2010). The importance of *Moringa oleifera* in ethanobotany as health remedy the antimicrobial property of crude extracts and anti-nutritional factor, particularly saponins can be removed through solvent and aqueous extractions of the petals of Moringa oleifera that has been studied as a part of the exploration for new and novel bio-active compounds (Makkar and Becker, 1997 and Richter et al, 2003). Few studies have showed the substitution of *Moringa oleifera* leaves or extract in broilers low protein diets on antimicrobial abilities: immune system: meat quality: antioxidative properties and physiological and productive performance of farm animals and poultry.

Material and Methods

Experimental site : The experiment was conducted at the poultry unit of PGI, VAS, MAFSU, Akola, Maharashtra during 1st December, 2018 to 27 February, 2019.

Climatological background : Akola is located at latitude 20.7° North and longitude 77.07° East. It is at an altitude of 925 ft (287m) to 1036.745 ft (316m) above sea level. Annual temperatures range from a high of 47.6°C (117.68 °F) to a low of 2.2°C (35.96 °F). Akola lies near the Tropic of Cancer and becomes very hot during the summer, especially in May. Although it can be very hot in the day, it is cooler at night. The annual rainfall averages 800 mm.

Experimental birds : The experiment was conducted on 240, day old Giriraja chicks; obtained from government hatchery, C.P. Nagpur, Maharashtra. The birds were from the same hatch and were reared under uniform management condition. On arrival, the chicks were weighed individually and randomly divided into eight treatments with three replications, each replication has ten birds.

Feed: For the experiment, commercial pre-starter, starter and finisher feed were used as basal diet.

Procurement of *Moringa oleifera:* The fresh *Moringa oleifera* leaves were collected from the field of Department of Horticulture, Dr. P.D.K.V., Akola during the present experimentation.

Preparation of *Moringa oleifera* powder: For preparation of *Moringa oleifera* powder (MOLP) the Moringa leaves were thoroughly wash with tap water, then slicing of leaves were done followed by drying of *Moringa oleifera* slices in desiccant dehumidified air dryer at temperature of 60-65 ^{0}C and RH of 18 per cent then dehydrated slices were ground in low temperature grinder to obtain *Moringa oleifera* leaves powder, at Department of Agriculture Processing Engineering, Dr, P.D.K.V., Akola.The powder was stored in air tight cellophane bag as stock sample in refrigerator for further analysis.

Dietary treatments

T_1	Standard Ration			Control	
T_2	Standard Ration	+	0.4%	MOLP	
T_3	Standard Ration	+	0.6%	MOLP	
T_4	Standard Ration	+	0.8%	MOLP	
T_5	Standard Ration	+		MOLP	Scavenging
T_6	Standard Ration	+	0.4%	MOLP	Scavenging
T_7	Standard Ration	+	0.6%	MOLP	Scavenging
T_8	Standard Ration	+	0.8%	MOLP	Scavenging

Where, MOLP- Moringa oleifera Leaves Powder

Distribution of experimental birds during the experimentation.

Treatment	Replication			Total
	R_1	R_2	R_3	
T_1	10	10	10	30
T_2	10	10	10	30
T_3	10	10	10	30
T_4	10	10	10	30
T_5	10	10	10	30
T_6	10	10	10	30
T_7	10	10	10	30
T_8	10	10	10	30
Total				240

Management practices : Different managemental practices such as thepens, brooders, waterers and feeders were thoroughly cleaned, washed and disinfected before the arrival of chicks. Ten chicks per replication i.e, thirty chicks per treatment were brooded separately on deep litter system up to the age of first week and reared separately up to the age of eight weeks. The brooding was carried out during first week only.All the Giriraja chicks were fed with ground maize for first two days of age. Chicks standard feed were purchased from market from 2-14 days birds fed with pre-starter, 15-28 days birds fed with starter and 28-56 days birds fed with finisher. The diets and water were fed *ad-libitum* to experimental groups by adding required amount of feed additives as per treatment. The birds of different groups were fed separately throughout the experimental period, twice a day i.e. at 8.30 am in morning and 6.30 pm in evening. The experimental birds were reared on deep litter system up to eight weeks of age. Fresh and clean water were offered to all the birds.

Record of observation

Feed consumption (g/day) : The daily feed consumption of each group was estimated as difference between the total quantity of feed offered and quantity of feed left over during 24 hours period. Feed consumption so recorded was added together for seven days of the week and was considered as weekly feed consumption.

Live body weight (g/week): Individual body weight of the birds from each group was taken at weekly interval starting from the day old stage. The birds were weighed during morning hours before feeding.

Body weight gain (g/week): Thegrowth rate of the birds was reflected through the weekly weight gain. The average weekly weight gain of the birds of various groups was calculated by subtracting the previous week average weight of the group of birds from the present week average weight of the group of birds.

Sensory evaluation of meat: To judge the consumer awareness about chicken quality, a sensory panel of semi trained judges drawn from staff were requested to evaluate the chicken quality attributes viz. appearance, flavor, juiciness, tenderness and overall acceptability as given in score sheet at appendix II.

Table-2 : Description of the scale to test sensory qualities of meat.

Sr. No.	Scale	Score
1.	Very desirable	9
2.	Desirable	8
3.	Moderately desirable	7
4.	Slightly desirable	6
5.	Neither desirable nor undesirable	5
6.	Slightly undesirable	4
7.	Moderately undesirable	3
8.	Undesirable	2
9.	Very undesirable	1

Economics of Giriraja production: The economics of feeding was calculated by taking into consideration inputs *viz*., cost of day old chicks, cost of feed, *Moringa oleifera* leaves powder. The prevailing market rates of feed, *Moringa oleifera* leaves powder and miscellaneous expenditure was considered for this purpose.

Statistical analysis: Data were arranged in CRD and analyzed by standard statistical method as per Amble (1975).

Results and Discussion

In poultry production, the feed containing balanced diet has played a crucial role in proper growth and performance of birds to make this sector more viable and successful. However, earlier, Moringa based feed diet was not given much importance, but recent many literature has highlighted significance of its nutritive values and wider use not only for humans but it act as good source of energy food among the animals. Considering this aspect in mind, the results of each proposed objective studied summarized in the following tables:

Conclusions

Supplementation of MOLP along with standard ration does not exert any detrimental effect on the health of birds.

The 0.4% MOLP with scavenging was reduced, cholesterol and triglyceride and increased in hemoglobin, PCV, RBC and WBC, total protein, glucose, albumin.

The dressing percentage values were found higher in treatment groups as compare to control group.

The mean score of sensory evaluation did not differ

Table-3 : Effect of Moringa leaves powder on overall average sensory attributes of meat (score on 9 point hedonic scale) Giriraja poultry birds with or without scavenging.

Treatments	Colour	Appearance	Flavour	Juiciness	Texture	Tenderness	Overall Acceptability	Mean
T_1	6.68	7.10	6.80	6.70	6.97	7.07	6.87	6.88
T_2	8.20	7.83	7.13	8.10	7.93	7.80	7.83	7.83
T_3	7.10	7.77	8.23	7.47	7.73	8.40	7.78	7.78
T_4	8.13	6.50	7.43	7.73	6.70	7.53	7.33	7.34
T_5	6.17	6.50	7.33	7.53	8.77	7.36	7.27	7.28
T_6	8.17	7.96	8.23	8.50	7.90	8.10	8.14	8.14
T_7	8.10	6.80	8.43	8.60	7.80	8.46	8.03	8.03
T_8	8.23	7.57	7.60	7.73	7.50	8.17	7.80	7.80
Mean	7.59	7.25	7.64	7.66	7.68	7.86	7.63	
SE ± (m)	0.092	0.009	0.092	0.092	0.012	0.092	0.011	
CD at 5%	0.029	0.027	0.029	0.029	0.038	0.029	7.80	
Significance	Sig	Sig	Sig	Sig	Sig	Sig	7.63	

significantly in treatment group and control. In case of appearance, flavour, juiciness, tenderness and overall appearance.

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Biochemical Changes in Mung Bean *Vigna Radiata* (L.) Wilczek induced by PSB

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Abstract

Phosphate solubilizing bacteria (PSB) are known as beneficial bacteria that enhance the growth of the plants, when applied into the crops. The pot experiment was conducted in the department of Pathology and Microbiology, Sardar Patel University of Agriculture and technology, Meerut, during *Rabi* 2017-20. The experiment was aimed to study the effect of PSB sp. i.e., *Pseudomonas* on the growth and development of mung bean. Seeds of *Vigna radiata* (L.) were obtained from seed certification office, Meerut. The healthy and uniform seeds were sort out and seed surface was sterilized with 0.2% hypochlorite, rinsed 2-3 times with double distilled water and allowed to grow (8 seeds per pot having loamy soil). The phosphate solubilizing bacteria were procured from Division of Microbiology, I. A. R. I., New Delhi. For control samples, tap water was used to dip the seeds for germination whereas test samples were inoculated with treatment of phosphate solubilizing bacteria (PSB) (20 ml) to evaluate the effect of PSB on the growth and development of mung bean by analyzing the biochemical parameters, viz. protein content, chlorophyll content and leghemoglobin content. The results revealed an overall increase in all growth parameters in inoculated plant samples rather than the controlled samples. In our study, effective level of PSB showed higher effect on the proline content, leghemoglobin and chlorophyll content in treated plants as compared to control. Therefore, PSB can be used as an eco-friendly approach for sustainable crop production.

Key words : *Vigna radiata (L.), phosphate solubilizing bacteria, protein estimation, leg-hemoglobin and chlorophyll estimation.*

Introduction

Mung bean (*Vigna radiata* L.) Wilczek is one of the important pulse crops grown in the arid and semiarid regions of India. The total pulse production was 23.22 million hectares during 2018-19 with an annual production of 13.84 million tonnes in the country. The important mung bean growing states are Orissa, Maharashtra, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Madhya Pradesh, Rajasthan and Bihar. It is a short duration Kharif pulse crop which can be grown as catch crop between Rabi and Kharif seasons. During summer, it can also be used as a green manure crop. Being a leguminous crop, it has the capacity to fix atmospheric nitrogen. Mungbean is an excellent source of protein (25%) with high quantity of lysine (4,600 mg/N) and tryptophan (60 mg/N) and it is consumed as whole grain and dal in variety of ways for table purposes. Different microorganisms present in soils, play an important role in the cycling of nutrients (Bautista-Cruz *et al.*, 2015; Ahmad & Khan, 2013). Terrestrial plants rely on their roots to survive and proliferate, as a result, role of rhizosphere microbes, which colonize the roots become more vital (Sahran & Nehra, 2011). Among these rhizosphere microbes, phosphate solubilizing bacteria (PSB) are naturally occurring soil bacteria (Sharma *et al.*, 2013). The PSB are a heterogeneous group of bacteria that profit the plants by providing nutrients (Sharma *et al.*, 2013). Directly, PSB provide the growth promoting substances. e.g. auxin and enhance the availability of the fixed nutrients, e.g. P in the soil (Sharma *et al.,* 2013; Alia *et al.*, 2013; Wakelin *et al.*, 2004). Therefore, it is essential to look for diverse and proficient strains of PSB's and conduct experiments in order to test their positive effects on increase of mung bean production on sustainable basis. This will also enable us to curtail the world's dependency on the synthetic fertilizers. Therefore, the present study was planned with the objective: to assess effect of PSB inoculation on the growth and development of mung bean (*Vigna radiata* L.) plant by analyzing the biochemical parameter study, i.e., leghemoglobin, protein, and chlorophyll estimation.

Materials and Methods

The field experiment was conducted during the *Kharif* season in the month of March to June 2017 on loam soil with pH 8.2. The soil of the pot experiment was low in the organic carbon (0.16%), available nitrogen (130 mg/pot), phosphorus (17.9 mg/pot), medium and available potassium (150 mg/pot). The field experiments were laid out in randomized block design (CRD) with two levels of PSB (no inoculation and with inoculation), 2 treatment of phosphate solubilizing bacteria (IARI PSB and Native PSB) and one is control. The healthy and uniform seeds (10) were sort out and seed surface was sterilized with 0.2% hypochlorite and rinsed 2-3 times with double

distilled water and allowed to grow (8 seeds per pot having loamy soil). The phosphate solubilizing bacteria were procured from I. A. R. I., New Delhi. Phosphate solubilizing bacteria inoculums of 20 ml bacterial solution were mixed in 5 cm depth from the surface were taken for soil and then distributed in each pot uniformly.

(a) Protein Content : The protein estimation was done according to Bradford (1976) method. To determine the protein contents in the nodules, the plants were uprooted carefully from the soil and rinsed with water to remove soil particles. The nodules were separated from roots, subjected to drying. After removing moisture 100 mg nodules sample were weighed and grind into fine powder using pre-chilled mortar-pestle with ice mixture in cold homogenizing Tris-EDTA buffer. The slurry was centrifuged at 10,000 rpm for 10 minutes to get clear supernatant. The supernatant was used as nodular protein extract for the estimation of total nodular protein and leghemoglobin. Supernatant was divided in three replicates in the test tubes. To 1ml supernatant in each test tube, 5ml brilliant blue was added in each test tube. The test tubes were incubated (whole solution) approximately for 15-20 minute at room temperature, and then O.D. was taken at A595 nm. In this way total soluble nodular protein was estimated. Casein was used for the preparation of standard curve for the estimation of nodular protein. In case of blank only buffer equal to the amount of dye was taken and mixed several times by gentle shaking of the test tube. After the standing period of 5-15 minutes, the color developed in the supernatant. Then O.D. was taken at A595 nm for the various nodular samples. The following formula was used for the measurement of protein content:

Protein (mg/g) : O.D. x Factor x Dilution (if any) x 1000/100 x Total volume/volume of replicate.

(b) Leg-Haemoglobin Content : To determine the leghemoglobin content in the nodules mix fresh or thawed nodules with 1-3 volume of phosphate buffer (100 mg nodules + 200µl phosphate buffer) and macerate in mixer filter through two layers of filter paper. Nodule debris was discarded and remainder reddish brown filtrate was centrifuge at 10,000 rpm for 10-30 minutes and further diluted. To an equal volume, alkaline pyridine reagent was added and mixed (2-5ml). The solution becomes greenish-yellow due to the formation of ferric hem chrome. The hem chrome was equally divided into two test tubes. Then one portion add few crystals of sodium dithionite to reduce the hem chrome and stirred without aeration. To the other portion, add a few crystals of potassium hexacyanoferrate were oxidize hem chrome and the contents of both the test tubes were measured at A556 nm and A539 nm. Then calculated the leghemoglobin content by using the following formula,

$$LB = (A556 - A539) X 2D/23.4$$

(c) Chlorophyll Content : The chlorophyll content was estimated according to the method of Arnon (1949). About 1 gm of leaf sample was cut in to small pieces and homogenized in a pre-cooled mortar and pestle using 80% (V/V) acetone. A pinch of calcium carbonate was added while grinding. The extract was centrifuged at 3000 rpm for 15 min and made up to 25 ml with 80% (V/V) acetone. The clear solution was transferred to a colorimeter tube and the optical density was measured at 645 nm and 663 nm, against an 80% acetone blank in Shimadzu double beam spectrophotometer (UV 240). The levels of chlorophyll 'a' and chlorophyll 'b' were determined using the equation given below :

Chlorophyll 'a' (µg/ml) = (12.7 x O.D. at 663 nm) – (2.69 x O.D. at 645 nm)

Chlorophyll 'b' (µg/ml) = (22.9 x O.D. at 645 nm) - (4.08 x O.D. at 663 nm)

Total chlorophyll (µg/ml) = (20.2 x O.D. at 645 nm) + (8.02 x O.D. at 663 nm)

The chlorophyll content was expressed as mg chlorophyll per gram fresh weight of the leaf.

Results and Discussion

(a) Protein Content : The plants treated with dose of IARI PSB showed increase in protein content than of IARI PSB treatments, as compared to control. So we can conclude in our results IARI PSB level of treatment is to be found effective level with respect to protein content in the mung bean (Table-1 and Figure-1). Mung beans contain higher amounts of protein with globulin and albumin as main storage proteins in the seeds (Kirchhoff, 2002). Increase in protein content by germination is attributed to a passive variation. Protein content was higher in Pusha Vishal, which is due to higher nitrogen content in seed of this genotype (Shoran *et al.,* 2008).

(b) Leg-Haemoglobin Content : The LB amount was higher in PSB treated plants. The leghemoglobin content was maximum in IARI PSB treatment as compare to other treatment of PSB. The nodule formation resulted in more leghemoglobin content under all the treatments namely IARI PSB and Native PSB (Table 2 & Figure 2). The leghemoglobin content increased with the increase in concentration of PSB because of maximum symbiosis between plant and phosphate solubilizing bacteria resulted more leghemoglobin and nodules formation as compare to control. The better nodulation under genotype Pusa Vishal might result in higher content of leg-hemoglobin in nodular tissues. Similarly, higher leg-hemoglobin content in PSB was mainly due to better root and nodules development (Sidhu *et al.,* 1967).

Table-1 : Protein content of *Vigna radiata* (L.) under control and under different treatments.

Treatments	Protein (%)
Control	13.11
IARI PSB	14.26
Native PSB	13.33
CD 5%	1.394
SE (m)	0.455

Table-2 : Leghemoglobin content of *Vigna radiata* (L.) under control and under different treatments.

Treatments	Leghemoglobin (mg/g)
Control	0.024
IARI PSB	0.026
Native PSB	0.025
CD 5%	0.004
SE (m)	0.001

Table-3 : Chlorophyll content (mg/g leaves) of *Vigna radiata* (L.) under control and different treatments.

Treatments	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Chlorophyll
Control	0.298	0.302	0.600
IARI PSB	0.348	0.342	0.690
Native PSB	0.334	0.329	0.663
CD 5%	0.056	0.034	0.090
SE (m)	0.018	0.011	0.029

(d) Chlorophyll Content : Our study revealed that IARI PSB shows maximum chlorophyll content (Table-3 and Figure-3). The effect of PSB on treated plants showed a greater increase in the chlorophyll content of leaves than the control plants. The increase in the level of PSB adversely affected the chlorophyll content of leaves resulting reduction in chlorophyll content. A positive result of chlorophyll content increases its photosynthetic ability because chlorophyll can capture a wider range of light in mung bean (Kumar, 2004). The chlorophyll content increased with the increase in concentration of PSB because of maximum photosynthetic ability between plant and phosphate solubilizing bacteria as compare to control plants. Our results were in accordance to Thaloot *et al.* (2006).

Design and Statistical Analysis : The experiment was planned into CRD design. The data from the experiments were statistically analysis by using the software IBM SPSS 20 (ANOVA).

Conclusions

Keeping in mind the harmful effects of artificial fertilizers and their increasing prices, it is need of the day to find out and utilize environmentally friendly and economical agro-technologies to improve crop production. In this regard, the use of PSB emerged as a potential strategy.

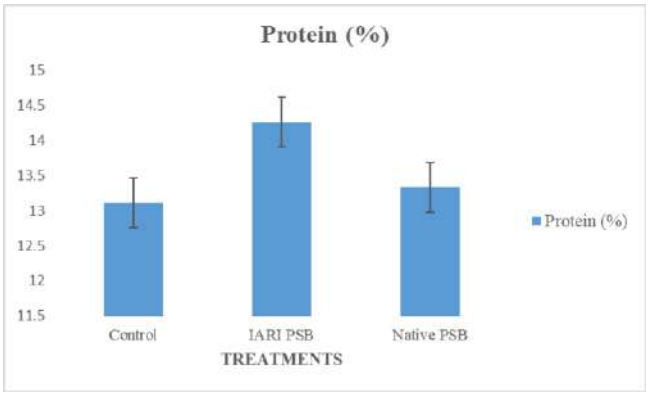

Fig.-1 : Effect of different treatments of PSB on Protein estimation in Vigna radiata (L.) variety Pusa Vishal, with respect to control.

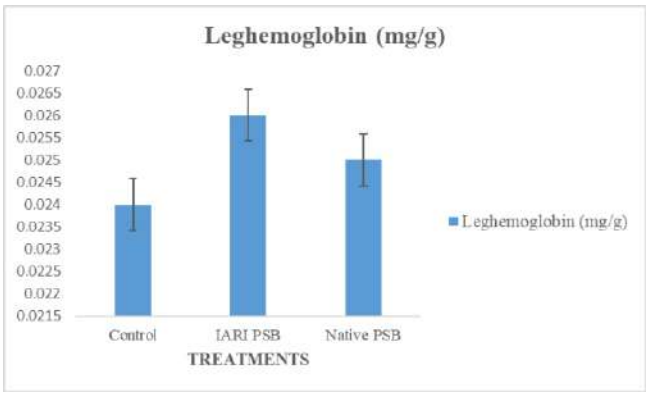

Fig.-2 : Effect of different treatments of PSB on Leghemoglobin estimation in *Vigna radiata* (L.) variety Pusa Vishal, with respect to control.

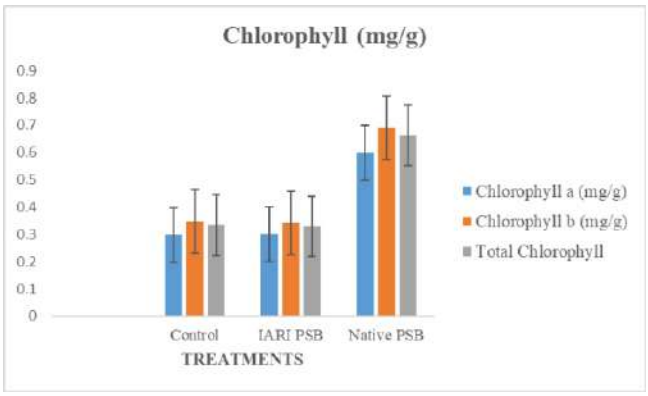

Fig.-3 : Effect of different treatments of PSB on Leghemoglobin estimation in *Vigna radiata* (L.) variety Pusa Vishal, with respect to control Chlorophyll estimation.

The PSBs had a convincingly positive impact on the growth, development, nutrients uptake and quality of the mung bean. Moreover, PSB also enhanced P and N availability in the soil, without polluting the environment.

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Bio efficacy of Metiram 70% WG Against Early and Late Blight Disease of Potato

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Abstract

Potatoes (*Solanum tuberosum* L.) are an important food crop that are cultivated in more than one hundred countries. Two foliar diseases, early blight (*Alternaria solani*) and late blight (*Phytophthora infestans*) threaten the crop and if not managed properly, may induce substantial yield losses. Potato plants severely affected by early blight disease had lower yields and produced smaller tubers. The pathogen causing late blight disease is highly variable and adapt to the newly breed varieties and fungicides. The field experiment was conducted at Regional Wheat Rust Research Station, Mahabaleshwar (Maharashtra) during *Rabi* season of the year 2015-16. During present investigation, various fungicides were evaluated for the management of early and late blight diseases. Considering the disease control ability and tuber yield of potato, Metiram 70% WG @ 1750 g a. i./ha was found to be superior over all other treatments. Also, none of the treatments resulted any phytotoxic symptom on potato leaves at concentration used in the experiment.

Key words : *Early blight, late blight, tuber yield, Phytotoxicity.*

Introduction

Potato (*Solanum tuberosum* L) is one of mankind's most valuable food crops cultivated in more than one hundred countries (FAO, 2004). It is the most important vegetable crop in terms of quantities produced and consumed worldwide (FAO, 2005). Potato production is limited by several factors, including the occurrence of diseases. Diseases that affect potato production include the early blight, caused by *Alternaria solani* Sorauer and late blight, caused by *Phytophthora infestans* (Mont.) de Bary are considered to be of great importance. Severe epidemics of early blight may restrict potato yields by up to 20-30% and late blight may result in complete crop failure in severe epidemics (Rotem, 1994; Shtienberg et al., 1996). Early blight is favored by high humidity and high temperatures. It usually destroys the crop completely if control measures are not implemented at the right time. When control measures fail, late blight epidemics may also destroy an entire production. The most common and effective method for the control of early blight is through the application of foliar fungicides used from early in the growing season (Warton and Kirk, 2012). In the present investigation, new molecules were tested against early & late blight disease of potato.

Materials and Methods

The field experiment was conducted at Venna Lake Farm, Regional Wheat Rust Research Station, Mahabaleshwar (Maharashtra) during the year *Rabi* 2015-16. The experiment was laid in Randomized Block Design (RBD) with seven treatments and three replications. The popular cultivar Kufri Pukhraj was planted at 30 X 15 cm^2 spacing with 4.2 m X 3.15 m plot size. Experiment was conducted with an objective to evaluate the bio-efficacy of fungicides for the management of Early and Late Blight disease of Potato. Three sprays were given at 15 days interval after appearance of blight disease.

The disease intensity of early and late blight of potato was recorded on the randomly selected 5 plants per plot based on 0-9 scale (Mayee & Datar, 1986). Disease intensity was monitored one day before each spray and final observation on PDI (Per cent Disease Index) was recorded 10 days after final spray. The yield of potato was recorded after harvesting (tones/ ha). The phytotoxic effects such as yellowing, chlorosis, epinasty, hyponasty, scorching, burning of leaves due to fungicidal treatments were recorded by visual observations based on 0-10 scale. The observations were recorded 1,3, 5, 7 and 10 days after 1^{st} spraying.

Results and Discussion

Results regarding per cent intensity of early blight and late blight diseases of potato and tuber yield tones / hectare after crop harvest are presented in Table-1. All the fungicidal treatments had showed significantly less early blight disease intensity as compared to untreated control. Amongst fungicidal treatments Metiram 70% WG @ 1750 g a. i./ha (T_4) had showed lowest disease intensity of 39.26 per cent. Same was followed by Mancozeb 75% WP@1500 g a. i. /ha (T_5), Metiram 70% WG @ 1400 g a. i./ha (T_3) and Metiram 70% WG @ 1050 g a. i./ha (T_2) which showed 52.59, 54.07 and 65.93 per cent disease intensity respectively which were on par with each other and found significantly less infected than rest of the

Table-1 : Bio-efficacy of Metiram 70 % WG against early and late blight diseases of Potato.

Treatment	Treatment details	Dose g a.i. /ha	Early Blight (PDI)	Per cent Disease reduction over Control	Late Blight (PDI)	Per cent Disease reduction over Control	Tuber Yield t/ha.	Per cent increase over control
T_1	Metiram 70% WG	700	77.78 (60.89)	13.22	54.07 (47.36)	33.03	18.60	17.10
T_2	Metiram 70% WG	1050	65.93 (53.48)	26.45	43.70 (41.38)	45.87	20.19	23.62
T_3	Metiram 70% WG	1400	54.07 (47.36)	39.67	39.26 (38.80)	51.38	22.46	31.34
T_4	Metiram 70% WG	1750	39.26 (37.90)	56.20	21.48 (27.57)	73.39	25.17	38.74
T_5	Mancozeb 75%WP	1500	52.59 (46.49)	13.77	33.33 (35.16)	19.57	21.35	27.77
T_6	Copper Oxy Chloride 50% WP	1250	71.85 (57.18)	19.83	45.19 (42.23)	44.04	19.94	22.67
T_7	Untreated control	—	89.63 (69.33)	-	80.74 (64.00)	-	15.42	-
	SE+		2.249	-	1.456	-	0.836	-
	CD at 5%		6.343	-	4.105	-	2.357	-

treatments. Maximum disease intensity of 89.63 per cent was observed in untreated control treatment. Data regarding maximum per cent disease reduction over untreated control was observed in treatment of Metiram 70% WG @ 1750 g a. i./ha (T_4) i. e. 56.20 per cent. Similar results were reported by Teng & Bissonnette (1985) that in Minnesota chemical control of early blight with captafol, triphenyltin hydroxide or maneb-Zn resulted increase in yield up to 90 % compared to unsprayed controls. Regardless of the manufacturers' specifications, it is recommended that contact fungicides (e.g. chlorothalonil, mancozeb, maneb, copper and fentin formulations) be applied regularly in the early stages of the disease to prevent infection. From early flowering onwards, 3 to 4 sprays of a systemic fungicide (e.g. difenoconazole, flusilazole, tebuconazole) should be applied. If symptoms appear before flowering, a systemic fungicide must be applied immediately (Mc Leod 1997).

All the fungicidal treatments had showed significantly less late blight disease intensity as compared to untreated control. Amongst fungicidal treatments Metiram 70% WG @ 1750 g a. i./ha (T_4) had showed lowest disease intensity of 21.48 per cent. This treatment was followed by Metiram 70% WG @ 1500 g a. i./ha (T_5) and Metiram 70% WG @ 1400 g a. i./ha (T_3) which showed 33.33 and 39.26 per cent disease intensity respectively which were on par with each other and found significantly less infected than rest of the treatments. Maximum disease intensity of 80.74 per cent was observed in untreated control treatment. Maximum per cent disease reduction over untreated control was observed in treatment of Metiram 70% WG @ 1750 g a. i./ha (T_4) i. e. 73.39 per cent. The neutralized phosphorous acid solution (1000mg/L) completely inhibited the mycelial growth and sporangial germination of *P. infestans* and when applied as foliar spray to the potato plants 2 to 4 times at 7 day interval, the severity was significantly and effectively suppressed (Tsai et al., 2009). Use of systemic fungicides early in the season is an effective strategy to manage late blight if source of primary infection is infected seed (Hermansen and Naerstad, 2009).

Tuber yield per hectare was found significantly higher in all the fungicidal treatments than untreated control treatment. Amongst fungicidal treatments, Metiram 70% WG @ 1750 g a. i./ha (T_4) had showed significantly higher tuber yield (25.17 t/ha) than rest of the treatments. This treatment was followed by Metiram 70% WG @ 1400 g a. i./ha (T_3) and Metiram 70% WG @ 1500 g a. i./ha (T_5) which showed significantly higher yield of 22.46 t/ha and 21.35 t/ha, respectively and found on par with each other. Minimum yield of 15.42 t/ha was observed in untreated control. Maximum percent increase in yield over untreated control was observed in treatment of Metiram 70% WG @ 1750 g a. i./ha (T_4) i.e. 38.74 per cent. None of the treatment showed any phytotoxic symptom on potato leaves at concentration used in the experiment.

Conclusions

As the pathogen of early and late blight causing disease has developed resistance to so many fungicides, new molecules with different mode of action need to be identified and used. In present investigation, considering

disease control ability of early blight, late blight diseases and tuber yield of potato, Metiram 70% WG @ 1750 g a. i./ha was found superior over rest of the treatments.

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Impact of Ready-Mix Insecticides against Cowpea Pod Borer, *Maruca vitrata* (Fabricius) and Toxicity Study on Natural Enemies

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Abstract

The experiment was conducted at Main Vegetable Research Station, AAU, Anand on bio-efficacy of ready-mix insecticides against cowpea pod borer, *M. vitrata* which indicated that the ready-mix insecticide applications effectively reduced the populations of *M. vitrata* based on pooled over year after spray application. The study also indicated that the lowest larval population was recorded in plots treated with T_4 Chlorantraniliprole 9.30%+Lambda-cyhalothrin 4.60% ZC [37.50 g a.i/ha; 0.75 larvae/plant] and T_5 Chlorantraniliprole 9.30%+Lambda-cyhalothrin 4.60% ZC [30 g a.i/ha; 0.92 larvae/plant] which were found also confined dose related as well as significantly at par with each other. The next effective group based on larval population was T_7 Chlorantraniliprole 18.5 SC [30 g a.i/ha; 1.19 larvae/plant] and T_6 Chlorantraniliprole 9.30%+Lambda-cyhalothrin 4.60% ZC [22.50 g a.i/ha; 1.43 larvae/plant]. The result on pooled over year indicated that the lowest pod damage was recorded in T_4 (1.80 %) which was equally effective with T_5 (2.10 %), T_7 (2.36 %) and T_6 (3.14 %). The next insecticide group based on pod damage (%) was ranged from 6.46 to 8.26 %. The population of spiders was uniform in all the treatments based on pooled over year as treatment difference was non-significant which showed that all the insecticidal treatments found more or less equally safer to this predator. The highest green pod yield (76.33 q/ha) was recorded in the treatment of T_4 which was equally effective with T_5 (75.53 q/ha), T_7 (73.37 q/ha) and T_6 (71.16 q/ha).

Key words *: Ready-mix insecticides, cowpea, Maruca vitrata, toxicity and natural enemy*

Introduction

Cowpea, [*Vigna unguicula*ta (L.) Walper] is nutritionally important pulse crop grown as vegetable cow pea as well as pulse grains in the semiarid and sub-humid tropics of Asia. It is minor pulse cultivated mainly in pockets of Punjab, Haryana, Delhi and West UP along with considerable area in Rajasthan, Karnataka, Kerala, Tamilnadu, Maharashtra and Gujarat. The total area under cowpea cultivation is 1.5 million hectare and 0.5 lakh hectare in India and Gujarat, respectively (Anonymous, 2020). It is also popularly known as *chauli* which an important legume vegetable crop. It is grown for its tender green pods and shelled immature seeds used as vegetable and dry seeds used as pulse which seeds contain 22-24% protein. The productivity of this crop is under threats by many biotic and abiotic factors (Ehlers and Hall, 1997). The key pests of cowpea include pod borers, aphid, leafhopper and sucking bug which affected 90% plants of total according to the field study for reduction in the quantity produced degradation in quality as well as spread of diseases which high in cowpea due to these insect pests (Jackai *et al*., 1992; Karungi, *et al*., 2000). The legume pod-borer, *Maruca vitr*ata (Fabricius) is one of the most important pests of grain legume throughout the tropics and sub-tropics of world (Jackai and Daoust, 1986). The larvae feed by webbing the flowers together, make holes on pods and also feed on seeds. There was mmainly one or two spray followed for the management of this pest, first at 50% flowering and second at 50% pod setting which found most effective. Several management tactics have been formulated and advocated but farmers commonly rely only on insecticides (Devaki *et al*., 2011). As the cowpea pods are more consumed as green vegetable therefore, residue and undesirable additive effect and spectrum of mammalian toxicity play a very important role for the near future. Pesticide mixtures may enhance the suppression of arthropod pest population due to either synergistic interaction or potentiating between or among pesticides that are mixed together and also may delay the onset of resistance developing in arthropod pest populations. Hence, the present experiment is laid out to check the bio-efficacy of ready-mix insecticides on cowpea pod borer.

Materials and Methods

The experiment was conducted at Main Vegetable Research Station, AAU, Anand. All the agronomical practices will be followed for raising the cowpea crop (Anand Vegetable Cowpea-1) except the plant protection measures. The randomized block design was used in the experiment with three replication and eight treatments including control. The spray was applied at the initiation of pest population by using manually operated knapsack sprayer with Duromist nozzle. The numbers of larvae were

Table-1 : Effectiveness of different insecticides against pod borer, *M. vitrata* infesting cowpea (Pooled over year).

Treatments	Number of larva/plant*			Pod damage (%) at each picking**		
	2020	2021	Pooled	2020	2021	Pooled
T_1 Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC 34.37 g a.i/ha	1.27d	1.60c	1.44c	12.29c	17.14b	14.72b
	(1.11)	(2.06)	(1.57)	(4.53)	(8.69)	(6.46)
T_2 Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC 27.50 g a.i/ha	1.43c	1.90b	1.67b	13.62bc	17.89b	15.75b
	(1.54)	(3.11)	(2.29)	(5.55)	(9.44)	(7.37)
T_3 Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC 20.63 g a.i/ha	1.62b	2.06b	1.84b	14.71b	18.70b	16.70b
	(2.12)	(3.74)	(2.88)	(6.45	(10.28)	(8.26)
T_4 Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC 37.50 g a.i/ha	1.05e	1.20e	1.12e	7.67f	7.76d	7.71c
	(0.60)	(0.94)	(0.75)	(1.78)	(1.82)	(1.80)
T_5 Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC 30 g a.i/ha	1.11e	1.26e	1.19de	8.37ef	8.28cd	8.33c
	(0.73)	(1.09)	(0.92)	(2.12)	(2.07)	(2.10)
T_6 Chlorantraniliprole 9.30%+Lambda-cyhalothrin 4.60% ZC 22.50 g a.i/ha	1.28cd	1.49cd	1.39cd	10.47d	9.92c	10.20c
	(1.14)	(1.72)	(1.43)	(3.30)	(2.97)	(3.14)
T_7 Chlorantraniliprole 18.5 SC 30 g a.i/ha	1.16de	1.44d	1.30cde	9.10e	8.58cd	8.84c
	(0.85)	(1.57)	(1.19)	(2.50)	(2.23)	(2.36)
T_8 Control	2.07a	2.55a	2.31a	27.49a	29.30a	28.40a
	(3.78)	(6.00)	(4.84)	(21.31)	(23.95)	(22.62)
S. Em.(±) Treatment (T)	0.04	0.05	0.07	0.44	0.54	1.16
Period (P)	0.03	0.03	0.02	0.31	0.38	0.25
Year (Y)	—	—	0.02	—	—	0.17
T x P	0.07	0.08	0.06	0.89	1.09	0.70
T x Y	—	—	0.05	—	—	0.49
P x Y	—	—	0.03	—	—	0.35
T x P x Y	—	—	0.08	—	—	0.99
C.D. at 5% Treatment (T)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)	9.67	8.05	9.13	11.88	12.85	12.43

Note : 1. Figures in the parentheses are retransformed values; those outside are *Transformed values;
2. Figures in the parentheses are retransformed values; those outside are **Arc sin transformed values
3. Significant parameters and its interaction: T, P, Y, T x P, T x Y; Sig.: Significant
4. Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance; Sig.: Significant

recorded from randomly selected 10 plants/plot. The observations on larvae and spider population were recorded before and 5th, 10th and 15th days after insecticidal application. The pod borer damage from the harvested pods was recorded from 100 green pods collected from each treatment after each picking. The yield (kg/plot) was recorded in each treatment. The data were analyzed by using standard statistical method.

Results and Discussion

Larval population : The results showed that all the ready-mix insecticide applications effectively reduced the populations of *M. vitrata* in pooled over periods. First year results (Table-1) on pooled over period after spray application indicated that the lowest (0.60 larvae/plant) larval population was recorded in plots treated with T_4 (0.60 larvae/plant) and T_5 (0.73 larvae/plant) were equally effective which at par with T_7 (0.85 larvae/plant). The next effective group based on larval population was T_6 (1.14 larvae/plant), T_1 (1.11 larvae/plant), T_2 (1.54 larvae/plant) and T_3 (2.12 larvae/plant) which recorded larval population between 0.85 to 2.12 plant. The results showed that all the ready-mix insecticide applications effectively reduced the populations of *M. vitrata* during second year of study (Table 1) which showed similar trend of first year of study. Results on pooled over period after spray application indicated that the lowest (0.94 larvae/plant) larval population was recorded in plots treated with T_4 and T_5 (1.09 larvae/plant) were also found equally effective. The next effective group based on larval population was T_7 (1.57 larvae/plant) and T_6 (1.72 larvae/plant). Results on pooled over year (Table 1) after spray application indicated that the lowest larval population was recorded in plots treated with T_4 (0.75 larvae/plant) and T_5 (0.92 larvae/plant) which were also found at par with each other. The next effective group based on larval population was

Table-2 : Effect of different insecticides on spiders in cowpea (Pooled over year).

Treatments	Number of spider/plant		
	2020	2021	Pooled
T_1 Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC 34.37 g a.i/ha	1.24	1.25	1.25
	(1.04)	(1.06)	(1.06)
T_2 Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC 27.50 g a.i/ha	1.27	1.27	1.27
	(1.11)	(1.11)	(1.11)
T_3 Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC 20.63 g a.i/ha	1.31	1.29	1.30
	(1.22)	(1.16)	(1.19)
T_4 Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC 37.50 g a.i/ha	1.26	1.27	1.27
	(1.09)	(1.11)	(1.11)
T_5 Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC 30 g a.i/ha	1.28	1.29	1.29
	(1.14)	(1.16)	(1.16)
T_6 Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC 22.50 g a.i/ha	1.30	1.30	1.30
	(1.14)	(1.19)	(1.19)
T_7 Chlorantraniliprole 18.5 SC 30 g a.i/ha	1.27	1.28	1.28
	(1.11)	(1.14)	(1.14)
T_8 Control	1.30	1.31	1.31
	(1.19)	(1.22)	(1.22)
S. Em.(±) Treatment (T)	0.03	0.03	0.02
Period (P)	0.02	0.02	0.04
Year (Y)	—	—	0.01
T x P	0.03	0.06	0.04
T x Y	—	—	0.03
P x Y	—	—	0.02
T x P x Y	—	—	0.06
C.D. at 5% Treatment (T)	NS	NS	NS
C.V. (%)	7.56	7.58	7.57

Note : 1. Figures in the parentheses are retransformed values; those outside are * transformed values
2. Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance; NS= Non significant

T_7 (1.19 larvae/plant) and T_6 (1.43 larvae/plant). However, T_7 treatment was also found at par with $T_{5 \text{ and }} T_6$. The rest of other insecticidal treatments were recorded larval population ranges from 1.57 to 2.88 per plant. The similar result was observed by Reddy and Hampaiah (2018) revealed that there was no larva of cowpea pod borer was found in the treatment lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC @ 0.50 ml/l and chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC @ 0.30 ml/l treated plants after 5 days of spraying. The similar results was noticed by Banka *et al*. (2016) that Lambda cyhalothrin 4.6% + chlorantraniliprole 9.3% ZC @ 30 g a.i/ha was found superior in the management of *M. vitrata* over other treatments. However, according to Kaushik *et al*. (2016) indicated that sprays of flubendiamide 39.35 SC @0.3 ml/l or Chlorantraniliprole 18.5 SC @ 0.006% @0.3 ml/l, first at 50% flowering and second at 50% pod setting was found most effective in management of cowpea pod borer *M. Vitrata*.

Pod damage (%) : The data on pod damage (%) was effectively reduced after pooled over period and year during study (Table-1). It was indicated that the lowest pod damage was recorded in T_4 (1.78%) which at par with T_5 (2.12 %) during first year of study. The next effective treatment was T_7 (2.50 %) which at par with T_5. The next effective group based on pod damage (%) was T_6 (3.30 %), T_1 (4.53%), T_2 (5.55%) and T3 (6.45 %) which recorded pod damage (%) between 3.30 to 6.45 per cent. The pod damage (%) was effectively reduced after second year of study which showed similar trend on pooled over period indicated that the lowest pod damage was recorded in T_4 (1.82 %) which at par with T_5 (2.07 %) and T_7 (2.23 %). The next effective treatment was T_6 (2.97 %) which at par with T_5 and T_6 . The next effective insecticide group based on pod damage (%) was T_1 (8.69%), T_2 (9.44%) and T3 (10.28 %) which recorded pod damage (%) between 8.69 to 10.28 per cent. The result on pooled over year indicated that the lowest pod damage was recorded

Table-3 : Impact of different insecticidal treatments on green cowpea pod yield (Pooled over year).

Treatments	Green pod yield (q/ha)		
	2020	2021	Pooled
T_1 Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC 34.37 g a.i/ha	55.58[b]	51.16[b]	53.37[b]
T_2 Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC 27.50 g a.i/ha	55.44[b]	48.19[b]	51.81[b]
T_3 Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC 20.63 g a.i/ha	51.71[b]	42.02[bc]	46.86[b]
T_4 Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC 37.50 g a.i/ha	74.55[a]	78.11[a]	76.33[a]
T_5 Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC 30 g a.i/ha	74.31[a]	76.75[a]	75.53[a]
T_6 Chlorantraniliprole 9.30% + Lambda-cyhalothrin 4.60% ZC 22.50 g a.i/ha	72.51[a]	69.80[a]	71.16[a]
T_7 Chlorantraniliprole 18.5 SC 30 g a.i/ha	73.95[a]	72.79[a]	73.37[a]
T_8 Control	33.36[c]	32.28[c]	32.82[c]
S. Em. (+) Treatment (T)	4.31	4.49	3.00
Year (Y)	—	—	1.56
T x Y	—	—	4.40
C.D. at 5% Treatment (T)	Sig.	Sig.	Sig.
C.V. (%)	12.17	13.22	13.06

Note: Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance; Sig.: Significant

in T_4 (1.80 %) which was equally effective with T_5 (2.10 %), T_7 (2.36 %) and T_6 (3.14 %). The next insecticide group based on pod damage (%) was ranged from 6.46 to 8.26 %. According to Chudamani *et al*. (2021), the lowest fruit damage was recorded in chlorantraniliprole (5.18%) followed by flubendamide (5.44%) which is more or less confirmed with the present study. The similar results also observed by Banka *et al*. (2016) that the lowest pod damage was recorded in lambda cyhalothrin 4.6% + chlorantraniliprole 9.3% ZC @ 30 g a.i/ha (15.82%). However, lambda cyhalothrin 4.6% + chlorantraniliprole 9.3% ZC @ 35 g a.i/ha was found to be the effective in reducing the infestation of borer pests in different crops *viz*., pigeon pea (Patel and Patel, 2013; Swami *et al*., 2017), soy bean (Birla, 2014), cotton (Bajya *et al*., 2015), cowpea(Grigolli *et al*., 2015) and brinjal (Sen *et al*., 2017).

Natural enemies : The population of spider after pooled over spray period was found non-significant during first as well as second of study (Table-2). There was similar trend also observed in pooled over year which showed that all the insecticidal treatments found more or less equally safer to this predator. The non-target toxicity of different treatments were recorded on prevailing natural enemies in cowpea eco-system Chlorantraniliprole + thiamethoxam followed by flubendiamide + thiacloprid showed mild effect on all the test combinations in the reduction of natural enemies which confirmed with present study of Roy *et al*. (2017).

Green pod yield : The data on first, second and pooled over year are presented in Table-3. The first year of study showed that the highest (74.55 q/ha) green cowpea pod yield was recorded in the treatment of T_4 which was equally effective with T_5 (74.31 q/ha), T_7 (73.95 q/ha) and T6 (72.51 q/ha) during the first year of study. The treatment T_3 recorded the lowest (51.71 q/ha) pod yield followed by T_2 (55.44 q/ha) and T_1 (55.58 q/ha) among the rest of insecticidal treatments. The highest (78.11 q/ha) green pod yield was also recorded in the treatment of T_4 which was equally effective with T_5 (76.75 q/ha), T_7 (72.79 q/ha) and T6 (69.80 q/ha) during second year of study (Table 3). The treatment T_3 recorded lower (42.02 q/ha) pod yield, however T_2 (48.19 q/ha) and T_1 (51.16 q/ha) treatments were found significantly equally effective which was higher than control (32.28 q/ha). The data on pooled over year indicated that the highest green pod yield (76.33 q/ha) was recorded in the treatment of T_4 which was equally effective with T_5 (75.53 q/ha), T_7 (73.37 q/ha) and T_6 (71.16 q/ha). Findings of the present study are more or less in conformity with the findings of Roy *et al*. (2017) indicated that mean green pod and seed yield of cowpea was higher in plots treated with different insecticidal combinations than untreated control which showed that ready mix insecticides are effective for the management of this pest in cowpea.

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In Vitro Evaluation of Complete Diets Based on Spineless Cactus (*Opuntia ficus indica*) and Moringa (*Moringa oleifera*) for Ruminant Feeding

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Abstract

Spineless cactus and Moringa were analyzed for proximate principles by chemical analysis. The ME content was determined by in vitro incubation and gas production technique (RIVIGP) according to Menke *et al* (1979). On dry matter basis with 8.41 per cent DM, the total ash, crude protein, ether extract, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) content of spineless Cactus were 11.6, 5.14, 1.79, 28.3, 17.1 and 3.06 per cent respectively and the ME content being 8.11 MJ/kg DM. The DM content in Moringa was 22.1 per cent with the crude protein and ME content of 23.3 per cent and 10.2 respectively. Based on the chemical composition and predicted ME content, five complete diets were formulated using varying proportions of Spineless Cactus and Moringa. The proportions of Spinesless Cactus and Moringa were 65:35; 60:40; 55:45; 50:50 and 45:55 in diets D1, D2, D3, D4 and D5 respectively. The ME content (MJ/kg) and crude protein (per cent) in the diets ranged from 9.12 to 9.48 and 11.5 to 15.1. Diet D3 with a combination of fifty five per cent of Spineless Cactus and forty five per cent of Moringa containing 9.32 MJ and 13.3 per cent protein per kg diet was considered to provide a balanced supply of ME and crude protein to meet the requirement for ruminants.

Key words : *Spineless cactus, moringa, metabolisable energy, crude protein, balanced diet.*

Introduction

Ruminant production system is mainly based on the availability of forage resources since the bulk component of the feeds is provided by the fibre rich roughage feeds. Spineless cactus or *Opuntia* (*Opuntia ficus indica*) is a xerophytic plant used for feeding animals, easy to grow and palatable (Shoop *et al*., 1977). As a drought resistant crop with an advantage of minimum agronomical input for its propagation, opuntia provide a major source of water and energy in the feed of ruminants.

Moringa (*Moring oleifera*) is a popular legume tree, the foliage and pods of which are known vegetable foods for humans. With a high nutritional value and good biomass production of both protein and energy, moringa can provide a fodder security for livestock, as a nutritional supplement (Devendra, 1990). The protein content (per cent on dry matter basis) of Moringa has been reported to be 25.1 (Foidl *et al*., 2001). With attributes of being drought resistance and low water requirement for cultivation, both Spineless Cactus and Moringa offer a huge potential as feedstuffs to provide balanced nutrition for ruminant feeding.

Materials and Methods

The experiment on *In vitro* evaluation of complete diets based on spineless Cactus (*Opuntia ficus indica*) and Moringa (*Moringa oleifera*) for ruminant feeding was conducted at the Department of Livestock Production Management (LPM), Veterinary College, Hebbal, Bengaluru.

Analytical Procedures

Chemical Analyses : The ash content in the samples was estimated as residue obtained after incineration of samples at 600°C for 3 hours. Crude protein (N × 6.25) was analyzed using Gerhardt digestion and distillation unit that agrees with macro Kjeldahl standards (AOAC, 1995). The ether extract (EE) content in the feed samples was analyzed after extraction with petroleum ether using the procedure of AOAC (1995). The neural detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin were determined according to the methods described by Van Soest *et al.* (1991).

Rumen *In vitro* incubation for gas production

Donor cow and collection of rumen fluid **:** A lactating dairy cow producing 3 kg of milk per day, fitted with a flexible rumen canula of large diameter (Bar Diamond, Inc. USA), receiving a basal diet consisting of finger millet straw (FMS) and a compounded feed mixture (CFM) (Maize 60% , WB 35% , Mineral mixture 2%, Urea 2%, Salt 1%) was used as the donor cow for rumen fluid.

Metabolisable energy (ME) determination : The ME

content in Spineless Cactus and Moringa was determined by *in vitro* incubation and gas production technique (RIVIGP) according to Menke *et al* (1979) using the following equations:

$$ME = 2.2 + 0.1357\ GP + 0.0057\ CP + 0.0002859\ EE^2$$

Where,

ME = Metabolisable energy, MJ/kg DM.

GP = Corrected Net Gas production, ml/200 mg. DM.

CP = Crude protein, g/kg. DM.

EE = Ether extract g/kg. DM.

Based on the chemical composition and predicted ME content of the Spineless Cactus and Moringa, five complete diets were formulated using varying proportions of Spineless Cactus and Moringa in the diet. The composition of experimental diet is as follows.

Table-1 : Experimental Diets.

	Spineless cactus	Moringa
	..... %	
Diet 1	65	35
Diet 2	60	40
Diet 3	55	45
Diet 4	50	50
Diet 5	45	55

The experiental diets were analysed for crude protein (per cent) and ME (MJ/kg DM) content using rumen in vitro incubation for gas production.

Results and Discussion

The results of the chemical analyses of Spineless Cactus and Moringa are presented in Table-2. Spineless cactus contained a dry matter of 8.41 per cent. On dry matter basis, the total ash, crude protein, ether extract, neutral detergent fibre (NDF), acid detergent fibre (ADF)and acid detergent lignin (ADL) content of Spineless Cactus were 11.6, 5.14, 1.79, 28.3, 17.1 and 3.06 per cent respectively. The ME content (MJ/kg DM) of Spineless Cactus was 8.11. With 8.41 per cent DM, Cactus could be a good source the water (91.59 per cent) for ruminants. The low crude protein content (5.14 per cent) was comparable to non legume forages. The relatively low NDF and ADF content indicated the digestibility of cactus could be higher with possibly higher energy content. The ME content of 8.11 MJ/kg DM indicated that Spineless cactus could provide a valuable source of energy in the diet of ruminants.

Moringa contained DM of 22.1 per cent. The crude protein content was higher (23.3 per cent) indicating that it can be a major protein source in the diet of ruminants. The ME content of 10.2 was higher than Spineless Cactus signifying that Moringa could provide a good source of energy. The NDF and ADF content in Moringa was higher than Spineless Cactus, however, lower than most of the roughage feeds used in feeding dairy cattle.

The results of analysis of ME (MJ/kg DM) and Crude protein (per cent) composition of the experimental diets are presented in Table-3. The proportion of Cactus in the diet varied from 45 to 65 per cent , whereas Moringa content in the diet ranged from 35 to 55 per cent. All the diets provided adequate energy (more than 9.00 ME, MJ/kg DM), whereas the protein content was low in diets 1 and 2. Crude protein content of more than 13.3 in the total diet 3 would ensure adequate amount of protein supply to meet the requirement of ruminants. Higher levels of Moringa (more than 45 per cent) in diets 4 and 5 may not be obligatory since the protein from Moringa forage could be saved. Spineless Cactus served as a source of energy, where as Moringa provided adequate amount of protein and energy in the diet. The combination of Spineless cactus and Moringa therefore would make up a balanced diet for feeding ruminants, not only to provide energy and protein to meet the requirement, but also the diet could be a good source of water, especially for feeding ruminants in dry season or drought prone areas.

Table-2 : Chemical composition*[1] (Per cent dry matter basis) energy (ME, MJ/Kg DM) content of spineless cactus and moringa.

Parameter	Spineless Cactus	Moringa
Dry Matter	8.41	22.1
Total Ash	11.6	14.3
Crude protein	5.14	23.3
Ether Extract	1.79	3.26
Neutral Detergent Fibre	28.3	41.7
Acid Detergent Fibre	17.1	20.2
Acid detergent Lignin	3.06	3.01
ME[2] (MJ per kg DM)	8.11	10.2

*Except dry matter and ME
[1]Mean of two replicates. Variations in duplicate measurements were within ±3% of the mean
[2]Determined by RIVIGP (Menke et al., 1979)

Table-3 : Metabolisable energy[1] (me, mj/kg dm) and crude protein[2] (Per cent dry matter basis) composition of the experimental diets.

Parameter	ME	Crude Protein
Diet 1	9.12 (57.1)	11.5
Diet 2	9.25 (58.3)	12.4
Diet 3	9.32 (59.2)	13.3
Diet 4	9.41 (59.1)	14.2
Diet 5	9.48 (63.1)	15.1

[1]Determined by RIVGP (Menke et al., 1979)
[2]Mean of two replicates. Variations in duplicate measurements were within ±3% of the mean
Values in parenthesis; Gas volume for 200mg sample/24h

Conclusions

The study concluded that nutritionally balanced and economical feeds could be formulated using Spineless Cactus and Moringa forage for feeding ruminants. The proportion of Spineless cactus and Moringa at 55 and 45 per cent respectively in the diet was found to be optimum to provide adequate energy and protein to balance the requirement of ruminants. Diets based on Spineless cactus could also provide adequate water to the ruminants and therefore mitigate the deficiency of water in extreme dry arid regions and in drought situations.

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Land Use and Land Cover Classification Using Artificial Neural Network for Improving Accuracy

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Abstract

Land use and land cover classified images are required to use the available land for more crop production. The main objective of present research work was to determine if the classification of features would be done using ANN (Artificial Neural Network) provides better classification accuracy of various categories on the satellite image of the year of 2000 and 2011 of East Champaran district of Bihar. Seven land use and land covers e.g. crop land, fallow land, dense built-up, river wetland, lakes/ ponds wetland, barren land and low built-up area are taken in to consideration. Basic idea is to perform the classification procedure first in the supervised maximum likelihood classification method and then in artificial neural network. For comparative purposes, standard ML and ANN classifications were done and tested on the basis of calculating producer's accuracy, user's accuracy, overall accuracy and the value of kappa coefficients using confusion matrix. After that comparative analysis among producer's accuracy, user's accuracy, overall accuracy and value of kappa coefficients of the various categories/ classes determined from the classification of the image 2000 and 2011 for both methodologies are done. The result shows that crop land, fallow land and dense built-up area exhibit higher producer and user accuracy than river wetland, lakes/ ponds wetland, barren land and low built-up area. It is observed that ANN approach exhibits better accuracies than the conventional standard ML classification approach for different land use and land covers. So the final recommendation in this study is that ANN is the better image classification technique than the standard ML technique.

Key words : *Image, supervised classification, accuracy, artificial neural network, land use and land cover.*

Introduction

Remote sensing is the technique used to collect information about the earth without physical contact of the earth's surface. A sensor is used to measure the energy reflected from the earth. This information can be displayed as a digital image. Sensors can be mounted on a satellite orbiting the earth. In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest. Remote Sensing data both in large form and digital format is utilized for deriving information about resources either adapting visual interpretation or computed aided analysis. Both types of measure require certain amount of ground support information. This information is normally termed to as "Ground Truth". Using the ground truth the remote sensing data are analyzed interpreted and maps related to resources are generated. Remote sensing image classification is a complex process and requires consideration of many factors. The major steps of image classification may include determination of a suitable classification system, selection of training samples, image preprocessing, feature extraction, selection of suitable classification approaches, post classification processing and accuracy assessment. The overall objective of the image classification is to automatically categorize all pixels in an image into land use and land cover classes or themes. A thematic map is an informational representation of an image, which shows the spatial distribution of a particular theme. Themes can be diversified as their areas of interest. Examples of themes are vegetation, water, built-up areas, agricultural lands, etc Classification of features in an image uses the visual interpretation to identify homogenous group of pixels, which represent various features of interest (themes). Digital image classification uses the spectral information represented by digital numbers in one or more spectral bands. This type of image classification is called spectral image classification. Spectral classes are groups of pixels, which are similar in their brightness values in various spectral bands.

Most of the image classification algorithms generally use either statistical methods, Neural networks or Fuzzy logic approaches. Mixed pixel classification is a challenge using standard ML method. ANN may be used to classify mixed pixels more accurately than the standard ML method (Lee *etal,* 1990). We have used both methods i.e. standard ML and ANN for image classification of East Champaran area of the years 2000 and 2011 for different land use and land covers. ANN classification may be used to estimate the production of crop (Kaul *etal,* 2005).

Classification has been done to identify different land use and land covers (Jenssen, 1990). Classification accuracy is usually evaluated. It shows a relation between

the predicted and the actual classes of membership for a set of pixels. With the help of confusion matrix, it is possible to obtain several measures of classification accuracy, such as producer's accuracy, user's accuracy, overall accuracy and the Kappa coefficient (Jenssen and Van der wel, 1994). So, the objective of this study is to classify images of East Champaran district for land use and land covers applying standard ML and ANN methods of classification of LISS III image of the year, 2000 and 2011. Calculation and comparison of accuracies of standard supervised ML and ANN classified images with the help of confusion matrix, error matrix or contingency matrix of all classes. Overall accuracy and value of kappa have also been calculated for both methodologies of classified images and comparison has been done for getting better classified images and methodology. Classified images are used to create map of study area (Roy, 1991). Land use and land cover (LULC) map of East Champaran district has been created after LULC classification.

Materials and Methods

Materials

Study Area : East Champaran district is located between 26° 15' to 27° 01' N latitudes and 84° 28' E to 85° 18' E longitudes (Fig.-1). The total area of the district is 4155 sq. km. Total cultivable area is 266200 hectare. A very hot and dry summer, southwest and northeast monsoon season characterize the climate of district. The climate is hot sub humid with eastern middle Gangetic north west alluvial plain zone. The altitude is 62 meter above mean sea level. Normal annual rainfall is 1202 mm. Te major field crops are rice, wheat, maize, sugarcane and pulses. The total wetland area in the district is 12477 ha, which includes the area contributed by 755 small wetlands (< 2.25 ha) which comprises about 3 per cent of the geographical area of the district. River/streams comprise about 49 per cent of wetland extent of the district that accounts for 6134 ha. The other major wetland types are ox-bow lakes/cut-off meanders (2481 ha), natural waterlogged areas (1481ha) and lakes/ponds (862 ha). The net irrigated area is 141000 ha.

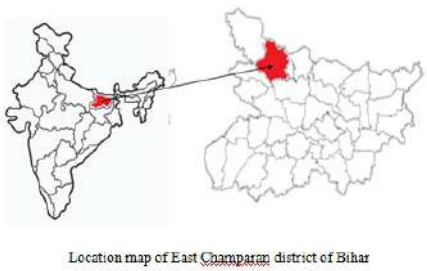

Fig.-1: Location map of East Champaran district of Bihar, India

Data Used : IRS LISS III data of the year 2000 and 2011 of 4 bands are used. Spatial resolution of LISS III data is 23.5 m, and bandwidth ranges from 0.52-0.59 m, 0.62-0.68 m, 0.77-0.86 ìm, 1.55-1.70 m and temporal resolution is of 24 days that enables proper identification of land use and land covers. False colour composite (FCC) images of East Champaran of year 2000 and 2011 are created from LISS III images collected from different websites (Fig.-2).

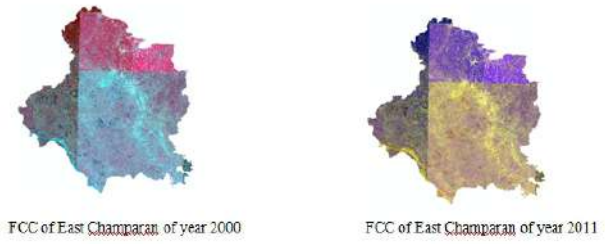

Fig.-2 : FCC map of East Champaran district of year 2000 and 2011.

Methods

First, preprocessing of satellite images have been done. Preprocessing of satellite images include geometric correction, atmospheric correction, radiometric calibration and radiometric rectification procedures. After preprocessing, images have been georeferenced. That is, establishing its location in terms of map projections or coordinate systems. In our study, the satellite data of the individual years of 2000 and 2011 were georeferenced with the help of the GCPs identified on the corresponding to Survey of India toposheet.

The study area has heterogeneity due to occurrence of urban built-up that comprises of different types of built up areas. Different types of water bodies are also available in study area such as rivers, dams and lakes. After preprocessing and georeferencing of images, training samples/ signatures were collected and different AOIs (Area of Interest) were also created for each categories/ classes. Then the LISS III images of year 2000 and 2011 were classified by using supervised standard maximum likelihood (ML) method using training signatures for different land use and land covers. After that the same images were classified using same training signatures to follow supervised artificial neural network (ANN) or simply neural network (NN) techniques.

Traditional parametric statistical approaches to supervised classification include Euclidean, maximum likelihood (ML) and mahalanobi's distance classifiers (Thomas, *etal,* 1987). There are many different types of neural networks (Dayhoff, 1990). Neural networks applied for supervised classification are similar to the K-nearest

neighbor algorithms but neural networks are more efficient and require less data for training (Lee *etal,* 1990).

Seven classes have been taken in to consideration that are crop land, fallow land, dense built-up (urban area), low built-up (rural area), river wet land, lake/ pond wet land and barren land.

Producer's accuracy, user's accuracy, overall accuracy and the value of kappa coefficients have been calculated for each standard ML and ANN classified images. At last comparison has been done among the accuracies of all classified images to get better classification methodology.

Results and Discussion

First the images of East Champaran district of year 2000 and 2011 are classified using maximum likelihood technique then in artificial neural network for comparison of accuracies to get better classified images of the study area for different land use and land covers (Fig.-3). The producer's accuracy (PA), user's accuracy (UA), overall accuracy (OA) and value of kappa coefficient of different land use and land cover categories determined from the classification of the original band of the LISS III data using maximum likelihood and ANN technique for the two different years of 2000 and 2011 of East Champaran district of Bihar using error or contingency or confusion matrix are shown in table (1-4) and figure (1-4). Classification of images has been done for training signatures. From the analyses of these figures and tables, the following observations have been made that crop land, fallow land and dense built-up area have higher producer's and user accuracy than wet land, barren land and low built-up area and the crop land exhibits the highest producer's and user's accuracy. Low built-up and barren land exhibit the lowest accuracy due intermixing of pixels with other LULC classes and dense built-up is also attributed to the occurrence of greater spectral homogeneity of the pixels to these categories than the pixels found in low built-up area. It is also observed that the PA, UA, OA and value of Kappa coefficients are higher for the year 2011 than the 2000 due to less intermixing of pixels among different LULC classes/ categories in the year of 2011 than 2000.

Conclusions

Different accuracies such as producer's, user's, overall accuracies and the value of kappa coefficients have been calculated for each classified images for both standard ML and ANN methodologies. Supervised Standard maximum likelihood and ANN classification methodologies have been used to classify images. After that comparative

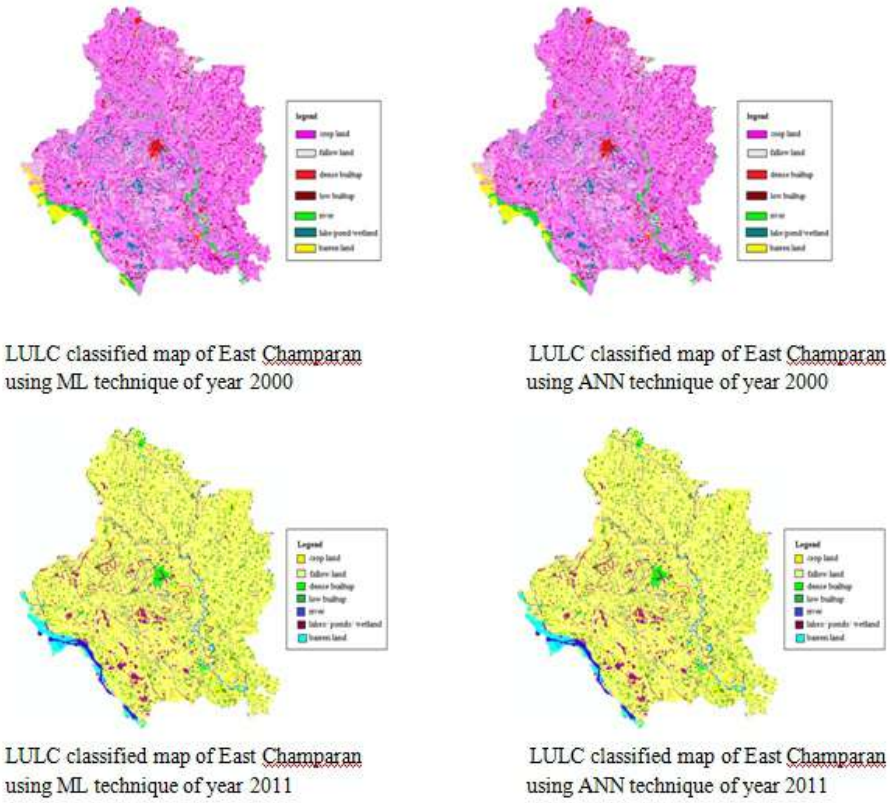

Fig.-3 : Classified maps of East Champaran district of Bihar using maximum likelihood (ML) and artificial neural network (ANN) of years 2000 and 2011 for different land use and land covers (LULC).

Table-1 : Producer Accuracy of different land use and land covers using standard ML and ANN methods of East Champaran of year 2000 and 2011.

Classes/categories	Year-2000		Year-2011	
	ML	ANN	ML	ANN
Crop land	95.12	97.42	96.64	98.21
Fallow land	93.14	94.26	94.18	95.32
Dense builtup (urban)	91.37	93.78	93.17	94.54
Low builtup (rural)	84.76	85.23	88.65	90.12
River-wetland	86.92	88.54	91.90	92.34
Lakes-ponds-wetland	85.68	87.52	89.34	90.78
Barren land	83.43	84.18	84.33	86.24

Table-2 : User Accuracy of different land use and land covers using standard ML and ANN methods of East Champaran of year 2000 and 2011.

Classes/categories	Year-2000		Year-2011	
	ML	ANN	ML	ANN
Crop land	94.15	96.28	95.24	97.32
Fallow land	92.24	93.16	93.78	94.42
Dense builtup (urban)	90.27	92.18	91.34	93.62
Low builtup (rural)	82.42	83.71	81.75	85.24
River-wetland	87.72	88.94	88.92	90.18
Lakes-ponds-wetland	86.34	87.32	87.64	89.48
Barren land	82.41	83.62	83.73	84.94

Table-3 : Overall Accuracy of different land use and land covers using maximum likelihood and artificial neural network for two years i.e. 2000 and 2011.

Year	ML	ANN
2000	86.76	91.37
2011	88.23	92.54

Table-4 : Value of kappa coefficients of different land use and land covers using standard maximum likelihood and artificial neural network for two years i.e. 2000 and 2011.

Year	ML	ANN
2000	83.64	87.12
2011	86.42	91.31

analysis among producer's accuracy, user's accuracy, overall accuracy and value of kappa coefficients of the various classes/categories determined from the classification of the images of year 2000 and 2011 for both methodologies. It is observed from tables and figures, ANN method produced the higher accuracies than the accuracies classified by using standard maximum likelihood techniques because ANN classify images containing mixed pixels more accurately than the maximum likelihood technique.

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Social-Cognition Development among Pre-School Children: An Intervention to Mothers

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Abstract

Social-cognition in pre-school children refers to, knowledge and awareness of mental states in oneself and others. Mother plays a vital role in children's social-cognition development. A study was carried out with objectives like, to know the development of social-cognition among urban and rural pre-school children. Developing and providing intervention programme for mothers on social-cognition and testing the efficacy of intervention programme on children's social-cognition and knowledge of mothers on social-cognition. Total sample comprised of 180 pre-school children, 94 children were from rural areas and 86 children were from urban areas of Dharwad Taluk. Based on results, 33 rural mothers, whose children were low in social-cognition were recruited for intervention programme. Theory of Mind Inventory by Hutchin *et al.,* (2014) was used to assess the social-cognition among urban and rural children. For intervention, self-structured questionnaire for assessing mother knowledge and social-cognition tasks were used to assess the children's social-cognition (pre-test, post-test 1 and post-test 2). Results revealed that, rural pre-school children had low social-cognition as compared to urban. Based on result, the intervention package was developed and provided for rural mothers for ten sessions. As an effect of intervention programme the mothers knowledge on social-cognition was gradually increased from pre-test to post-test 1and post-test 2. There was also significant mean difference found between pre to post test on children's social-cognition tasks like diverse belief and knowledge access tasks. So early intervention for mothers needed for children's social-cognition development.

Key words : *Social-cognition, pre-school children, mothers.*

Introduction

In developmental psychology, the early years of life are viewed as a crucial period for the achievement of social-emotional, cognitive, and linguistic milestones. Beginning in toddlerhood, children go through many changes : For example, they make significant advances in social cognition, a theoretical construct that includes the ability to infer the internal states such as, the intentions, goals, emotions, desires, beliefs, and thoughts of other people. Social cognition concerns young children's knowledge of themselves, other people and the groups to which they belong. It encompasses a variety of interpersonal domains including an individual's knowledge, perception, attitudes, and behavior in relation to social situations. The characterization of social cognition has focused most frequently upon the study of "theory of mind" (ToM), the awareness that other people have beliefs and desires of own and that behavior can be explained by reference to others. Since children develop an early understanding of other people in terms of their internal psychological states in preschool years, it is not surprising that some features of parent–child interactions in this period have been linked to children's advances in social-cognition. Mother with highly elaborative style in which they provided rich amounts of information in their statements and questions, children of these mothers were with high social-cognition skills and vice-versa. Social-cognition development results from children's repeated interaction and communication with mothers. Through cumulative interactive experience, children initially develop simple expectations about others' actions extracted from contingency and regularities in interaction, with which they form the basis for further interaction. There is also evidence that parent–child conversational turns that are semantically connected and elaborated go some way towards developing children's understanding of the representational nature of mental states(Hughes *et al,* 2014). In pre-school period, children are spending good amount of time in home so mothers play an effective role in children's social-cognition development.

So intervening mother during pre-school years may provide the most beneficial impact on the child and family due to the rapid developmental changes at this age and the high prevalence of mental state understanding. Mother-child dyadic interventions focused on parent interactive behavior and sensitivity are more effective and less costly than longer-term parenting programs. Hence the study was taken with the following objectives, to know the development of social-cognition among urban and rural pre-school children. To develop and provide intervention programme for mothers on social-cognition

and to test the efficacy of intervention programme on social-cognition among pre-school children and knowledge of mothers.

Materials and Methods

The target population of the study were the mother-child dyads with children in age group of 2-6 years residing in Dharwad taluk of Karnataka. Out of 119 villages, four villages were randomly selected and one Anganvadi from each village was selected to form the rural sample. Total 96 children were randomly selected from four Anganvadis from rural area. The urban sample (86 children) collected from four Anganwadis from urban locality of Dharwad city. Based on results, the 33 rural mothers of children with low social-cognition were requited in the intervention programme.

A Quasi experimental research design with interrupted time series was used to study the efficacy of intervention package to improve, parent's knowledge on methods to improve social-cognition in children. In the present study, rural mothers whose children were in the low level of social-cognition and who had poor awareness about social-cognition were provided intervention. Single group with one pre-test and two post-test with an interval of five sessions between the two post-tests were used to measure the change in parent's knowledge and social-cognition among children.

The social-cognition of urban and rural children was assessed using Theory of Mind inventory (Hutchins *et al.,* (2014). Which consists of total 42 items with 5 point likert scale, designed to tap a wide range of social cognitive understandings. The respondent is asked to read a statement and tick the appropriate one. Higher the score indicates the higher social cognition.

The knowledge of the mothers with respect to their children social-cognition development was measured using questionnaires (self-structured by researcher) before the commencement of intervention programme (pretest). The same questionnaires were again used at the middle of the intervention programme (after completion of five sessions; posttest 1) and at the end of the intervention programme (after completion of ten sessions; Posttest).

Children's social-cognition (pre-test, post-test 1 and post test 2) was assessed using a set of six standardized tasks (Wellman & Liu, 2004). It was used only for intervention group. Each task involved one story, researcher have to tell story to child. After each tasks one control and key question was asked. All of the tasks were coded in terms of success or failure and to succeed in each of the tasks, the children had to answer both the control and the key questions correctly. If child answers both control and key question correctly, then only 1 point was given and considered as success. If child answer only one question correctly, 0 point was given and if child answers both questions wrongly also 0 point was given and considered as failure. Thus, the range of scores was from 0 to 6.

Intervention

The intervention programme consisting of ten sessions "Educational package on children's social-cognition development: bridging knowledge to mothers" was developed. The programme was developed in such a way that most of the topics related to better development of social-cognition were addressed with the aim to develop knowledge and improve caregiver and child interaction among rural mothers which enhances their children social-cognition.

The programme was designed for ten sessions, each session was planned for duration of two hours. Information was disseminated in the form of lectures, activities, games, role plays and discussion on videos in

Activity chart : Intervention program

Sessions	Topic	No of hrs	Teaching aids used
1	Introduction classes, briefing about topic, meaning	2hrs	Lecture and interaction
2	Need of social cognition among pre-school children	2hrs	Lecture and PPT
3	Developmental mile stones in social cognition	2hrs	Lecture, poster presentation, video shows
4	Role of mother-child interaction in development of social-cognition among pre-school children	2hrs	Lecture, PPT, role-play, video shows, group discussion
5	How to interact with your child	2hrs	Lecture, flash cards, PPT, group discussion
6	Ways to improve social-cognition	2hrs	Lecture, flash cards, PPT, video shows, group discussion
7	General instructional strategies for development of social-cognition	2hrs	Lecture, flash cards, group discussion
8	Tasks to develop social-cognition	2hrs	Lecture, activities and interaction
9	Activities on social-cognition	2hrs	Activities and interaction
10	Conclusion	2hrs	Lecture and interaction

Table-1 : Association and comparison between levels of social-cognition among urban and rural pre-school children. N=180

Locality	Levels of social-cognition				Modified $_2$	Mean ± SD	t-Value
	Low	Average	High	Total			
	N (%)	n (%)	n (%)	n (%)			
Urban	21 (24.42)	46 (53.49)	19 (22.09)	86 (100)	11.36*	98.17±7.64	2.97**
Rural	32 (34.04)	48 (51.06)	14 (14.89)	94 (100)		81.97±6.48	
Total	53 (29.44)	94 (52.22)	33 (18.33)	180 (100)		124±12.39	

Figures in the parenthesis indicates percentage
** Significant at 1 per cent level, * Significant at 5 per cent level

Table-2 : Percentage distribution of mother's knowledge on social-cognition with before, during and after intervention of mothers participating in intervention. N=33

Mothers knowledge	Levels	Pre-test	Post test 1	Post test 2
	Low	14 (63.63)	6 (43.03)	3 (23.03)
	Moderate	8 (24.24)	22 (54.66)	10 (33.30)
	High	4 (12.12)	10 (33.30)	22 (45.06)
	Total	33 (100)	33 (100)	33 (100)

Table-3 : Comparison of mean scores of mother's knowledge on social-cognition before, during and after intervention among mothers participating in intervention. N=33

Time	Score range	Mean	SD	F–value
Pre-test	0-40	0.48	2.01	13.69**
Post-test 1		1.27	0.74	
Post test 2		1.63	0.32	

order to convey the message effectively. The activity book on social-cognition development among children developed by the researcher and guide was also distributed to the participants for better take home message.

The programme was delivered in the regional Kannada language. Participants consent to attend all the sessions was taken. The intervention was carried out for ten weeks from January 3rd, 2022 to Mar 17th, 2022. Sessions were conducted usually in the afternoons when the mothers (house wives) were free from their domestic responsibilities. Almost all of them attended all the sessions but some of the mothers were irregular with the completion of at least five sessions out of ten sessions.

Frequency and percentages were used to interpret the intervention group at pre-test, post-test1 and post-test2. The t-test was used to know the differences in social-cognition among urban and rural areas. Paired t-test and ANOVA was used to test the efficacy of intervention programme at before, middle and after the intervention programme.

Results and Discussion

Social-cognition among urban and rural pre-school children : The Association and difference between levels of social-cognition among urban and rural pre-school children was presented in Table-1. Result showed that, among both urban and rural locality majority of pre-school children were belonged to average level of social-cognition followed by low and high. The mean score of urban children with regard to levels of social-cognition was found to be high (98.17) compared to rural locality (81.97) and 't' value found to be significant between levels of social-cognition and locality. This situation may have originated from the fact that, poor social-skills and distractive peer-play behavior of rural children may hinder their social-cognition skills. Also parents in rural locality having poor knowledge on development of social-cognition. They were un-aware of methods and strategies to improve the social-cognition. Such as, lack in using proper way of communication, use of mental states words and giving cause and effect relationship during conversation with their children. So, children might show the poor social-cognition development. Astington *et al.,*

Table-4 : Percentage distribution of child's social-cognition with before, during and after intervention. N=33

S. No.	Social-cognition tasks	Codes	Pre-test	Post-test 1	Post-test 2
1.	The Diverse Beliefs task	Success	10 (30.30)	12 (36.36)	15 (45.45)
		Failure	23 (69.69)	21 (63.63)	18 (54.54)
		Total	33 (100)	33 (100)	33 (100)
2.	The Knowledge Access task	Success	11 (33.33)	13 (39.39)	16 (48.48)
		Failure	22 (66.66)	20 (60.60)	17 (51.51)
		Total	33 (100)	33 (100)	33 (100)
3.	Unexpected Contents task	Success	13 (39.39)	15 (45.45)	19 (57.57)
		Failure	20 (60.60)	18 (54.54)	14 (42.42)
		Total	33 (100)	33 (100)	33 (100)
4.	Explicit False Belief task	Success	15 (45.45)	17 (51.51)	20 (60.60)
		Failure	18 (54.54)	16 (48.48)	13 (39.39)
		Total	33 (100)	33 (100)	33 (100)
5.	Unexpected Contents task 2	Success	9 (27.27)	12 (36.36)	16 (48.48)
		Failure	24 (72.72)	20 (60.60)	17 (51.51)
		Total	33 (100)	33 (100)	33 (100)
6.	Unexpected Location task	Success	13 (39.39)	15 (45.45)	19 (57.57)
		Failure	20 (60.60)	18 (54.54)	14 (42.42)
		Total	33 (100)	33 (100)	33 (100)

Table-5 : Comparison of mean scores of children on social-cognition before and after intervention. N=33

Sl. No.	Social-cognition tasks	Intervention	Score-range	Mean	SD	Paired t test
1.	The Diverse Beliefs task	Pre-test	0-1	0.53	0.09	2.28*
		Post-test		0.66	0.08	
2.	The Knowledge Access task	Pre-test	0-1	0.61	0.17	3.00*
		Post-test		0.79	0.05	
3.	Unexpected Contents task	Pre-test	0-1	0.41	0.02	1.00NS
		Post-test		0.42	0.01	
4.	Explicit False Belief task	Pre-test	0-1	0.45	0.05	0.45 NS
		Post-test		0.60	0.03	
5.	Unexpected Contents task 2	Pre-test	0-1	0.41	0.12	0.21NS
		Post-test		0.43	0.03	
6.	Unexpected Location task	Pre-test	0-1	0.51	0.08	1.01NS
		Post-test		0.52	0.07	

* Significant at 5 per cent level, NS-Non significant

(2015) pointed out that, environmental factors such as disciplinary strategies and conversations with family influence the development of social-cognition. Aslan and Emen (2019) also in-line with the same results that, there is significant difference found between the urban and rural locality on social-cognition. Rural children having low level of social-cognition compared to urban children. Children's social-cognition absolutely depend on reasoning is provided when correcting their misbehaviors during their conversations with their mothers about their thoughts, desires, and emotions. While social-cognition develops further in children whose mothers talk with them about causes and effects of behaviors and events, punishment behaviors without explanation have a negative impact on the development of children's social-cognition by causing insufficient stimulation (Sigman *et at.,* 2013).

Impact of intervention on social-cognition development

Mother's knowledge on their children's social-cognition development before, during and after intervention : There is gradual increase in mean scores of mother's knowledge from pre-test to post-test 1 and 2. At pre-test, majority (63.63) belonged to low level of knowledge, during posttest 1; after the completion of 5 sessions, majority (54.66%) belonged to moderate level of knowledge. After the completion of intervention, majority (45.66%) mothers belonged to high level of knowledge (Table 2). The significant difference was observed among pre-test, post-test 1 and post-test 2 of mother's knowledge on social-cognition. Mothers scoring high on their knowledge during posttest-2 (CD = 1.25, F=13.69). There

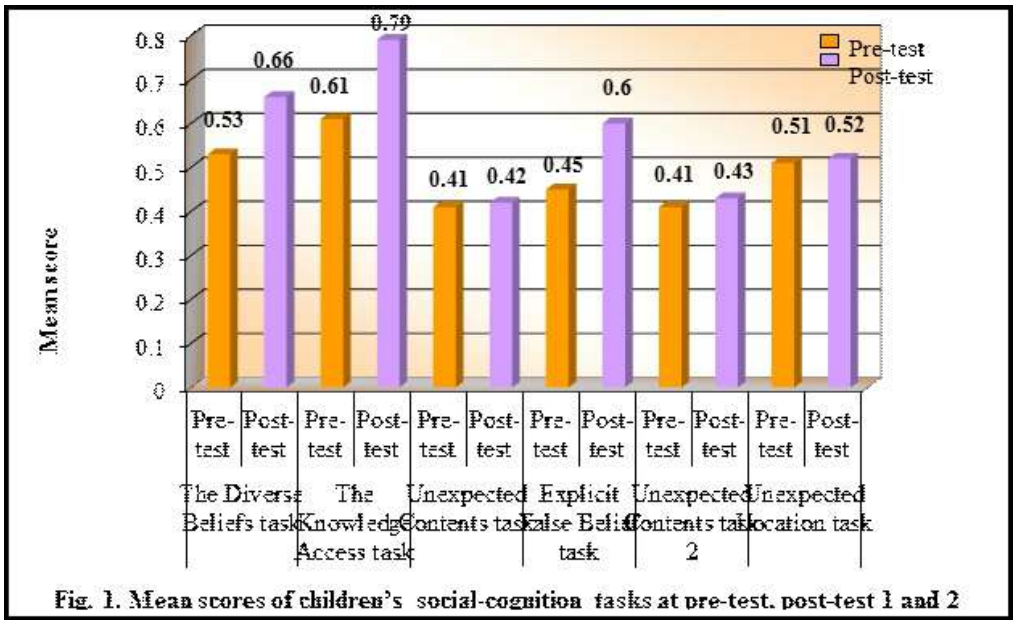

Fig. 1. Mean scores of children's social-cognition tasks at pre-test, post-test 1 and 2

was an increase of 1.15 in the mean scores on mothers knowledge from pretest to posttest-2 (Table-3). The intervention program involved topics like, interaction with child, channels and strategies for development of social-cognition, parent-child conversation, importance of developmental mile stones, imparted through use of flash cards, charts, group interaction, educational package and mobile application on social-cognition among pre-school children might helped mothers to gain knowledge on social-cognition. Banerjee *et al.,* (2015), Reese *et al.,* (2013) and Thomas *et al.,* (2013) revealed the same results that, there was significant change in mother's talk from pre-test to post-test, who were talking more elaborately than before.

The children social-cognition before during and after intervention among mothers of intervention group : The participant's children also showed better improvement on their social-cognition tasks like diverse belief and knowledge access. At pre-test, with respect to diverse belief tasks, 30.30 per cent belonged to success category, at post-test 1, after 5 sessions, 36.36 per cent belonged to success category and at post-test 2, after intervention, 37.37 per cent belonged to success category (Table 4). The mean difference of pre-test and post-test found to be significant on social-cognition tasks like diverse belief and knowledge access (Table 5). The activity book which was delivered to mothers during intervention programme, with activities like, stories, casual talk with children using mental state terms, match the following, fill in the blanks, which were aimed at stimulating children to reflect and discuss about the nature and the different ways to express emotions (face, voice, body…)**.**, played an important role in children social-cognition development. Newcombe and Reese (2007), Thomas *et al.,* (2013), Reese *et al.,* (2013) also in-line with result that, children of mothers who attended programme showed better social-cognition scores. This is the evidence that, training of mother played important role in children's social-cognition improvement.

Conclusions

The present study threw light on development of social-cognition among urban and rural pre-school children. The rural children were having the low level of social-cognition compared to urban children. Based on result "Educational package on children's social-cognition development: bridging knowledge to mothers" was developed and provided to mothers for tension session. As impact of intervention, the mothers knowledge on their children's social-cognition was increased and the significant difference was observed among pre-test, post-test 1 and post-test 2. Mothers scoring high on their knowledge during posttest-2. The children of mothers who were attended intervention programme also showed positive result on social-cognition tasks like diverse belief and knowledge access. So intervening mother during pre-school years may provide the most beneficial impact on the child and family due to the rapid developmental changes at this age and the high prevalence of mental state understanding.

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In Vitro Assessment of Phyto Extracts and Bioagents on Bell Pepper Anthracnose Incited by *Colletotrichum capsici* (Syd.) Butler and Bisby

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Abstract

The efficacy of different botanicals and bioagents were tested against anthracnose of bell pepper caused by *Colletotrichum capsici*. Eight botanicals *viz.* Garlic, Barberry, Aloe-vera, Onion, Turmeric, Artemisia, Ginger and Vach were tested at three concentrations. Among botanicals Garlic at all concentrations was found most effective *i.e.* (68.56, 75.38 and 82.09%) and minimum was found in Barberry *i.e.* (35.34, 43.06 and 48.31%). Five bioagents *viz. T. harzianum, T. viride, T. asperellum, P. fluorescens* and *B. cereus* were tested against pathogen, among bioagents *Trichoderma viride* was found maximum mycelial growth inhibition (65.25%) and minimum was found in *Bacillus cereus* (38.75%).

Keywords : *Bell pepper, anthracnose, Colletotrichum capsici, botanicals, bioagents, per cent inhibition.*

Introduction

Bell Pepper (*Capsicum annuum* L var*. grossum* Sendt), commonly known as sweet pepper or capsicum or Shimla mirch is belongs to family Solanaceae and believed to have originated from South America. It was introduced in India by the Britishers in the 19th century in Shimla hills, (Ajith, 2012). Total production was 327 thousand tons from an area of 46,000 ha with the productivity of 7108.70 Kg/ha in India (Anonymous, 2017). In Uttarakhand capsicum accounts a total growing area of 2.48(000, ha) with the production of 13.78 thousand MT, (NHB,2016-17). India ranks fourth in the production of capsicum. Bell pepper commercially cultivated in Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Arunachal Pradesh and Darjeeling district of West Bengal during April-May. Capsicum production is always low during the rainy season because most of the low lands are planted with rice, and the upland, farmers don't have planted capsicum because of the high failure rate due to anthracnose disease (Kementrian, 2020). Anthracnose, derived from a Greek word meaning 'coal', is the common name for plant dieases characterized by very dark, sunken lesions, containing spores (Isaac, 1992). Than *et al*., 2008 observed *Colletotrichum capsici*, the asexual stage, consist of hooked shaped conidia produced from acervuli, a fruiting body. An estimated annual loss of about 29.5%, amounting whopping figure of US$ 491.67 million has been reported from India alone (Garg et al., 2014). Keeping the above facts in view, the present investigations were carried out to management the efficacy of various botanicals and bioagents on anthracnose of bell pepper caused by *C. capsici.*

Materials and Methods

The experiment was conducted at Plant Pathology laboratory, College of Horticulture, VCSG UUHF, Bharsar (Pauri Garhwal) Uttarakhand.The poisoned food technique was adopted for *in vitro* testing of botanicals (Nene and Thapliyal, 1993). Eight samples namely Garlic (*Allium sativum*), Barberry (*Barberies aristata*), Aloe-vera (*Aloe barbadensis*), Onion (*Allium cepa*) Turmeric (*Curcuma longa*), Artemisia (*Artemisia absinthium*) ginger, (*Zingiber officinale*) and vach (*Acorus calamus*). Aqueous extracts from eight plants were evaluated *in vitro* against *C. capsici.* The extract of the tested plants were prepared by grinding with a mixture-grinder. 100 g washed plant samples were macerated separately in 100 mL of distilled water (w/v) and the macerates obtained were filtered separately through a double-layer muslin cloth. Each of the resulting filtrates was further filtered through Whatman no. 1 filter paper using a funnel and volumetric flasks (100 mL). The final clear extracts obtained formed the standard plant extracts at a concentration of 100 per cent.

These were evaluated each at (10, 20 and 30%) *in vitro* against *C. capsici*, applying the poisoned food technique (Nene and Thapliyal, 1993) and using potato dextrose agar (PDA) as the basic culture medium. An appropriate amount of each aqueous test extract (100%) was carefully mixed separately with autoclaved and cooled (40 ° C). PDA medium in conical flasks (250 mL) to obtain concentrations at (10, 20 and 30%). The PDA medium amended separately with the aqueous extract to be tested was then poured (20 mL/plate) into sterile glass Petri plates (90 mm in diameter) and allowed to solidify at room temperature. For each botanical extract tested and

their respective concentrations were maintained and all treatments were replicated three times. After solidification of the modified PDA medium, all treatment plates were aseptically inoculated by placing in the centre a 5 mm mycelial disc obtained from a pure culture of actively growing seven days old culture of *Colletotrichum capsici*. Plates containing PDA without any botanical extracts and inoculated with a mycelial disc of the pathogen tested served as an untreated control. All of these plates were then incubated at temperatures of 27 ±2 ° C for a week or until the untreated control plates were completely covered with mycelial growth from the pathogen tested, calculated by using formula by Vincent (1947) :

$$I \quad \frac{C \quad T}{C} \quad 100$$

Where; I = Per cent growth inhibition; C= Mycelial growth in control and T = Mycelial growth in the treatment.

Five bioagents agents namely *Trichoderma harzianum, T. viride, T. asperellum, Pseudomonas fluorescens* and *Bacillus cereus* were evaluated for their efficacy against *C. capsici* by a dual culture technique (Faheem *et al*., 2010). The biological agents and the fungus tested were inoculated side by side on a single Petri dish containing solidified PDA medium. Four replications were maintained for each treatment with control keeping only the pathogen and the biological agent separately. The inoculated plates were incubated at 28°C for four days. The colony diameter of both biological agents and pathogen measured in both directions and the average were recorded. In experiment, Complete randomized design (CRD) was used and statistical analysis of the data was done with the help of OPSTAT.

Results and Discussion

Efficacy of Botanicals : The data had presented in (Table-2) at 10% concentration all the treatments found a significant difference in mycelial of the pathogen at concentration of 10, 20 and 30 %, it had ranged from 35.34 to 68.56%. At 10% The maximum inhibitions were observed in garlic (68.56%) illuminated by vach (55.70 %) and aloe vera extract (53.69%) followed by turmeric, onion, ginger and artemisia and while minimum inhibition of the mycelium was observed in barberry extract *i.e.* (35.34%). At 20% concentration it ranges from 75.38 % to 43.06 %. Maximum inhibition was found in garlic (75.38%) and statistically comparable to vach (67.67%) followed by ginger, aloe vera, turmeric, onion and artemisia whereas, the minimum mycelium inhibition was observed in barberry extract (43.06%). At 30% concentration it had varied from 48.31 to 82.09 %. Maximum inhibition of mycelium was found in garlic (82.09%). Garlic different bioactive compounds like *i.e.* Allicin, allin, diallyl sulphide, diallyl disulphide, diallyl trisulphide and statistically comparable to vach (78.18%), ginger (71.81%), turmeric extract (67.33%) followed by aloe vera extract, onion and artemisia . While minimum inhibition was observed in barberry (48.31%). Begum and Nath (2015) studied on the effect of four botanical oils *viz.,* Garlic (*Allium sativum*), Onion (*Allium cepa)*, Ginger *(Zingiber officinale*) and Turmeric (*Curcuma longa*) at concentrations of 10%, 20% and 30%. Garlic showed cent per cent inhibition of mycelial growth of all the four isolates of *C. capsici* at all concentrations. Rahman *et.al.* (2019) studied the *in-vitro* evaluation of some phyto extracts against *Colletotrichum capsici* causing anthracnose of chilli. Chusa *et al*. (2020) observed the *in vitro* evaluation of botanicals against *Colletotrichum capsici* inciting fruit rot of Chilli. A similar type of study was also carried out by Waghe *et al*. (2015). Vivekanand *et al.* (2018) The efficacy of different chemicals, botanicals and bioagents were tested against anthracnose of chilli pathogen (*Colletotrichum capsica*). Alone and in other way combination garlic extracts were tested at five concentrations, showed effective result. Rahman *et.al.* (2019) recently studied the *in vitro* and found Barberis extract (barberine) against *Colletotrichum capsici* causing anthracnose of chilli. Similar work also done by Lokhande, *et al.,*2019 ; Chusa *et al.* (2020) also revealed the *in vitro* assessment of botanicals against *Colletotrichum capsici* inciting fruit rot of Chilli.

Efficacy of bioagents : They effect of biocontrol agents summarized in (Table 3) and indicated that *Trichoderma viride* was found most effective with 65.25% inhibition of the mycelial growth of *C. capsici* whereas *Bacillus cereus* was least effective with 38.75% inhibition. Gowtham *et.al*. (2018) reported plant growth promoting bacteria *Bacillus* improves plant growth promotion and induce resistance in chilli against anthracnose disease. Saxena *et al.* (2020) studied about the Differential Reprogramming of Defence network in *Capsicum annuum* L. plant against *Colletotrichum truncatum* Infection by phyllospheric and Rhizospheric *Trichoderma* strains. Jagtap *et al.* (2013) evaluated *in vitro* bioagents against *C. truncatum* causing pod blight of soybean *T. viride* was found most effective and recorded 18.53 mm mean colony diameter and recorded significantly highest growth inhibition (79.40%) of the test pathogen. This was followed by *T. harzianum* and *Pseudomonas fluorescence* with 73.74 and 69.31 per cent growth inhibition, respectively. Previous researchers like Ekbote, 2005 also observed a similar result for the percentage inhibition of mycelium. Among the various fungal antagonists, a potential species of *Trichoderma* has been widely used by plant pathologists due to its high efficacy, broad spectrum activity, and ease of isolation and mass multiplication. Among bacterial bioagents, *P. fluorescence* (Pyoverdine) and *Bacillus cereus* (Cerein)

Table-1 : Details of plant parts used.

Common Name	Botanicals	Plant parts used	Bioactive compounds (Biochemical compounds)
Garlic	*Allium sativum*	Bulb extract	Allicin, Alliin, diallyl sulfide, diallyl disulfide, diallyl trisulfide.
Barberry	*Barberis aristata*	Root extract	Barberine
Aloe-vera	*Aloe barbadensis*	Leaf extract	Anthranol, Aloetic acid, barbaloin, Aloin
Onion	*Allium cepa*	Bulb extract	Flavonoids, Organosulfur compounds, Fructooligosaccharides.
Turmeric	*Curcuma longa*	Rhizomes	Curcumin, Curcuminoid
Artemisia	*Artemisia absinthium*	Leaf extract	Artemisinin
Ginger	*Zingiber officinale*	Rhizomes	Gingerols, Zingiberene, Shogaols, Paradols.
Vach	*Acorus calamus*	Rhizomes	Asarone, Terpineol, Acorenone, Eugenol.

Table-2 : Effect of different treatments on per cent mycelium inhibition of *C. capsici* at different concentration 10, 20 and 30%, after seven days of inoculation.

Treatments	Per cent mycelial growth inhibition		
	10%	20%	30%
Control	0.00 ±0.00 (0.00)	0.00 ±0.00 (0.00)	0.00 ±0.00 (0.00)
Garlic extract	68.56* ±0.68 (55.87)	75.38*±0.44 (60.23)	82.09*±0.81 (64.94)
Barberry extract	35.34*±0.59 (36.46)	43.06*±0.48 (40.99)	48.31*±0.77 (44.01)
Aloe vera extract	53.69*±0.38 (47.09)	60.40*±0.38 (50.98)	64.64*±0.59 (53.49)
Onion extract	50.33*±0.38 (45.17)	56.81*±0.59 (48.89)	62.97*±0.78 (52.49)
Turmeric extract	51.89*±0.44 (46.06)	60.06*±0.19 (50.78)	67.33*±0.80 (55.12)
Artemisia extract	42.72*±0.59 (40.80)	52.34*±0.39 (46.32)	59.28*±0.80 (50.32)
Ginger extract	49.88*±0.40 (44.91)	62.41*±0.67 (52.16)	71.81*±0.51 (57.90)
Vach extract	55.70*±0.38 (48.25)	67.67*±0.29 (55.32)	78.18*±0.51 (62.13)
S.E.(d)	0.66 ± (0.39)	0.60 ± (0.36)	0.93 ± (0.58)
C.D. (P=0.05)	1.40 ± (0.82)	1.28 ± (0.76)	1.98 ± (1.24)

( ) Value in parenthesis are angular transformed.

Table-3 : Effect of bioagents on per cent inhibition against *C. capsici.*

Treatments	Per cent mycelium inhibition
Control	0.00 ± 0.00 (0.00)
Trichoderma harzianum	57.50*±0.73 (49.29)
Trichoderma viride	65.25*±0.32 (53.85)
Trichoderma asperellum	54.43*±0.21 (47.52)
Pseudomonas fluorescens	45.75*±0.32 (42.54)
Bacillus cereus	38.75*±0.32 (38.48)
S.E.(d)	0.54± (0.31)
C.D. (p=0.05)	1.15± (0.67)

( ) =Values in parenthesis are angular transformed

has been shown to be potential agents for biocontrol Ganeshan and Kumar (2009). Padder and Sharma (2011) similarly found the potential of different bioagents *viz., T. viride, T. harzianum* and *Gliocladium virens in vitro* condition observed that *T. viride* and *T. harzianum* showed maximum mycelial growth inhibition. Related study was carried out by Linu and Jisha (2013) studied the efficacy of *Pseudomonas* spp. against *Colletotrichum capsici*. Two isolates of *Pseudomonas* spp. were tested against *Colletotrichum capsici* on PDA by dual culture technique. Both the isolates showed more than 70% inhibition of the mycelial growth of the test pathogen *Colletotrichum capsici*. Isolate PI showed 78% of reduction whereas isolate P6 showed 89% of the radial growth of the test pathogen *C. capsici*. The efficacy of

three biocontrol agents (*T. harzianum*, *T. viride* and *P. fluorescence*) against isolates of *C. capsici in vitro* given by Begum and Nath (2015). Vivekanand *et al.* (2018) different bioagents agents tested *T. harzianum* also were found more effective against anthracnose of chilli pathogen, *Colletotrichum capsici.* Pandey *et al.* (2019) *In vitro* efficacy of biocontrol agents against anthracnose of french bean caused by *Colletotrichum lindemuthianum.* Similar work also done by Lokhande *et al.,* 2019. Recently Saxena *et al.* (2020) was also observed the antagonistic activities of *Trichoderma* strains against chilli anthracnose pathogen.

Conclusions

Management of bell pepper anthracnose (*C. capsici*) in Bharsar, Pauri Garhwal, Uttarakhand. Our recent study was based on different treatments showed that under *in vitro* study, Garlic (*Allium sativum*) among botanicals maximum per cent mycelial growth inhibition at all three concentrations. *Trichoderma viride* among all the bioagents observed maximum per cent mycelial growth inhibition.

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Soil Moisture Estimation Using Sentinel-1 SAR Data and Land Surface Temperature in Bhadar Canal, Gujarat State

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Abstract

This paper presents the potential for soil moisture (SM) retrieval using Sentinel-1 C-band Synthetic Aperture Radar (SAR) data acquired in Interferometric Wide Swath (IW) mode along with Land Surface Temperature (LST) estimated from analysis of LANDSAT-8 digital thermal data. In this study Sentinel-1 data acquired on 10March 2023 was downloaded from Copernicus website and LANDSAT-8 OLI data acquired on 10 March 2023 from the website https://earthexplorer.usgs.gov/.The soil samples were collected from 45 test fields in different villages of four talukas for estimating soil moisture content using the gravimetric method. The Sentinel-1 SAR microwave data was analysed using open-source tools of Sentinel Application Platform (SNAP) software for estimation of backscattering coefficient. Land surface temperature estimated using Landsat-8 thermal data. The Landsat8, Thermal infrared sensor Band-10 data and operational land imager Band-4 and Band-5 data were used in estimating LST. The Soil Moisture Index (SMI) for all field test sites was computed using the LST values. The regression analysis using ó0VV and ó0VH polarization with soil moisture indicated that ó0VV polarization was more sensitive to soil moisture content as compared to ó0VH polarization. The multiple regression analysis using field measured soil moisture (MS %) as dependent variable, and ó0VV and SMI as independent variable was carried which resulted in the coefficient of determination (R2) of 0.6812,0.7015,0.8183 for Jetpur, Dhoraji, Upleta talukas of Rajkot district, and 0.897 Junagadh taluka respectively. These linear regression equations were used to compute the predicted soil moisture in four talukas.

Key words : *analysis soil moisture, sentinel-1 SAR data, LST, SMI, backscattering coefficient, Landsat 8 OLI, TIRS data, bhadar canal*

Introduction

The Sentinel-1, a polar orbiting satellite system mission is a part of the Global Monitoring for Environment and Security (GMES) program of the European Space Agency (ESA) and the European Commission (EC) and is intended to provide continuous global all weather, day and night radar imaging in support of GMES applications (Drusch et al., 2012). Soil moisture content plays a key role in the crop production as it acts as a nutrient and serves as a solvent for other nutrients such as sodium, potassium, carbon, and nitrogen. It makes a significant impact on plant growth, percolation, and evaporation, microbiological decomposition of the soil organic matter. For many applications in hydrology, horticulture, geotechnical, agriculture and meteorology moisture content on surface of the soil is an important parameter (Ansari and Deshmukh, 2017). In agriculture point of view, soil moisture information is essential for many applications like plant stress, plant turgidity, irrigation scheduling and improving crop yield. The soil moisture affects the amount of water available for vegetation growth (Bezerra, et al., 2013). Soil moisture has a vigorous structure and thus, monitoring spatial and temporal variations in soil moisture is great importance for ecological balance.

Microwave Remote Sensing for Soil Moisture estimation : Microwave remote sensing, both active and passive, has already revealed its potential in soil moisture retrieval independent of weather conditions. This capacity is due to the fact that microwave signals are influenced by dielectric properties (and thus the water content) of the soils (Wang, 1980). There are many studies on estimating soil moisture using both passive and active remote sensing satellites. Active microwave remote sensing systems have been recently preferred in soil moisture studies because of the remarkable penetrating capabilities of radar signal into the surface. In SAR images, the sigma naught (0) which is considered as backscattering coefficient, presents the amplitude of the signal returned from target to SAR antenna that is influenced by the soil surface characteristics which is linked to the soil moisture and soil surface roughness. Retrieval of soil surface parameters from SAR data normally can be realized using the backscattering model that presents the relation between the target parameters (soil moisture and roughness) and the SAR sensor configurations such as incidence angle, polarization, and frequency (Sahebi et al., 2002). The backscattered SAR signal is affected strongly from soil moisture and surface roughness on bare soil. For bare soils, different theoretical and empirical approaches have been developed and many approaches assumed that there is a linear behaviour between surface soil moisture and SAR backscattering coefficient (sigmanought : 0) (Gao,

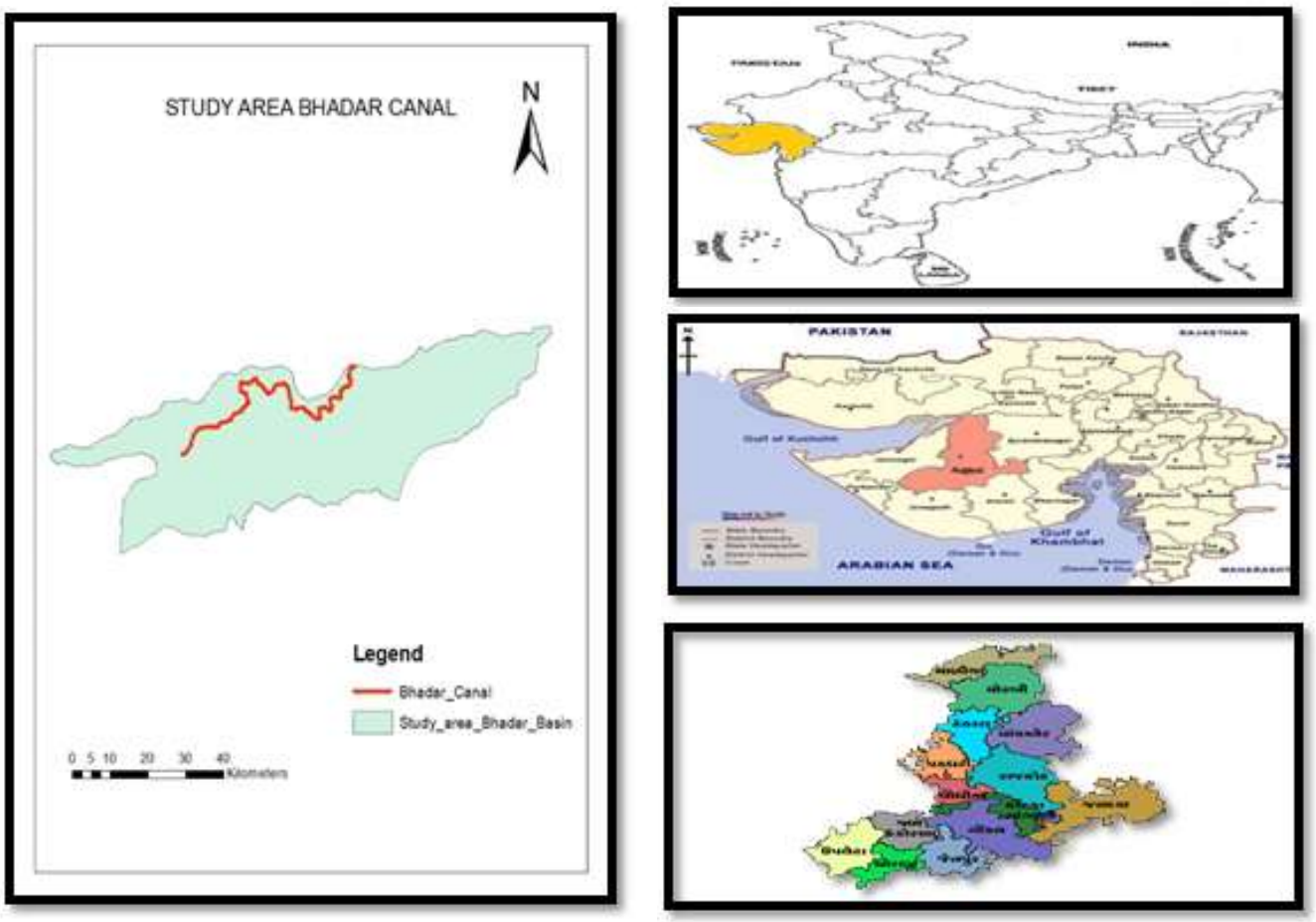


Fig.-1 : Location map of Bhadar canal.

Escorihuela, and Baghdadi, 2017, Baghdadi, Holah, and Fafin, 2005). The relative SMC ranges from zero in dry soil to unity (or 100%) in a completely saturated soil. Wagner et al., 1999a, b, developed a SMC retrieval algorithm for the ERS scatterometer. ERS backscattering is described in terms of empirical backscatter parameters and the relative surface SMC according to 0 (, t) = 0 dry (, t) + S(t)ms(t), where is the local incidence angle, t is the time, 0 dry is the backscattering coefficient observed under completely dry soil conditions in decibels, and S is the sensitivity in decibels of the 0 to changes in soil moisture.

Thermal Remote Sensing for Soil Moisture Estimation : For alternatively use to microwave remote sensing approaches, thermal remote sensing has also been extensively used to monitor soil moisture and its related variables (Amazirh et al., 2018). The land surface temperature (LST) derived from (Avdan and Jovanovska, 2016; Sekertekin et al., 2016; Ýncekara et al., 2017; Çelik et al., 2019; Sekertekin, and Bonafoni, S. 2020) the use of the LANDSAT 8 thermal infrared sensor Band 10 data and operational land imager Band 4 and Band 5 data. To understand the interaction between SAR signals and the surface many models have been developed. Different theoretical and empirical approaches have been developed for estimating soil moisture and many approaches assumed that there is a linear correlation between surface soil moisture and SAR backscattering coefficient (0) (Amazirh et al., 2018; Sekertekin et al., 2018; Paloscia et al., 2013 and Esetlili and Kurucu, 2016). The soil moisture distribution was estimated using Cband Synthetic Aperture Radar (SAR) data in an agricultural region in Bergama, a district of Ýzmir city (Þekertekin et al, 2016). In-situ soil moisture measurements were carried out in 20 test fields simultaneously with SAR data acquisition. The effects of soil moisture and local incidence angle on backscattering coefficient were analysed using these acquisition data, and then a multiple regression analysis was performed to generate an empirical model. The results showed a high correlation between SMC and SMI, coefficient of determination (R2) reached 0.81 between actual soil moisture and SMI. Furthermore, a significant correlation was also shown by Sentinel-1 data, with R2 of 0.83 between actual soil moisture content and backscattering coefficient (dB). The main objective of this study is to estimate and map soil moisture distribution using Sentinel-1 C-band SAR data in combination with LST estimated from Landsat-8 OLI data.

Table-1 : The specification of satellite data used in the study.

Satellite/Sensor	Specifications	
Landsat-8 OLI & TIRS	Acquisition date	10-march-2023
	Spatial Resolution(m)	30 m(OLI) & 100 m (TIRS)
	Path/Row	148/44
	Data Product	Collection-1 Level-1
Sentinel-1 SAR	Acquisition date	12-March-2023
	Acquisition orbit	Descending
	Imaging frequency	C-band (5.4 GHz)
	Spatial Resolution	10
	Imaging Mode	IW
	Polarization	VV-VH
	Data product	Level-GRD

Table-2 : Spectral Band characteristics of LANDSAT-8.

Band	Resolution (m)	Spectral Band	Wavelength (m)	Solar irradiance (W/(m^2 m)
4	30	Red	0.630-0.680	1574
5	30	Near Infrared	0.845-0.885	955
10	100	Longwave Infrared	10.60-11.19	-

Materials and Methods

Study Area : The experiment was conducted in the bhadar canal command area (Fig.-3.1). The bhadar canal covers two districts(Rajkot, Junagadh) under four taluka's (Jetpur, Dhoraji,Upleta, Junagadh)villages. No of farmers in this area are 8506. Irrigation Potential is 14889.08 Ha. and No. of farmers under this area are 10796. Total C.C.A. under Rajkot district is 43,114 ha.

Remote Sensing Satellite Data Used : The LANDSAT-8 OLI digital data was downloaded from the United States Geological survey official website, NASA, website of USGS. The Sentinel-1 SAR data was downloaded from the Copernicus website. Landsat-8 is an American Earth observation satellite launched on February 11, 2013. In this study, Landsat-8 satellite imagery acquired on 10-March-2023 (Path/Row: 148/44) was downloaded from USGS website. Sentinel-1 satellite provides C-band images in both singular and dual polarization within 12 days of repeat cycle. It can acquire images in three acquisition modes as Strip map (SM), Interferometric Wide Swath (IW), Extra Wide Swath (EW) and Wave (WV) with different processing levels (Drusch et al., 2012).

Soil Sample Collection in the Field : 45 villages were selected infour different taluka and in each village five soil sample collection sites were identified on the maps created in GIS. The soil samples were collected near synchronous with respect to the Sentinel-1 acquisition date. It was observed that there was no crop or vegetation cover in the test fields. The surface roughness, which is another important variable which affecting backscattering coefficient, was ignored because it was not so high for the test sites. Also, the selected fields for soil sample collection were not irrigated or there were no rains in the study area. A total number of 70-soil samples were collected from the identified sample points in different villages of Jetpur, Dhoraji, Upletaand Junagadh talukas (Figure). The collected soil samples were oven-dried in the laboratory. The process of soil sample collection in the field and drying them in the hot-air oven is given in Figure.

Soil Moisture Determination using Field Data : In recent decades, many different methods are available to determine soil moisture content. Determining soil moisture is generally considered in two groups, namely direct and indirect methods. In direct methods, the soil moisture is calculated relating to the difference between the weights of the soil sample before and after drying. In indirect methods, soil moisture content is determined by sensors and using other variables which affect the moisture content and it depends upon the device accuracy. So, the gravimetric method (direct method) is more authentic and provides accurate soil moisture than the indirect method such as dielectric method, tensiometric method etc. In this study, a gravimetric soil moisture determination method was used (Myhre and Shih, 1990; Bittelli, 2011). In the gravimetric method firstly the soil samples are collected from the field and weighted, then placed in the hot-air oven and dried at 105°C temperature for 24 hours (Almaw et. al., 2018). After complete drying the samples are weighted again to obtain dry weights, and soil moisture is estimated using the following equation (1) :

$$\text{Soil Moisture } (\%) = (Mw / Ms) \times 100 \quad \ldots\ldots 1$$

Where, Mw is mass of water and Ms is the mass of dry soil.

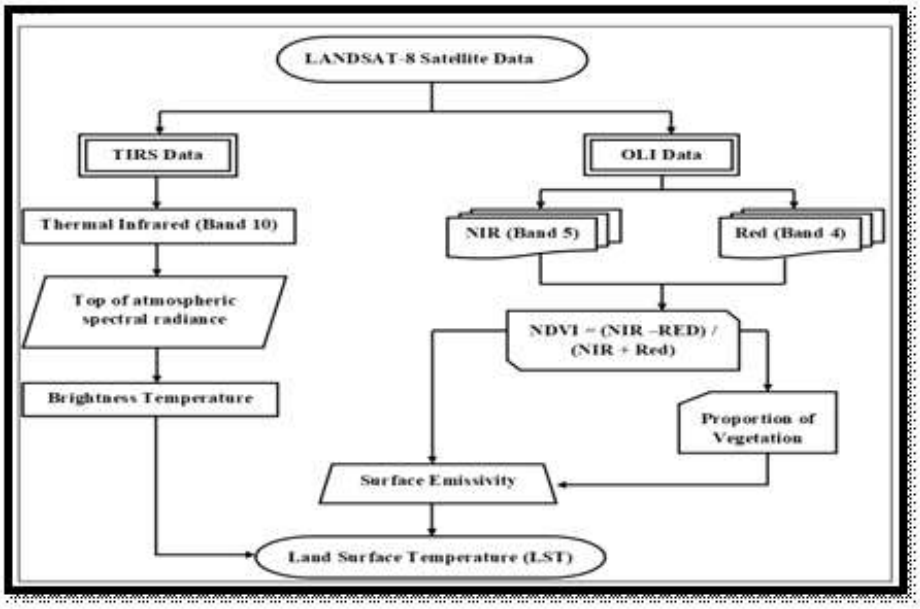


Figure-2 : Flow chart for LST estimation using Landsat8 data.

Mw = (weight of wet soil + can) – (weight of oven dry soil + can)

Ms = (weight of oven dry soil + can) – weight of can

The average mean values for each plot were computed from all the soil samples within each plot. The range of the soil moisture values are between 5 to 17 %, for Jetpur, Dhoraji, Upleta and Junagadh Taluka.

Land Surface Temperature (LST) Estimation : The Landsat-8 OLI and TIRS digital data was analysed for estimation of Land Surface Temperature (LST) of the study area. Thermal infrared sensor Band-10 data and operational land imager Band-4 and Band-5 data were used in estimating LST and characteristic of these bands (Department of the Interior U.S. Geological Survey, 2016) shown in Table-2. From the Landsat-8 digital data; Red, NIR and TIRS bands were used for calculation of LST and steps described by Avdan and Jovanovska, 2016 were followed in this study. The major steps are:

(i) Converting digital numbers (DN) to top-of-theatmosphere (TOA) radiance values (ii) Conversion of radiance to at-sensor brightness temperature,

(iii) Calculation of Normalized Difference Vegetation Index (NDVI),

(iv) Computation of Proportion of Vegetation (PV),

(v) Estimating the surface emissivity using an empirical relationship based on the NDVI, vi) Calculating LST using the simplified Plank's law.

The flow chart of LST estimation is given in Figure-5. The details of each step are described in following sections:

(i) Top of atmospheric spectral radiance : In the first step of LST estimation, band 10 from Landsat-8 OLI data has been used for estimation of top of atmospheric (TOA) spectral radiance (L) :

$$L \quad ml \quad QCal \quad Al \quad Qi$$

Where, L =Top of atmospheric spectral radiance, Ml=Band-specific multiplicative rescaling factor, Qcal = Band 10 image, Al =and-specific additive rescaling factor, Qi =correction for Band 10.

(ii) Conversion of Radiance to at Sensor Temperature: Conversion of radiance to at-sensor temperature is carried out to estimate the brightness temperature using the thermal constants which are given in Landsat-8 metadata file :

$$BT \quad \frac{K2}{ln(K1)} L \quad 1 \quad 273.15$$

Where, BT= Brightness temperature, K1 and K2 =Band-specific thermal constants, Lë=Top of atmospheric spectral radiance

(iii) Calculation of Normalized Difference Vegetation Index (NDVI) for Emissivity Correction : The amount of vegetation present can be estimated using NDVI and it can also be used to infer general vegetation condition. The NDVI is required for computing the Proportion of Vegetation (PV) which is highly related with NDVI, and emissivity ( ) should be calculated, which is related to the PV :

$$NDVI \quad \frac{NIR\ (band\ 5) + R(band\ 4)}{NIR\ (band\ 5) + R(band\ 4)}$$

Where, NDVI=Normalized Difference Vegetation Index,

NIR = Near-infrared band (Band-5), R = Red band (Band-4)

(iv) Computation of Proportion of Vegetation (PV)

$$PV \quad \frac{(NDVI \quad NDVI_s)^2}{(NDVI_v \quad NDVI_s)}$$

Where, Pv= Proportion of Vegetation, NDVI=Normal Difference Vegetation Index, NDVIV=0.5, NDVIS=0.2.

(v) Estimating the surface emissivity (LSE) using an empirical relationship based on the NDVI For calculating LSE in the model : when the NDVI value is less than 0, it is classified as water, and the emissivity value 0.991 is considered. For NDVI values between 0 to 0.2, it is classified as the land is covered with soil and there is no vegetation, and the emissivity value 0.996 is considered and the NDVI value is greater than 0.5, it is classified as land covered with vegetation and the emissivity value of 0.973 is considered. The NDVI values between 0.2 and 0.5 are classified as mixtures of soil and vegetation and the emissivity can be calculated follows :

$$_v \; P_v \quad s \; (1 \quad P_v) \quad C$$

Where, T_s = Land Surface Emissivity, Pv= Proportion of Vegetation, v 0.973, s 0.996, C Surface roughness (0.005).

(vi) Land surface temperature Computation : Land surface temperature (LST) is computed using the following equation :

$$Ts \quad \frac{BT}{1 \quad [\; BT \;] \ln}$$

Where, T_s=land surface temperature ( ), BT = Brightness temperature, = Land Surface Emissivity, = limiting wave length (10.895), $= 1.438 \times 10^{-2}$ m.

Soil Moisture Index (SMI) Computation using LST : The soil moisture index (SMI) is defined as the proportion of the difference between the current soil moisture and the permanent wilting point to the field capacity and the residual soil moisture. The index values range from 0 to 1 with 0 indicating extreme dry conditions and 1 indicating extreme wet conditions (Chandrasekar, 2016). The SMI has been retrieved directly according to (Moawad, 2012) using LST as follows:

$$\mathbf{SMI = (LST_{max} - LST) / (LST_{max} - LST_{min})}$$

Where : SMI is Soil Moisture Index, LST_{max}, LST_{min}, LST are the maximum, minimum and value of the retrieved LST respectively.

Sentinel-1 Image Pre-processing : Sentinel-1 provides data with a spatial resolution of 10 m and a temporal resolution of 12 days, in both VV and VH polarizations. In this present study, VV polarization data were used to estimate the soil moisture. Previous studies have shown that VH data has only a limited potential for the estimation of soil moisture, in particular as a consequence of its high sensitivity to volume scattering, which depends strongly on the geometrical alignment andcharacteristics of the vegetation (Karjalainen, et l., 2004; Chauhan, and Srivastava, 2016). ESA announced some steps to be performed with open source tools of Sentinel Application Platform (SNAP) software for determining backscattering coefficient (ó0). The steps of this analysis included: apply orbit file, thermal noise removal, border noise removal, radiometric calibration, speckle filtering, range doppler terrain correction and Conversion to dB (Filipponi, 2019). After applying all these steps, final backscattering coefficient image was generated from the high-resolution Level-1 Ground Range Detected (GRD) product with a spatial resolution of 10 m x 10 m. For Sentinel-1 SAR data preprocessing the Sentinel Application Platform (SNAP) software was utilized to perform radiometric and geometric corrections. The DN values of raw Sentinel-1 data were first converted to ó0 using radiometric calibration. Then, the calibrated Sentinel-1 data was georeferenced using the terrain correction algorithm. In the second step, the mean values of ó0 are extracted for each field sample. For this, the selected fields were identified on image based on their geographic coordinate. Then the boarder of each field was determined and the average of ó0 for internal pixels was calculated. The methodology flow-chart adopted for data analysis is given in Figure-3.

Pre-processing (Calibration) of Sentinel-1 Product : The main task of calibration is to derive the calibration constant by measurements of targets with exactly known backscatter coefficients. The methodology for performing the data analysis of backscatter data (Filipponi, 2019) as is follows :

(i) Apply Orbit File

(ii) Thermal Noise Removal

(iii) Border Noise Removal

(iv) Calibration

(v) Conversion to dB

Landsat-8 and Sentinel-1 Satellite data analysis : In this study, back scattering coefficient ^{0} vv (dB) and soil moisture index (SMI) is considered as a function of soil moisture as given in Equation -9.

$$\mathbf{MC\ (\%) = X1 * SMI + X2 * \ 0\ vv\ (dB) + c}$$

Where 0 (dB) is backscattering coefficient, and SMI is the Soil Moisture Index. In this multiple regression analysis, MC (%) is considered as a dependent variable, whereas 0 (dB) and SMI are independent variables.

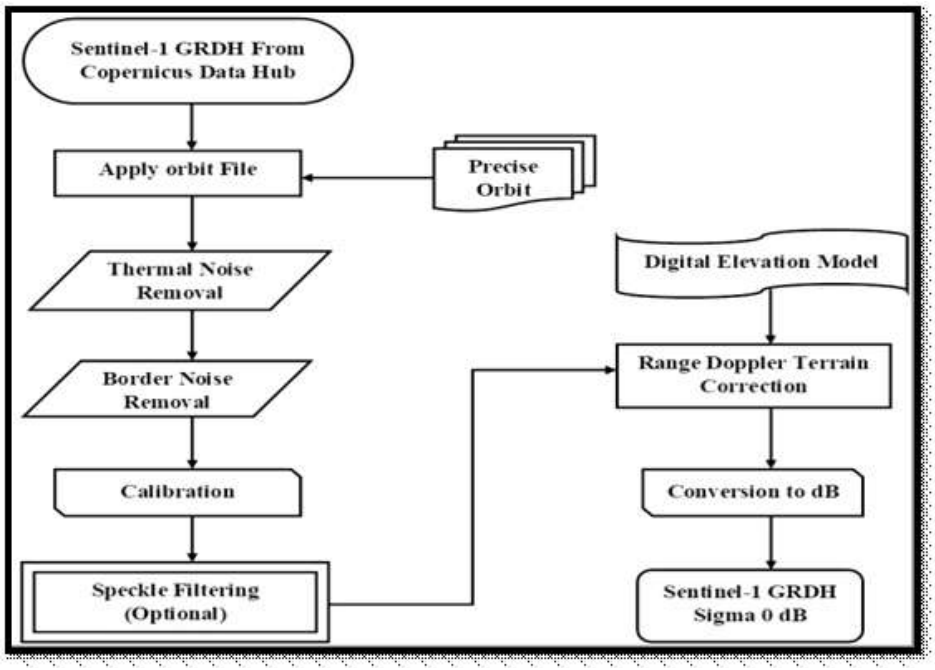


Figure-3 : Methodology flow chart of Sentinel-1 SAR data analysis.

Validation of Soil Moisture : For the validation of the predicted soil moisture, performance indices namely coefficient of determination (R^2) and NSEwere utilized. The equation of these performance indices is presented in Equation 10 and 11.

$$R^2 \quad \frac{\sum_{i=1}^{n}(O_i - O)(P_i - P)}{\sum_{i=1}^{n}(O_i - O)^2 \sum_{i=1}^{n}(P_i - P)^2}^{2}$$

Where Oi and Pi are the observed soil moisture and predicted soil moisture respectively, ??¯and ??¯are the means of the observed soil moisture and predicted soil moisture respectively) n is the number of data sets.

Nash – Sutcliffe efficiency

$$NSE \quad 1 \quad \frac{\sum_{t=1}^{T}(Q_o^t - Q_m^t)}{\sum_{t=1}^{T} Q_o^t - \overline{Q_0}}$$

Where, is the mean of observed soil moisture Qm, is modelled soil moisture, Qtois observed discharge at time t

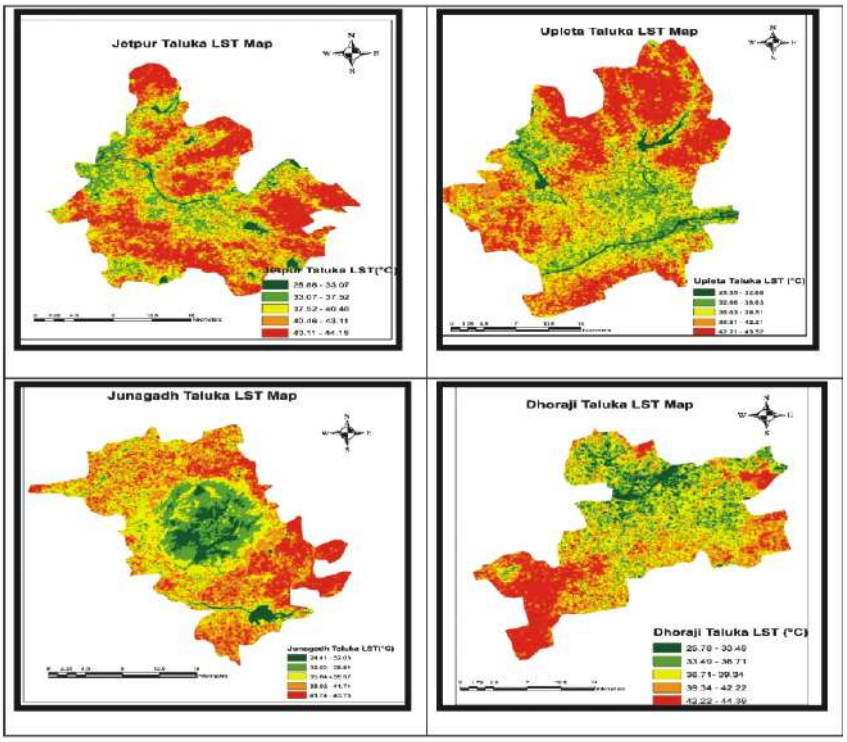
Results and Discussion

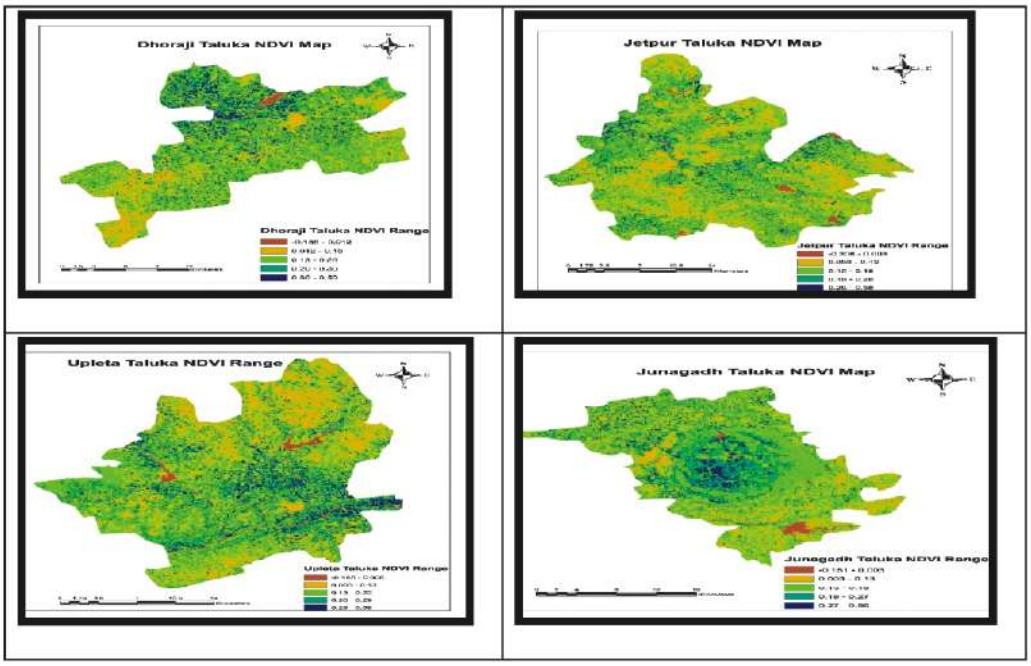
Estimation of Land Surface Temperature from Landsat-8 Satellite Data : The algorithm was created in ArcGIS for estimating land surface temperature using Landsat-8 OLI and TIRS data. For estimating LST, the TIRS band-10 was used to estimate brightness temperature and bands-4 (Red) and 5 (NIR) were used for calculating the NDVI. Land surface temperature ofJetpur, Dhoraji, Upleta and Junagadh talukas of Rajkot and Junagadh district was estimated using the LANDSAT-8 data of 10-March-2023 and the results of four the talukas.

For Jetpur taluka LST from Landsat -9 minimum temperature is 25.88(°C) and 47.76(°C) maximum temperature and standard deviation 2.64.

For Upleta taluka LST from Landsat -9 minimum temperature is 27.66(°C) and 47.07(°C) maximum temperature and standard deviation 3.11.For Junagadh taluka LST from Landsat -9 minimum temperature is 24.92(°C) and 55.10(°C) maximum temperature and standard deviation 2.87.For Dhoraji taluka LST from Landsat -9 minimum temperature is 25.78(°C) and 47.39(°C) maximum temperature and standard deviation 2.17. Higher temperatures area was increased because of barren land or harvesting of crop and exposed soil. (andhle and Parmar (2020).

NDVI Calculation : The NDVI have been used widely to examine the relation between Spectral variability and the changes in vegetation growth rate. Lower values were found the less vegetated soils and presumably because reflection from the soil was high and produce low values in near infra-red band and high values in red band: hence the NDVI values were low(Parmar and Gontia (2016)). The maximum dry edge of the soil is equal to 1, and the minimum wet edge equals 0. The soil moisture index is based on the relationship between LST and NDVI. It is also useful to determine the production of green vegetation as well as detect vegetation changes. (Fig.4.10,4.11,4.12,4.13) NDVI values range from –1 to 1. High photosynthetic activity leads to lower reflectance in the red region of the spectrum and higher values in the near infrared. The ratio of these indicators to each other makes it possible to clearly distinguish vegetation from





other natural objects. The index only takes positive values. NDVI values cannot be less than 0 for vegetation. (Parmar and N.K.Gontia (2019)).

Estimation of backscattering coefficient Ó0 (DB) from sentinel-1 satellite : Here Different steps in SNAP image different Back scattering coefficient Sigma VV- dB and Sigma VH-dB for Bhadar region are given below.

For calibrated SNAP image for Bhadar canal area Sigma VV-dB and Sigma VH- dB image For Bhadar canal area are there.The Sentinel-1 backscattering coefficients ó?VV and ó?VH were related to measured soil moisture using linear regression (Figure-3). During this study, the soil moisture values varied between 4 and 25 vol.% and the values of °VH and °VV ranged from -20.40 dB to -25.27dB and from -7.04dB to -14.40 dB, respectively. By

Table-12 : Back scattering coefficient Sigma VV-dB of Bhadar canal.

	Minimum Sigma VV-dB	Maximum Sigma VV-dB
Calibration	-7.0456	-25.278
Speckle filtering	-8.2177	-23.9765
Range Doppler Terrain	-8.1592	-20.4058

Table-13 : Back scattering coefficient Sigma VH-dB of Bhadar canal

	Minimum Sigma VH-dB	Maximum Sigma VH-dB
Calibration	-13.44314	-29.090
Speckle filtering	-14.4025	-27.748
Range Doppler Terrain	-14.3246	-25.282

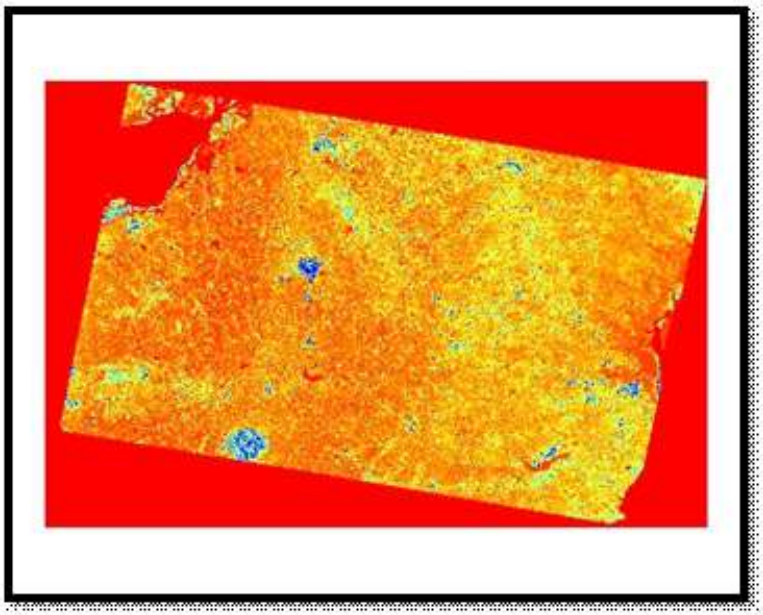


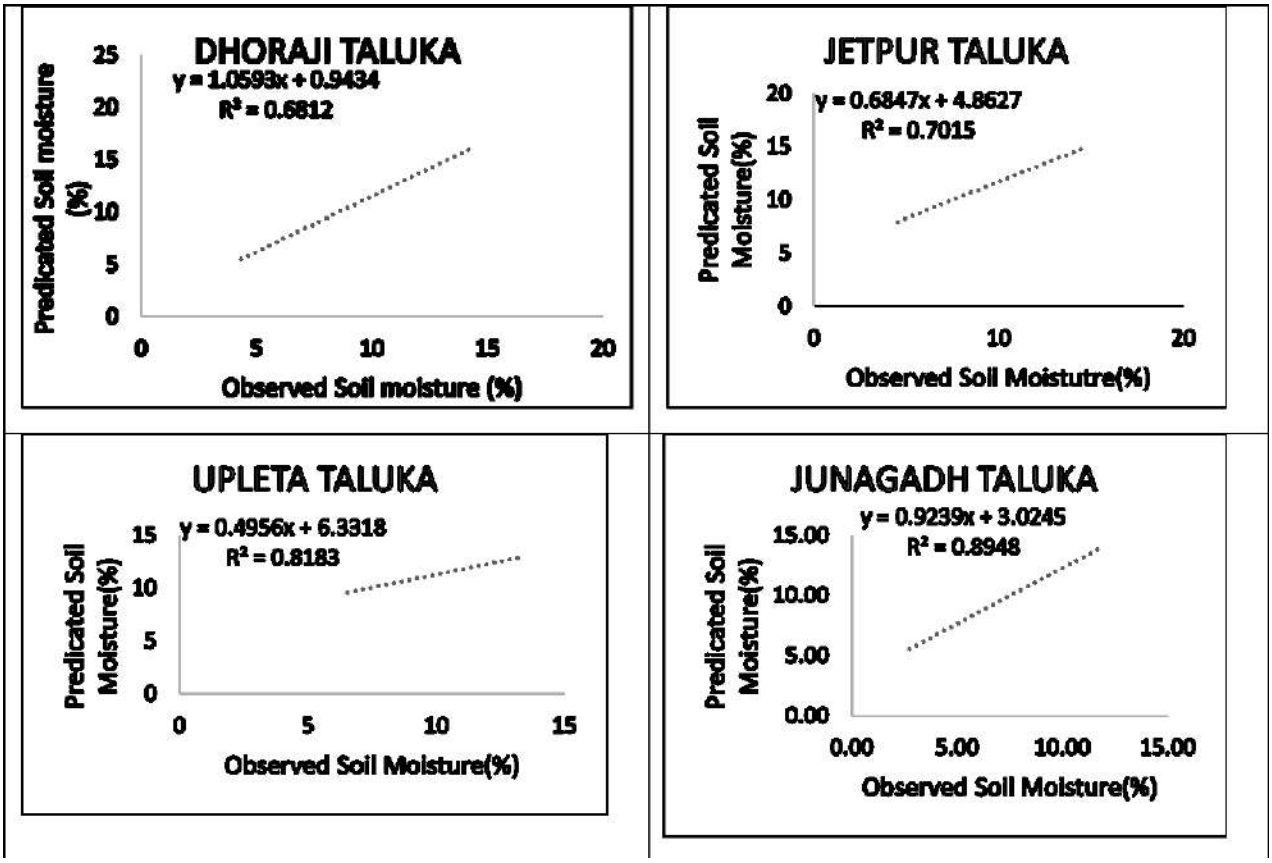
Fig.-4 : RGB image of Sentinel-1 Bhadar canal.

analyzing this figure, it can be clearly seen that the Sentinel-1 radar at VV polarization is significantly correlated with the measured soil moisture compared to the VH polarization which showed more dispersion.

Linear regression analysis between observed and predicted moisture content : The linear regression analysis between observed and predicted moisture content was also carried out which resulted in coefficient of determination (R^2) 0.6812, 0.7015 and 0.8183 and 0.89 for, Jetpur, Dhoraji,Upleta and Junagadh talukas, respectively. The linear regression analysis between observed and predicted soil moisture (%) of Dhoraji, Jetpur, Upleta and Junagadh talukas are given in Figure-4.7, 4.8, 4.9, 4.10 respectively. NSE is 0.23 Jetpur, 0.25 Dhoraji, 0.22 Upleta,0.21 Junagadh Taluka.

Conclusions

In this study, Sentinel-1 C-band SAR and Landsat-8 OLI data was analyzed for soil moisture estimation in four talukas of Rajkot and Junagadh district, Gujarat State. A total number of 45-soil samples were collected near synchronous with respect to the Sentinel-1 acquisition date from the identified sample points in different villages of Jetpur, Dhoraji, Upletaand Junagadh talukas. The in-situ soil moisture content was determined using the gravimetric method. The Sentinel-1 SAR microwave data was analysed using Open-source tools of Sentinel Application Platform (SNAP) software for estimation of backscattering coefficient. The Land Surface Temperature (LST) estimated using Landsat-8 thermal data. The Landsat-8, Thermal infrared sensor Band-10 data and operational land imager Band-4 and Band-5 data were used in estimating LST. The Soil Moisture Index (SMI) for all field test sites was computed using the LST values.The ó0VV (dB), and ó0VH (dB) was generated and used in regression analysis to estimate soil moisture content. The regression analysis using ó0VV and ó0VH polarization with soil moisture indicated that ó0VV polarization was more sensitive to soil moisture content as compared to ó0VH polarization and the coefficient of determination (R2) values for ó 0 VV and ó 0 VH polarizations were 0.72 and 0.276, respectively in Godhra



Taluka. The multiple regression analysis using field measured soil moisture (MS %) as dependent variable, and ó0 VV and SMI as independent variables was carried which resulted in the coefficient of determination (R^2) of 0.6812, 0.70, 0.81 and 0.89 for Jetpur, Dhoraji, Upleta and Junagadh talukas, respectively.

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Bio-Efficacy of Different Doses of Pyridaben 10% EC with Some Novel Insecticides against Brinjal Shoot and Fruit Borer, *Leucinodes orbonalis*

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Abstract

The present investigation on "Bio-efficacy of different doses of pyridaben10% EC with some novel insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis*" was carried out at the Vegetable Research Farm Institute of Agriculture Sciences, BHU, Varanasi. The shows the mean larval population of *L. orbonalis* after the first spray was lowest in Emamectin benzoate 5% SG (0.45 larvae/plant) and mean reduction over control (84.45%) and the highest mean population in imidacloprid 17.8 % SL (1.25 larvae/plant) with mean reduction over control (67.61%). The mean larval population after 2nd spray was lowest in Emamectin benzoate 5% SG (0.41 larvae/plant) and mean reduction over control (88.28 %) followed by pyridaben 10% EC @ 50g (0.59 larvae/plant) and mean reduction over control (83.14%) and the highest mean population in the treated plot is imidacloprid 17.8 % SL (1.41 larvae/plant) with a mean reduction over control (59.71%).The percentage of fruit infections was lowest among all the treatments in emamectin benzoate 5% SG with 15.33% followed by imidacloprid 17.8 % SL (16%), and the maximum fruit infestation among insecticides in pyridaben 10% EC (35%). Among all the treatments, the highest mean yield was recorded under emamectin benzoate 5% SL (266.66 q/ha) with 89.12% percent yield increase over control followed by imidacloprid 17.8% SL (258.66 q/ha.) with 83.45% percent yield increase over control, and the lowest yield in pyridaben 10% EC @ 20g (173.33 q/ha) with 22.92% percent yield increase over control.

Introduction

Brinjal (*Solanum melongena* L.) is one of the most common vegetables grown throughout the country; known as eggplants belongs to the Solanaceae family. The Solanaceae family covers more than 2450 plant species distributed in 95 genera (Mabberley, 2008). Brinjal is originating in India. It is cultivated as a vegetable throughout tropical, sub-tropical, and warm temperate areas across the world. The name brinjal is derived from Arabic and Sanskrit while the name eggplant has arisen from the shape of the fruit of some varieties and is similar to chicken eggs in form of shape. Brinjal is the second most important vegetable crop next to tomato. Brinjal is a short-lived perennial herb grown as an annual plant. It is one of the most consumed fruit vegetables in tropical Africa; probably the third after tomato and onion, and before okra. It has high nutritional value it contains high Ca, Mg, P, K, and Fe. Vitamins -A and C are obtained from brinjal. The purple variety of brinjal is a good source of copper whereas green varieties have high Fe content. White brinjal is mostly preferred by diabetic patients as it has healthy effects on blood sugar levels. Due to its nutritive value, consisting of minerals like iron, phosphorous, calcium, and vitamins like A, B, and C, unripe fruits are used primarily as vegetables in the country (Singh *et al.*, 1963).

Materials and Methods

The present studies were conducted during the *kharif* season 2017-18. The field experiments were carried out at the Vegetable Research Farm Institute of Agriculture Sciences, BHU, Varanasi to study the "Effective dose evaluation of pyridaben10% EC along with some novel insecticides, against major insect pests of brinjal". The experimental plot is in the eastern U.P. between 25° 15' N Latitude and 83° 03'E longitude at an elevation of 129.23 m above MSL.

Experimental Details : Investigate the effect of novel insecticides on the brinjal hybrid variety H-704 with 7 treatments and three replications. The size of the plot is 3x2 m^2 and the spacing is 60x45 cm^2 all other details are given in table-1.

Table-1 : Experiment details.

Particulate	Details
Crop	Brinjal
Variety	H-704
Season	Kharif 2017-18
Replication	3
Treatment	7
Spacing	60 x 45 cm^2
Plot size	3 × 2 m^2
Date of sowing	12th August 2017
Date of transplanting	11th September 2017

Application of Treatments : At first, water spray was done over the untreated control plot to determine the amount of water needed to prepare the insecticide solution from the formulation for different treatments (table no. 2). The application of insecticides started five weeks after transplanting when the moderate infestation was observed and only two insecticidal applications were sprayed during the crop growth period between 20-day intervals on 17/10/2017, and 27/10/2017.

Table-2 : Treatments Details.

Treatments	Insecticides	Dose of insecticide g a.i/ha
T_1	Pyridaben10% EC	20g a.i.
T_2	Pyridaben10% EC	30g a.i.
T_3	Pyridaben10% EC	40g a.i.
T_4	Pyridaben10% EC	50g a.i.
T_5	Imidacloprid 17.8% SL	50g a.i
T_6	Emamectin benzoate 5% SG	10g a.i.
T_7	Untreated Control	-

Results and Discussion

Effect of insecticides on brinjal shoot and fruit borer, *L. orbonalis* : The brinjal shoot and fruit borer population has variable results in response to various insecticides in all treatments. Under the management of the shoot and fruit borer larvae population in field conditions, the insecticides tested for their effectiveness against shoot and fruit borer were significantly better than untreated control.

First spray : The observation of the larval population of the shoot and fruit borer was recorded on the brinjal field in all the treatments one day before, 3rd, 7th, 10th, and 15th days after insecticide application during *Kharif* season 2017-18, data shown in table-3 and 4.

Second spray : The mean population of *L. orbonalis*varied one day before 2nd spray from 2.36 to 4.92 larvae/plant in the treatments which were non-significantly different from each other. Overall the mean of population after the second spray was observed lowest in Emamectin benzoate 5% SG (0.41 larvae/plant) and mean reduction over control (88.28 %) followed by pyridaben 10% EC @ 50g (0.59 larvae/plant) and mean reduction over control (83.14%) and the highest mean population in the treated plot is imidacloprid 17.8 % SL (1.41 larvae/plant) with a mean reduction over control (59.71%).The present findings are similar toMandal *et al*. (2010) reported that emamectin benzoate 5% SG was the most effective insecticide to manage the shoot and fruit borer in brinjal. The overall fruit damage reduction is 69.93 % to 73.04%.

Effect of insecticidal treatments on percent fruit infestation of brinjal : The percentage of fruit infections was minimum among all the treatments in emamectin benzoate 5% SG with 15.33% followed by imidacloprid 17.8 % SL (16%), pyridaben 10% EC @ 50g (18%), pyridaben 10% EC @ 40g (24%), pyridaben 10% EC @ 30g (28%) and the maximum fruit infestation in the untreated plot (50%) data shown in table-5.

Effect of insecticidal treatments on yield of brinjal : Overall, the maximum yield was reported in emamectin benzoate 5% SL (16.00 kg/plot) treated plot followed by imidacloprid 17.8% SL (15.52 kg/plot) and the minimum fruit yield in the untreated control (8.46 kg/plot) followed by

Table-3 : Effect of insecticidal treatments on the larval population of brinjal shoot and fruit borer (*L. orbonalis*) after the second spray.

Treatment	Dose (g a.i. ha^{-1})	No. of larvae/ plant before spray	No. of larvae/plant					
			3 DAS	7 DAS	10 DAS	15 DAS	Mean	MRC %
Pyridaben 10% EC	20g a.i.	3.22* (2.05)**	2.15 (1.77)	1.31 (1.51)	1.03 (1.42)	0.93 (1.38)	1.35	61.42
Pyridaben 10% EC	30g a.i.	2.91 (1.97)	1.69 (1.63)	1.18 (1.47)	0.85 (1.36)	0.76 (1.32)	1.12	68.00
Pyridaben 10% EC	40g a.i.	2.75 (1.93)	1.41 (1.55)	0.79 (1.33)	0.55 (1.24)	0.49 (1.22)	0.81	76.85
Pyridaben 10% EC	50g a.i.	2.48 (1.86)	1.16 (1.46)	0.66 (1.28)	0.30 (1.14)	0.25 (1.11)	0.59	83.14
Imidacloprid 17.8% SL	50g a.i	3.48 (2.11)	2.50 (1.86)	1.25 (1.50)	1.11 (1.45)	0.81 (1.34)	1.41	59.71
Emamectin Benzoate 5% SG	10g a.i.	2.36 (1.83)	0.81 (1.34)	0.40 (1.8)	0.27 (1.12)	0.19 (1.01)	0.41	88.28
Untreated Control	-	4.92 (2.43)	6.22 (2.68)	3.08 (2.02)	2.48 (1.85)	2.35 (1.81)	3.50	-
SEm±	-	-	0.056	0.033	0.07	0.07	-	-
CD at 5 %	-	NS	0.122	0.103	0.22	0.23	-	-

*Mean value, ** Square root transform value, DAS- Day after the spray, NS- Non-significance, MRC- Mean Reduction Over Control.

Table-4 : Effect of insecticidal treatments on the population of brinjal leaf hopper *A. biguttulabiguttula* after the first spray.

Treatment	Dose (g a.i. ha^{-1})	No. of hoppers/ plant before spray	No. of hoppers/plant					
			3 DAS	7 DAS	10 DAS	15 DAS	Mean	MRC%
Pyridaben10% EC	20g a.i.	12.20* (3.63)**	7.03 (2.83)	4.00 (2.23)	6.10 (2.69)	6.50 (2.73)	5.95	54.99
Pyridaben10% EC	30g a.i.	12.43 (3.66)	6.19 (2.68)	3.43 (2.10)	4.13 (2.26)	4.33 (2.30)	4.52	65.80
Pyridaben10% EC	40g a.i.	12.68 (3.69)	5.00 (2.44)	2.55 (1.88)	3.41 (2.09)	3.95 (2.22)	3.75	71.63
Pyridaben10% EC	50g a.i.	12.32 (3.65)	4.43 (2.33)	2.39 (1.84)	2.83 (1.95)	2.96 (1.98)	3.15	76.17
Imidacloprid 17.8% SL	50g a.i	12.13 (3.62)	4.03 (2.24)	1.90 (1.69)	2.50 (1.86)	2.89 (1.96)	2.83	78.59
Emamectin Benzoate 5% SG	10g a.i.	12.45 (3.66)	7.26 (2.87)	4.76 (2.39)	6.13 (2.66)	7.00 (2.82)	6.28	52.49
Untreated control	-	12.57 (3.68)	12.52 (3.67)	13.03 (3.74)	13.53 (3.81)	13.80 (3.84)	13.22	-
SEm±	-	-	0.06	0.05	0.06	0.10	-	-
CD at 5 %	-	NS	0.19	0.15	0.18	0.32	-	-

*Mean value, **- Square root transform value, DAS- Day after the spray, NS- Non-significance, MRC- Mean Reduction Over Control.

Table-5 : Effect of insecticidal treatments on percentage fruit infestation of brinjal.

Treatment	Dose (g a.i. ha^{-1})	% fruit infestation
Pyridaben 10% EC	20g a.i.	35.00%
Pyridaben 10% EC	30g a.i	28.00%
Pyridaben 10% EC	40g a.i	24.00%
Pyridaben 10% EC	50g a.i.	18.00%
Imidacloprid 17.8% SL	50g a.i	16.00%
Emamectin Benzoate 5%	10g a.i	15.33%
Untreated check	-	50%
SEm±	-	1.44
CD at 5%	-	4.44

Table-6 : Effect of insecticidal treatments on yield of brinjal.

Treatment	Dose (g a.i. ha^{-1})	Yield Kg/ plot					Percent yield increase over control
		1^{st} picking (Kg)	2^{nd} picking (Kg)	3^{rd} picking (Kg)	Total yield (kg/plot)	Mean yield (q/ha)	
Pyridaben 10% EC	20g a.i.	2.10	5.50	2.80	10.4	173.33	22.92
Pyridaben 10% EC	30g a.i.	2.50	5.70	2.93	11.13	185.5	31.56
Pyridaben 10% EC	40g a.i.	3.00	6.86	3.20	13.06	217.66	54.37
Pyridaben 10% EC.	50g a.i.	3.30	7.13	3.46	13.89	231.50	64.18
Imidacloprid 17.8% SL	50g a.i.	3.86	7.86	3.80	15.52	258.66	83.45
Emamectin Benzoate 5% SG.	10g a.i.	3.90	8.00	4.10	16.00	266.66	89.12
Untreated check	-	1.96	4.00	2.50	8.46	141	-
SEm±	-	0.12	.017	0.191	-	-	-
CD at 5 %	-	0.37	0.54	0.59	-	-	-

pyridaben 10% EC @ 20g (10.40 kg/ plot). Among the different treatments, highest mean yield was recorded under emamectin benzoate 5% SL (266.66 q/ha) followed by imidacloprid 17.8% SL (258.66 q/ha.), pyridaben 10% EC @ 50g (231.50 q/ha), pyridaben 10% EC @ 40g (217.66 q/ha), pyridaben 10% EC @ 30g (185.60 q/ha), pyridaben 10% EC @ 20g (173.33 q/ha).

The present investigation shows the percent yield increase over control among all the treatments after two

sprays was the maximum in Emamectin benzoate 5% SL (89.12) followed by imidacloprid 17.8% SL (83.45%), pyridaben 10% EC @ 50g (64.18%), pyridaben 10% EC @ 40g (54.37%), pyridaben 10% EC @ 30g (31.56%), pyridaben 10% EC @ 20g (22.92%).

The present findings are similar to Kameshwaran *et al*. (2015) reported that the emamectin benzoate 5% SG and imidacloprid 17.8 % SL produce the maximum yield among all the treatments.

Conclusions

The present experiment was conducted to study the "Effective dose evaluation of pyridaben 10% EC along with some novel insecticides against major insect pests of Brinjal. The efficacy of insecticides was studied, and the most effective insecticide for the management of brinjal shoot and fruit borer (*L. orbonalis*) is emamactin benzoate 5% SG with mean population (0.41 larvae/plant) and mean reduction over control (88.28 %) followed by pyridaben 10% EC @ 50g (0.59 larvae/plant) and mean reduction over control (83.14%) and the highest mean population in the treated plot is imidacloprid 17.8 % SL (1.41 larvae/plant) with a mean reduction over control (59.71%) after two sprays of insecticides.

The lowest fruit infestation and highest yield in the Emamectin benzoate 5% SG with 15.33% infestation and 266.66 q/ha yield followed by imidacloprid 17.8% SL with 16% infestation and 258.66 q/ha and the highest fruit infestation in pyridaben 10% EC @ 20g, 35% infestation and lowest yield 177.33 q/ha in treated plots. The percent yield increase over control among all the treatments after two sprays was the maximum in Emamectin benzoate 5% SL (89.12) followed by imidacloprid 17.8% SL (83.45%) and the minimum in pyridaben 10% EC @ 20g (22.92%) under-treated plots.

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Effect of Seaweed Extract on Growth, Yield and Quality of Chickpea (*Cicer arietinum* L.) in Eastern Rajasthan

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Abstract

A field experiment entitled "Effect of Seaweed Extract on Growth, Yield and Quality of Chickpea (*Cicer arietinum* L.) in Eastern Rajasthan" was conducted during *Rabi* season of 2022-23 at Titerwada, Sainthal, Dausa, (Vivekananda Global University, Jaipur). The experiment consisting of nine treatment combinations of nutrients and thiourea *viz.* control (T_1), water spray (T_2), seed treatment with seaweed extract (3 ml/kg seeds) (T_3), foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_4), foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_5), foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_6), seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_7), seed treatment + foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_8) and seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) were laid out in randomized block design with three replications. For experimentation, chickpea variety CSJ - 515 was used.

Key words : *Seaweed, quality, extract, yield and chickpea.*

Introduction

India has become self-sufficient with respect to the production of cereals but still lags behind with respect to the production of pulses. Ever increasing population pressure, resulting in protein malnutrition causes a serious concern and urgently calls for stepping up the productivity of pulses. The role of pulses in human diet and in diversified systems of farming is well known. Pulses are important source of dietary protein and have unique ability of maintaining and restoring soil fertility through biological nitrogen fixation as well as addition of ample amount of residues to the soil. About a dozen pulse crops *viz.* chickpea, pigeon pea, mungbean, urdbean, lentil, field pea, lathyrus, cowpea, common bean, mothbean and rice bean are cultivated under varied agro-ecological conditions.

Chickpea (*Cicer arietinum* L.) is also known as gram, Bengal gram, or Spanish pea and is considered to be the third most important pulse crop of the world after French bean (*Phaseolus vulgaris* L.) and ?eld peas (*Pisum sativum* L.). It is an important source of protein in human diet. It plays a significant role in sustaining production of the subsistence farming system. There is a growing demand for chickpea due to its nutritional value as seeds of chickpea containing 20-22% protein, 60-62% carbohydrate, 5% fat and is rich in calcium and iron. Chickpea is classified based on seed size, shape and color. The types are common; the small angular and colored seeds are classified as desi and the larger ram-head shaped and beige colored seed are called Kabuli.

Globally, chickpea is mostly consumed as a food in several different forms and preparation determined by ethnic and regional factor (Muehlbauer and Tullu, 1997). In Indian subcontinent chickpea is consumed as split (*dal*) and flour (besan), used to prepare different snacks (Chavan *et al.,* 2003). In other part of the world especially in Asia and Africa, chickpea is used in sweets, soups, salads and consumed in roasted, boiled, salted and fermented forms (Gecit, 1991). Chickpea is basically winter season crop which requires good moisture with optimum temperature from 24 to 30 degree Celsius for well growth (Raheja, 2016).

Materials and Methods

An experiment was conducted at Vivekananda Global University, Jaipur during *rabi* 2022-23. The field's soil was loamy sand, with low organic carbon (0.21%), an alkaline pH (pH 8.2), low available nitrogen (132.87 kg ha^{-1}), medium available phosphorus (20.64 kg ha^{-1}) and medium available potassium (238.10 kg ha^{-1}). The experiment consists 9 treatments (T_1: Control, T_2: Water spray, T_3: Seed treatment with seaweed extract (SE) (3 ml/kg seeds), T_4: Foliar spray of seaweed extract (3 ml/lit.) at tillering stage, T_5: Foliar spray of SE (3 ml/lit.) at heading stage, T_6: Foliar spray of SE (3 ml/lit.) at tillering and heading stage, T_7: Seed treatment + foliar spray of SE at tillering stage, T_8: Seed treatment + foliar spray of SE at heading stage, T_9: Seed treatment + foliar spray of SE at tillering and heading stage was laid out in Randomized

Block Design and replicated three time. Plot size was 2.0 m × 2.0 m. Crop variety CSJ – 515 with 80 kg seed rate ha^{-1} was taken for experiment.

For evaluation of the experiment observations procedure following : the grains harvested from each net plot were sun dried for 2-3 days to attain 10 per cent moisture and then the weight of grains net $plot^{-1}$ area was recorded and expressed in kg ha^{-1}. Nitrogen content in seed and stover was estimated by digesting the samples with sulphuric acid using hydrogen peroxide to remove black colour. Estimation of nitrogen was done by colorimetric method using Nessler's reagent to develop colour (Snell and Snell, 1949). Nitrogen content was calculated and expressed in percentage. Phosphorus and potassium content in seed and stover was determined by digesting the samples with tri-acid mixture. Phosphorus content determination by vanadomolybdo phosphoric acid, yellow colour method by Spectrophotometer (Jackson, 1973) and potassium content by using Flame photometer (Jackson, 1973). The uptake of N, P and K by seed and straw was estimated by using the following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Per cent nutrient (NPK) content in seed or straw} \quad \text{Seed or straw yield (kg ha}^{-1}\text{)}}{100}$$

The crude protein content in seed was calculated by multiplying the nitrogen per cent in seed with a factor 6.25 (A.O.A.C., 1960). Protein yield was estimated by using the following formula.

$$\text{Protein yield (kg ha}^{-1}\text{)} = \frac{\text{Per cent protein content in seed} \quad \text{Seed yield (kg ha}^{-1}\text{)}}{100}$$

The net returns and B:C ratio on the basis of prevailing market price for inputs and produce of the experimentation was calculated as under: The gross returns (? ha^{-1}) occurred due to different treatments in the present study were worked out by considering market prices of economic product and by product during the experimental year. Net returns were calculated by subtracting the total cost of cultivation from gross returns and expressed as ? ha^{-1}. Treatment wise benefit-cost (B-C) ratio was also calculated to ascertain economic viability of the treatments by using the following formula :

$$\text{Benefit} - \text{Cost ratio} = \frac{\text{Gross return (ha}^{-1}\text{)}}{\text{Total cost (ha}^{-1}\text{)}}$$

Experimental data recorded in various parameters were statistically analyzed with the help of Fisher's analysis of variance technique (Fisher, 1950). The critical difference (CD) for the treatment comparisons was worked out wherever the variance ratio (F test) was found significant at 5% level of significance. To elucidate the nature and magnitude of treatments, summary tables along with S.Em. ± and CD (P=0.05).

Results and Discussion

Seed yield (kg ha^{-1}) : The seed yield of chickpea as influenced by different treatment combinations are presented in table 1.0 and graphically illustrated in fig. 1.0 The data clearly indicated that seed yield of chickpea was found statistically significant by the seaweed extract application. Among different treatment combinations, maximum seed yield of chickpea was recorded with seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) which was closely followed by seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_7) and seed treatment + foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_8) and was significantly higher over control (T_1), water spray (T_2), seed treatment with seaweed extract (3 ml/kg seeds) (T_3), foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_4), foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_5) and foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_6). However, the lowest seed yield of chickpea was recorded in control treatment. Seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) registered an increase in seed yield of chickpea to the tune of 39.7, 37.7, 16.7, 18.1, 18.8 and 15.8%, respectively as compared to T_1, T_2, T_3, T_4, T_5 and T_6.

Haulm yield (kg ha^{-1}) : That haulm yield of chickpea was found statistically significant with the seaweed extract over control and water spray. Among different treatment combinations, seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) registered maximum haulm yield of chickpea which was significantly higher as compared to control (T_1), water spray (T_2), seed treatment with seaweed extract (3 ml/kg seeds) (T_3), foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_4), foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_5) and foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_6) and remained at par with seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_7) and seed treatment + foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_8). The data also revealed that significantly lowest haulm yield was produced in control. Seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) recorded a significant increase in haulm yield of chickpea to the tune of 38.7, 37.8, 17.4, 18.6, 19.4 and 16.2%, respectively as compared to T_1, T_2, T_3, T_4, T_5 and T_6.

Table-1 : Effect of seaweed extract on yields and harvest index of chickpea.

Treatments	Yield (kg ha^{-1})			Harvest index (%)
	Seed	Haulm	Biological	
Control	1609	2803	4412	36.42
Water spray	1632	2822	4454	36.65
Seed treatment with seaweed extract (SE) (3 ml/kg seeds)	1925	3312	5237	36.80
Foliar spray of seaweed extract (3 ml/lit.) at tillering stage	1902	3277	5179	36.67
Foliar spray of SE (3 ml/lit.) at heading stage	1892	3255	5147	36.79
Foliar spray of SE (3 ml/lit.) at tillering and heading stage	1941	3345	5286	36.79
Seed treatment + foliar spray of SE at tillering stage	2229	3812	6041	36.90
Seed treatment + foliar spray of SE at heading stage	2208	3700	5908	37.38
Seed treatment + foliar spray of SE at tillering and heading stage	2247	3888	6135	36.65
SEm+	82	133	166	1.28
CD (P = 0.05)	246	400	497	NS

*NS= Non-significant

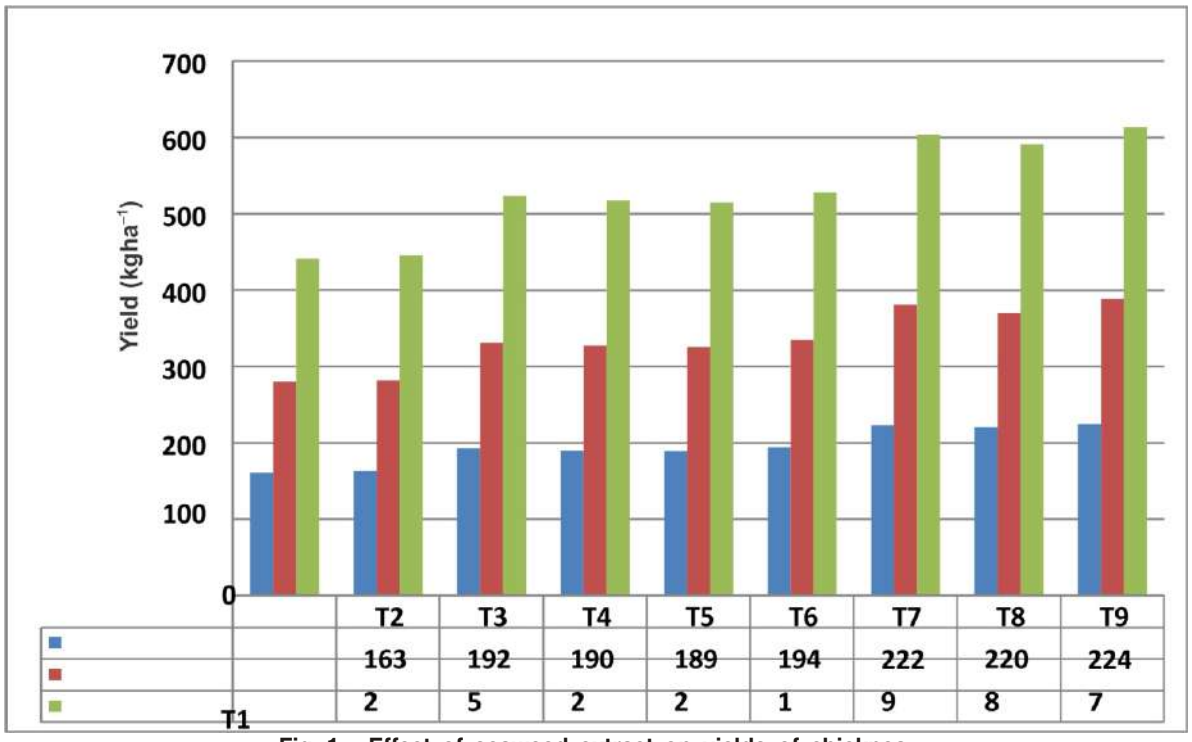

Fig.-1 : Effect of seaweed extract on yields of chickpea.

Biological yield (kg ha^{-1}) : Experimental findings that biological yield of chickpea was found statistically significant with the application of seaweed extract over control and water spray. Among different treatment combinations, seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) registered maximum biological yield of chickpea which was significantly higher as compared to control (T_1), water spray (T_2), seed treatment with seaweed extract (3 ml/kg seeds) (T_3), foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_4), foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_5) and foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_6) and remained at par with seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_7) and seed treatment + foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_8). The data further revealed that significantly lowest biological yield was produced in control treatment. Seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) recorded an increase in biological yield of chickpea by 39.1 and 37.7%, respectively over control and water spray.

Harvest index (%) : The harvest index of chickpea as influenced by different treatment combinations are presented in table 1.0 The data indicated that harvest index of chickpea was found statistically non-significant

Table-2 : Effect of seaweed extract on nitrogen and phosphorus content of chickpea.

Treatments	Nitrogen Content %		Phosphorus Content %	
	Seed	Haulm	Seed	Haulm
Control	2.76	0.509	0.547	0.258
Water spray	2.78	0.516	0.550	0.260
Seed treatment with seaweed extract (SE) (3 ml/kg seeds)	2.96	0.548	0.592	0.283
Foliar spray of seaweed extract (3 ml/lit.) at tillering stage	2.95	0.546	0.589	0.281
Foliar spray of SE (3 ml/lit.) at heading stage	2.94	0.544	0.588	0.279
Foliar spray of SE (3 ml/lit.) at tillering and heading stage	2.97	0.551	0.596	0.284
Seed treatment + foliar spray of SE at tillering stage	3.14	0.584	0.636	0.306
Seed treatment + foliar spray of SE at heading stage	3.13	0.581	0.633	0.304
Seed treatment + foliar spray of SE at tillering and heading stage	3.17	0.586	0.638	0.307
SEm+	0.05	0.008	0.011	0.006
CD (P = 0.05)	0.14	0.023	0.033	0.017

Table-3 : Effect of seaweed extract on nitrogen and phosphorus uptake in chickpea.

Treatments	Nitrogen uptake (kg ha^{-1})		Phosphorus uptake (kg ha^{-1})	
	By seed	By haulm	By seed	By haulm
Control	44.46	14.27	8.79	7.23
Water spray	45.36	14.57	8.98	7.34
Seed treatment with seaweed extract (SE) (3 ml/kg seeds)	57.03	18.14	11.39	9.36
Foliar spray of seaweed extract (3 ml/lit.) at tillering stage	56.02	17.90	11.22	9.21
Foliar spray of SE (3 ml/lit.) at heading stage	55.63	17.68	11.13	9.08
Foliar spray of SE (3 ml/lit.) at tillering and heading stage	57.67	18.47	11.59	9.51
Seed treatment + foliar spray of SE at tillering stage	70.04	22.29	14.18	11.65
Seed treatment + foliar spray of SE at heading stage	69.11	21.50	13.98	11.24
Seed treatment + foliar spray of SE at tillering and heading stage	71.21	22.78	14.34	11.93
SEm+	2.70	0.86	0.56	0.39
CD (P = 0.05)	8.09	2.57	1.69	1.17

Table-4 : Effect of seaweed extract on economics of chickpea.

Treatments	Economics			
	Total cost	Gross returns (ha^{-1})	Net returns (ha^{-1})	B : C ratio
Control	36160	91446	55286	2.53
Water spray	36760	92711	55951	2.52
Seed treatment with seaweed extract (SE) (3 ml/kg seeds)	37354	109323	71969	2.93
Foliar spray of seaweed extract (3 ml/lit.) at tillering stage	37954	108026	70072	2.85
Foliar spray of SE (3 ml/lit.) at heading stage	37954	107448	69494	2.83
Foliar spray of SE (3 ml/lit.) at tillering and heading stage	39148	110242	71094	2.82
Seed treatment + foliar spray of SE at tillering stage	39148	126541	87393	3.23
Seed treatment + foliar spray of SE at heading stage	39148	125197	86049	3.20
Seed treatment + foliar spray of SE at tillering and heading stage	40342	127653	87311	3.16
SEm+	—	—	4421	0.09
CD (P = 0.05)	—	—	13254	0.27

(*common cost of cultivation – 36160 ha^{-1})

among all the treatments tried and all the treatments recorded uniform value for harvest index of chickpea.

Effect on nutrient content, uptake and quality of chickpea

Nitrogen content (%) : Those different treatments combinations of nutrients and thiourea had significant influence on nitrogen content in seed and haulm of chickpea. The highest nitrogen content in seed and haulm was recorded with seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) which was closely followed by seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_7) and Seed treatment + foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_8) and significantly higher over treatment T_1, T_2, T_3, T_4, T_5 and T_6. The corresponding increase in nitrogen content of chickpea due to seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) was and 14.0% in seed and 15.1 and 13.6% in haulm, respectively as compared to control and water spray.

Phosphorus content (%) : Seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) recorded significantly higher phosphorus content in seed and haulm of chickpea over control (T_1), water spray (T_2), seed treatment with seaweed extract (3 ml/kg seeds) (T_3), foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_4), foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_5) and foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_6). The increase was 16.6 and 16.0% in phosphorus content in seed and 19.0 and 18.1% in phosphorus content in haulm due to seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) as compared to control and water spray, respectively.

Nitrogen uptake (kg ha^{-1}) : (Table-2) that different treatments had significant influence on nitrogen uptake by seed and haulm of chickpea. Among different treatment combinations, maximum nitrogen uptake by seed and haulm was recorded with seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) which was closely followed by seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_7) and seed treatment + foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_8) and significantly higher over all other remaining treatments. Seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) registered a significant increase in nitrogen uptake was 60.2 and 57.0% by seed and 59.6 and 56.4% by haulm as compared to control and water spray, respectively.

Phosphorus uptake (kg ha^{-1}) : The phosphorus uptake by seed and haulm of chickpea as influenced by different treatment combinations of nutrients and thiourea are presented in table 4.9. The data clearly indicated that among different treatment combinations, seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) recorded maximum phosphorus uptake by seed and haulm of chickpea which was significantly higher control (T_1), water spray (T_2), seed treatment with seaweed extract (3 ml/kg seeds) (T_3), foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_4), foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_5) and foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_6). The corresponding increase in phosphorus uptake by chickpea due to seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) was 63.1 and 59.7% by seed and 64.9 and 62.4% by haulm over control and water spray, respectively.

Economics

Net returns : Net returns of chickpea was presented in table 4 revealed that the net returns of chickpea were significantly influenced by different treatments combinations. The highest net returns were obtained when seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) was applied to chickpea crop which was significantly higher when compared to control (T_1), water spray (T_2), seed treatment with seaweed extract (3 ml/kg seeds) (T_3), foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_4), foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_5) and foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_6) but gave significantly similar net returns with seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T_7) and seed treatment+ foliar spray of seaweed extract (3 ml/lit.) at heading stage (T_8). However, the minimum net returns was obtained in control treatment (T_1).

B:C ratio : The B: C ratio of chickpea was significantly influenced by different treatment combinations. The highest B: C ratio of chickpea was observed with seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T7) which was significantly superior as compared to control (T1), water spray (T2), seed treatment with seaweed extract (3 ml/kg seeds) (T3), foliar spray of seaweed extract (3 ml/lit.) at tillering stage (T4), foliar spray of seaweed extract (3 ml/lit.) at heading stage (T5) and foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T6) but gave significantly similar B: C ratio with seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T9) and seed treatment + foliar spray of seaweed extract (3 ml/lit.) at heading stage (T8).

Discussion

Effect on yield and yield attributes : Based upon the results of present investigation it was observed that seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) significantly improved the yield attributes (number of pods plant^{-1}, number of seeds pod^{-1} and yields (seed yield, haulm yield and biological yield) of chickpea as compared to T_1, T_2, T_3, T_4, T_5 and T_6.

The reason of overall improvement in yield attributes and yield of chickpea is seaweed extracts are rich source of several primary nutrients like K, P; secondary nutrients like Ca, Mg; trace elements like zinc (Zn), copper (Cu), iron (Fe), manganese (Mn) and beneficial elements like nickel (Ni), sodium (Na) etc. Sea weed extracts stimulate various aspects of growth and development resulting in around good health of the plants, while deliberating the effect of seaweed extracts on crops the aspects of root development and mineral absorption, shoot growth and photosynthesis and ultimately crop yield, even vegetative propagation can also be taken into consideration. Due to the presence of good amount of P in it, the liquid seaweed fertilizers proliferate root development, enhance root to shoot ratio, thereby, making the plants more able to mine adequate nutrients from the deeper layer of soil and influence crop maturity as a whole. As liquid seaweed fertilizers is a very good source of K, it helps in regulating the water status of the plants, controls the opening and closing of stomata and thereby the photosynthesis to a large extent. The meristematic growth, translocation of photosynthates and disease resistance are also influenced by it due to the manifestation of good impact of K. Ca being present in seaweed extracts helps in enzyme activation, cell elongation and cell stability. Liquid seaweed fertilizers are the opulent source of secondary nutrients like Mg; hence, it helps in photosynthesis, phloem export, root growth and nitrogen metabolism. It also influences the N-fixation in legumes as it contains Mn. Mn is a constituent of several cation activated enzymes like decarboxylase, kinase, oxidase etc., and hence, essential for the formation of chlorophyll, reduction of nitrates and for respiration. The trace elements like Fe, Cu and Zn being present in considerable amount in seaweed extracts inspire redox reaction of respiration and photosynthesis, promote reduction of nitrates and sulphates and stimulate the cation activated enzymes. The organic constituents of seaweed extract include plant hormones which elicit strong physiological responses in low doses. A panorama of phytohormones and plant growth regulators are found indifferent seaweed concentrates and marine macroalgal extracts viz. Auxins, Gibberellins, Cytokinins etc. which simulate rooting, growth, flower initiation, fruit set, fruit growth, fruit ripening, abscission and senescence when applied exogenously. Seaweeds also contain a diverse range of organic compounds which include several common amino acids inter alia aspartic acid, glutamic acid and alanine in commercially important species. Alginic acid, laminarin and mannitol represent nearly half of the total carbohydrate content of commercial seaweed preparations. Apart from the above organic and inorganic constituents, there is an evidence of existence of different other stimulatory and antibiotic substances. These findings are in agreement with Mancuso *et al.* (2006), Norrie and Keathley (2006) and Rayorath *et al*. (2008). Thus, being a wealthy source of versatile plant nutrients, phytohormones, amino acids, vitamins, stimulatory and antibiotic substances, the liquid sea weed extract enhances root volume and proliferation, bio-mass accumulation, plant growth, flowering, distribution of photosynthates from vegetative parts to the developing fruits and promotes fruit development, reduces chlorophyll degradation, disease occurrence etc. resulting in improved nutrient uptake, water and nutrient use efficiency causing sound general plant growth and vigor ultimately reflecting higher yield and superior quality of agricultural products. Significant improvement in grain yield with seaweed application could be ascribed to the fact that yield of crop is a function of several yield components which are dependent on complementary interaction between vegetative and reproductive growth of crop. As seaweed saps contain cytokinins, auxins, and also hydrolyzed proteins which may have improved chickpea productivity and its quality. These results are in the line with the findings of Pramanick *et al.* (2013), Mahajan *et al.* (2016), Raverkar *et al.* (2016), Aslam *et al.* (2019), Iswarya *et al.* (2019) and Kurakula and Rai (2021).

Effect on nutrient content, uptake and quality : Significantly highest N and P content in seed and haulm and their uptake, protein content and protein yield of chickpea were obtained with seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage.

The positive influence of seaweed extract on nutrient content in chickpea appears to be due to improved nutritional level both in the root zone and plant system. The increase in nutrient content due to seaweed extract might be because of promotive effects on root proliferation, thus higher uptake of nutrients particularly those needed as constituents in protein synthesis resulting in higher protein synthesis. The increased availability of nutrient in root zone coupled with increased metabolic activity at cellular level might have increased nutrient uptake and their accumulation in vegetative plant parts. This may be due to the presence of micro elements and plant growth regulators especially cytokinin present in

the cell sap. All these beneficial effects of seaweed extract, increased accumulation of nutrients in vegetative plant parts with improved metabolism led to greater translocation of nutrients to reproductive organs of the crop and ultimately increased the contents in seed and haulm. The uptake of N, P and K might have increased due to increased content and yield of chickpea with the seaweed extract. Similar finding also reported by Mahajan *et al.* (2016), Raverkar *et al.* (2016), Aslam *et al.* (2019), Iswarya *et al.* (2019) and Kurakula and Rai (2021).

Increase in protein content might be outcome of increased concentration of N in seed by seaweed extract application which promote protein synthesis. The improvement in protein yield seems to be the fact that protein yield is a product of seed yield and protein content. Similar finding also reported by Aslam *et al.* (2019), Iswarya *et al.* (2019) and Kurakula and Rai (2021).

Effect on economics : The economic evaluation of chickpea production in terms of gross returns, net returns and B: C ratio was significantly influenced due to seaweed extract. The seed treatment + foliar spray of seaweed extract (3 ml/lit.) at tillering and heading stage (T_9) fetched highest gross, net returns and B: C ratio of chickpea. This might be due to significantly higher yield obtained under treatments over other treatments. Similar findings have also been reported by Mahajan *et al.* (2016), Raverkar *et al.* (2016), Aslam *et al.* (2019), Iswarya *et al.* (2019) and Kurakula and Rai (2021).

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Role of Nutri-Cereals in Improving Food and Nutritional Security : A Review

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Abstract

Nutri-cereals play an important role both in terms of their cultivation with low water requirement as well as providing nutritional securities to the deprived population across the world. Because of the abundance of nutrients like B-vitamins, minerals (calcium, magnesium, iron, zinc, potassium), protein, essential fatty acids, phyto-chemicals, antioxidant etc. Due to the richness of millets in polyphenols and other biological active compounds, they are also considered to impart role in lowering rate of fat absorption, slow release of sugars due to low glycaemic index and thus reducing risk of heart disease, diabetes, protein energy malnutrition, nutritional anaemia and high blood pressure. An increasing tendency towards millets' consumption has been noted as a result of growing awareness of their nutritional benefits. A significant step toward long-term sustainability is making a concerted effort to incorporate millet crops into cropping systems, particularly in areas of vulnerability. Because millets are very important plant genetic resources for agriculture sector, which increases food security for impoverished farmers with marginal, dry and poor lands, particularly in Asia and Africa. Millets as climate change compliant crops score highly over other grains like wheat and rice in terms of marginal growing conditions and high nutritional value. Thus, millets cultivation can keep dry lands productive and ensure future food and nutritional security.

Key words : *Millets, nutritional security, nutri-cereals, PEM .*

Introduction

Millets have the potential to play a significant role in both food security and nutritional security in India, because millets are hardier than most cereals, can grow in rain-fed lands with minimal agricultural inputs, and are more nutrient-rich than most other cereals. They are often referred to as 'nutri-grains' since they are rich in micronutrients like minerals and B-complex vitamins (Konapur *et al* 2014). According to Kumar *et al* (2018) the demand of food will increase proportionately with growth in world population. At present about 50% of world's total calorie intake is derived directly from cereals. Wheat, rice and maize have emerged as the major staple cereals with a lesser extent of sorghum and millets. Konapur et al (2014) evaluated that with the changing dietary patterns the millets also became less important in our daily diets. This trend is often considered one of the reasons for India's current nutritional inconsistency where problems of undernutrition and micronutrient deficiency co-exist. Although India is the leading producer of millets, they have never been promoted by food and farming system and have always been marginalized both in policy and priorities of agriculture. Numerous research organizations worldwide have focused more on improving millet varieties and expanding their use in processed food items due to the nutritional value and drought-resistant qualities of millets. Considering that there is increasing realization of the importance of millets, this review will concentrate on how millets might support balanced diets and dietary diversity, as well as offer future directions for using millets to address issues related to food and nutrition security in India.

Nutritional composition

Millets are superior to other cereal grains in terms of nutrients. They are a good choice for a health food because of its numerous benefits, which included being rich in bioactive compounds, low glycaemic index, high fiber content, and gluten-free proteins. Similar to wheat and rice, millets have an energy content of 307–361 kcal/100g. Millets have a protein level that is higher than that of rice and comparable to that of wheat, ranging from 6.2 to 12.5g/100g. Compared to rice and wheat, millets have a higher fat content, ranging from 1.1 to 8.3g/100g. While millets' percent carbohydrate content is lower than that of rice (78.2g) and similar to that of wheat (69.4g), their fiber content is higher in millets than in wheat. Millets have 57–198 mg of phytic acid per 100 grams, which is lower than wheat (238mg). Millets are well comparable and even superior to many cereals in terms of mineral and micronutrient contents. In comparison to wheat and rice, millets are a good source of thiamine, riboflavin, and pyridoxine. Millets have a mineral concentration that varies from 1.7 to 4.3 g/100 g, which is significantly higher than that of staple grains like rice and wheat (Konapur *et al*

Table-1 : Proximate composition of different millets (per 100 g).

Millet type	Carbohydrates	Protein	Fat	Crude fbre	Ash	Calorific value
Rice	82.86±7.53	4.99±1.38	1.90±1.03	1.63±0.42	0.99±0.42	369±27.82
Wheat	69.88±1.66	13.78±1.40	2.81±0.18	1.77±0.15	1.63±0.26	438±1.75
Sorghum	72.97±2.25	10.82±2.45	3.23±1.60	1.97±0.35	1.70±0.66	329.0
Pearl millet	69.10±1.52	11.4±0.8	4.87±0.12	2.0±0.55	2.13±0.21	363.0
Foxtail millet	67.30±5.70	11.34±0.91	3.33±0.76	8.23±1.66	3.37±0.12	352±1.41
Finger millet	71.52±3.59	7.44±0.87	1.43±0.12	3.60	2.63±0.06	334±2.82
Barnyard millet	56.88±6.86	10.76±1.11	3.53±1.19	12.8±2.4	4.30±0.26	300.0
Proso millet	67.09±4.79	11.74±0.86	3.09±1.18	8.47±3.4	2.73±0.72	352.5±1.62
Kodo millet	63.82±7.94	9.94±1.6	3.03±1.03	8.20±2.3	2.83±0.40	349.5±4.95

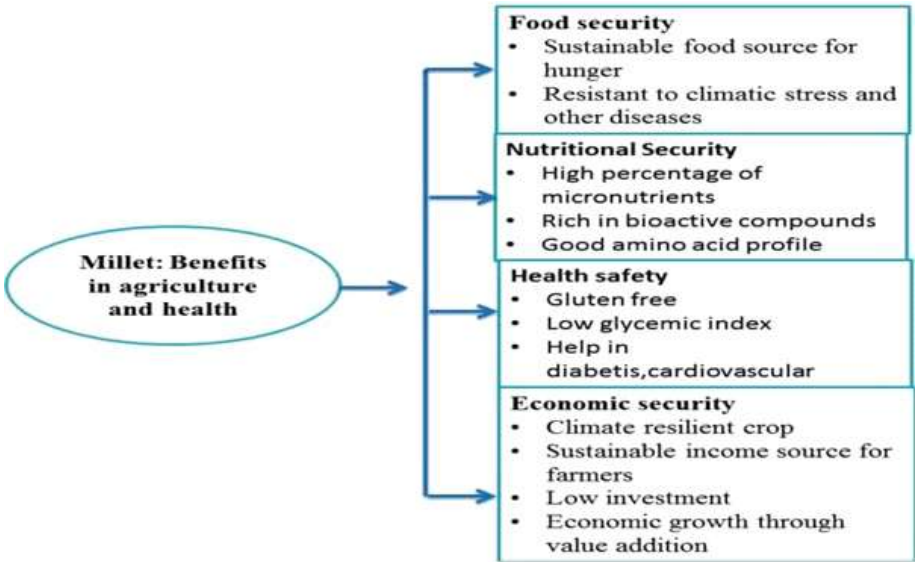
(Kumar *et al* 2018)

2014). The phenols found in millets are said to possess antiviral, anti-inflammatory, anti-mutagenic, anti-oestrogenic, and platelet aggregation-inhibiting properties. Total antioxidant capacity of finger, little, foxtail and proso millets is higher due to their high total carotenoid and tocopherol content which varied from 78 to 366 and 1.3 to 4.0 mg/100 g, respectively, in different millet varieties (Kumar *et al* 2018). The incorporation of millets in the diet can help to eradicate nutritional deficiencies. Platel has proposed for the use of millet as a vehicle for iron and zinc fortification in India. While millets are still a staple diet in many parts of the world, they rank sixth globally in terms of cereal grain production from agriculture. A comparison of nutritive value of millets, rice and wheat is given in Table-1.

Challenges of food security in the developing countries : Food security refers to a state where every person has the means to obtain adequate, safe and nutritious food that aligns with their dietary requirements and preferences, allowing them to lead healthy and active lives. The Food and Agriculture Organisation (FAO) of the United Nations identifies four crucial aspects of food security: the presence of enough food, the ability to access it, its proper utilization and the assurance of stability over time. Any deficiency in these dimensions can result in food insecurity posing risks to the health and welfare of communities. Food security challenges are often narrowed to supply of agricultural produce such as livestock. However, the challenges are believed to be more complex than just increasing the supplies. The challenges include a wide range of factors, including accessibility and urbanization. Furthermore, institutional failures as well as structure and processes which are governing economies and societies are also listed as some of the factors which cause food insecurity. The role of underutilized, locally produced grains like millet cannot be ignored when discussing the challenges facing food security in emerging nations. Ensuring food security in the modern world is a complex and pressing challenge that requires collaboration between governments, international organisations and communities The conventional grain crops are not enough to overcome some of these challenges. From the climatic change context, millets are the crops with the potential to survive harsh conditions and contribute to the stability of food security. Padulosi *et al*(2009) reported that due to genetic adaptation, minor millets including fnger, kodo, foxtail, little, proso and barnyard can grow well in a variety of soil types, with variable rainfall patterns, photoperiods and marginal conditions. These characteristics quality the millets to replace commodities like wheat and rice in harsh climatic zones, eventually leading to food security in these areas. However, millet is considered a neglected agro-biodiversity, though it has the potential to agricultural system and food security among the poor population in Sub- Saharan Africa (Hassan *et al* 2021).

By working together and prioritizing the goal of ensuring ample access to nutritious and healthy food for all, we can build a more sustainable, resilient, and compassionate world, where food security is not a distant dream but a reality for everyone. Through concerted efforts and continued commitment, we can shape a future where no one goes to bed hungry, and where the dignity and well-being of all individuals are upheld through a robust and just food system.

Role of millets in food and Nutritional security : The relationship between food security and nutrition security is complex, as illustrated by the malnutrition outcomes of overweight and obesity. Research indicates that households experiencing food insecurity prefer to prioritize food quantity over food quality or diversity in order to prevent extreme hunger. If food is only available or accessible during specific times, households may not be able to afford a consistent and adequate diet, which can lead to nutrition insecurity even in the presence of an abundance of calories. In these situations, people may cope by overindulging in food when it is available or accessible, which can contribute to overweight and obesity. Nutrition security is an essential element of food



security, as sound nutrition requires more than just enough energy for every man, woman, and child. Human needs can only be satisfied through a diversity of macro- and micronutrients to ensure good health and prevention from disease (Hwalla *et al* 2016).

According to Global Nutrition Report 2020, Despite the burden caused by many other critical global health concerns, poor eating is the biggest cause of morbidity and mortality worldwide. The resulting global malnutrition crisis includes hunger and undernutrition – mainly stunting, wasting, underweight and micronutrient deficiencies – and diet-related non-communicable diseases (NCDs) – mainly overweight, obesity, diabetes, cardiovascular disease and cancer. Malnutrition is a double burden that affects every country in the globe in some way. It is two sides of a single problem with enormous health, economic, and environmental implications. Currently, 820 million people worldwide—1 in 9—are undernourished or hungry. Since 2015, this number has increased, particularly in West Asia, Africa, and Latin America. Due to conflict, food insecurity, shocks from the climate, and economic instability, around 113 million people in 53 countries suffer from acute hunger To fix the global nutrition crisis equitably, we must shift our approach dramatically in two ways: focusing on food and health. According to Sailabala Dei and AK Sinha (2019) In India, the total area under millet production is around 17 - million hectares with 18-million metric tons production which contributes towards approx.10% of the country's food grain basket. However, momentum is yet to be gained in the production, productivity and consumption pattern of people by taking care of the following weaknesses in the system like lack of awareness of the nutritional merits, inconveniences in food preparation, lack of processing technologies, lack of Govt. policies for incentives, non-subsidised prices, lack of promotion of popular dishes of millets and ignorance of its health benefits.

Konapur *et al* (2014) observed that contributing towards nutrition security through millets India's food security is dependent on only two crops- wheat and rice. Millions of hectares of arid land have been left uncultivated by farmers due to the sharp decline in millets' production and consumption, which was the foundation of India's food and farming systems. In the poorest regions of India, these lands may generate income if they could be put to use for farming. Many programs are being implemented by Government of India where cereals are provided at subsidized prices to poorer households, but Food Security Bill is supposed to be the first program which have introduced millets to the Public Distribution System (PDS). Millets have a higher mineral concentration than other grains, but anti-nutrient factors limit their absorption. According to scientific research, soaking, malting, popping, puffing, germination and fermentation are just a few of the easy and affordable home processing techniques that can improve the mineral availability of millets and increase their nutritional value. Therefore, nutrition security will be addressed along with food security to some extent within the given means if beneficiaries of the food security bill receive education about these basic techniques.

Conclusions

Millets can easily grow in extreme conditions like drought, and some wild varieties can even prevail in flooded areas and swampy grounds. These are high in minerals (calcium, iron, copper, magnesium, etc.), B vitamins, and antioxidants. They also contain gluten-free protein and a low glycaemic index. These exceptional characteristics render them nutrient-dense and resistant to climate change crops. These can benefit the general health of the

community in addition to providing farmers with a source of income. By incorporating of millet-based foods in international, national and state-level feeding programs will help to overcome the existing nutrient deficiencies of protein, calcium and iron in developing countries and ultimately help in reducing the food and nutritional security.

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Role of Arbuscular Mycorrhiza Fungi in Mustard Plant Growing in Rajasthan

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Abstract

Arbuscular mycorrhizal (AM) fungi establish a mutualistic symbiotic association with the roots of various plant species, including mustard plants. This symbiosis offers numerous benefits to mustard plants, influencing their growth, nutrient acquisition, and overall health. AM fungi facilitate nutrient absorption by forming arbuscules within the root cells, enhancing the exchange of nutrients, particularly phosphorus and micronutrients, between the fungus and the plant. Additionally, the extensive fungal network expands the root system's reach, allowing mustard plants to access water that would otherwise be inaccessible, thereby improving plant height, seed numbers and yielding capacity. The presence of AM fungi stimulates root development, resulting in increased root surface area and nutrient exploration capacity. Furthermore, this association induces the production of defense compounds, activation of defense genes, and reinforcement of the plant cell wall, contributing to disease resistance in mustard plants. The experiment results suggest that there are complex interactions between fungal quantity and the measured parameters. While higher fungal growth may promote root colonization and an increased number of seeds per pod, there seems to be an optimal range for achieving maximum plant height and yield. Beyond this range, the plant height, seeds per pod and yield may decrease. Therefore, it is important for farmers and researchers to carefully consider the appropriate amount of fungi to optimize crop production and maximize yields. Further studies exploring a wider range of fungi could provide additional insights into this relationship.

Key words: *Arbuscular mycorrhizal fungi, mustard plant, symbiotic relationship, plant height, root colonization, yield and production.*

Introduction

Arbuscular mycorrhizal (AM) fungi are a diverse group of soil-dwelling fungi that form mutualistic symbiotic associations with the roots of the majority of land plants, including agricultural crops, trees, and wild plants. This symbiosis is one of the most prevalent and ancient plant-microbe interactions on Earth, dating back hundreds of millions of years. AM fungi belong to the phylum Glomeromycota and are characterized by their ability to form unique structures called arbuscules and vesicles within the root cells of their host plants.

Brassicca Juncea, belongs to Brassica family and commonly called as mustard, is a popular condiment with a fascinating history, shares a symbiotic relationship with Arbuscular Mycorrhizal Fungi (AMF) that profoundly impacts its growth and health. When mustard plants grow in the soil, they form a mycorrhizal association with AMF, a group of beneficial fungi. This partnership is termed arbuscular mycorrhizal symbiosis. In this relationship, the AMF colonizes the plant's root system, extending their thin hypha networks far beyond the plant's root zone. This allows the fungus to access nutrients, such as phosphorus and nitrogen, present in the soil that may be otherwise difficult for the mustard plant to acquire. In return, the mustard plant provides the AMF with carbohydrates produced during photosynthesis. This mutually beneficial exchange ensures enhanced nutrient uptake for the mustard plant and improved soil structure and health, making arbuscular mycorrhiza a vital contributor to the successful growth and sustainability of mustard plants in diverse ecosystems.

The mustard plant (*Brassica* spp.) forms a remarkable symbiotic relationship with several beneficial arbuscular mycorrhizal fungi (AMF) such as *Glomus intraradices, Glomus mosseae, Glomus aggregatum, Funneliformis mosseae, and Rhizophagus irregularis*. These AMF species play a vital role in supporting the growth and health of mustard plants in various soil conditions. Through arbuscular mycorrhizal symbiosis, these fungi establish a close association with the mustard plant's root system, forming intricate hyphal networks that extend into the surrounding soil. The extensive hyphal network acts as a "secondary root system," increasing water absorption and helping the mustard plant endure drought and water stress. Furthermore, AMF improve the plant's resistance to environmental stresses, such as drought, salinity, and heavy metal contamination, while also enhancing its natural defense mechanisms against soil-borne pathogens. The activity of AMF positively influences soil health by promoting better aeration, drainage, and soil stability through the formation of

aggregates and binding soil particles. Ultimately, these beneficial effects lead to increased plant growth and higher yields for the mustard plant, making the symbiotic relationship with AMF a valuable asset in promoting sustainable agriculture and ecosystem health.

The research was carried out in the first week of November, 2022 as it is the ideal climate for the growth of mustard crops in the fields of Rajasthan. The study mainly emphasis to analyze the positive effect of AM fungi *(Glomus intraradices, Glomus mosseae, Glomus aggregatum, Funneliformis mosseae, and Rhizophagus irregularis*) which generally grows in mustard (*Brassica juncea*) plants of Rajasthan. This study is to find out the particular fungus group which shows positive impact on the growth of the mustard plant and also the quantity of fungi to be applied for major positive and negative effect on mustard plant.

Materials and Methods

Materials : The tools, used for determining the fly ash fineness by wet sieving, comprises a special stainless steel sieve, 0.045 mm opening, a spray nozzle 17.5 mm dia. with 17 holes 0.5 mm diameter oriented and spaced conforming to the specifications, a pressure gauge 80 mm dia. and fittings for connection to the water supply.

Methods : Mustard plant (*Brassica junceae*) was sown on the first week of November, 2022, in the fields of Vivekananda Global University, Jaipur on October, 20222. Seeds were washed in lukewarm water; surface sterilization of seeds was done by keeping them in 2% of Sodium hypochlorite to ensure the early breakdown of seed dormancy. Then, these seeds were sown in the earthen pots measuring about (25x30) cm diameter filled with 8 kg of soil mixed with growth media of sand: soil: FYM, (1:2:1) in ratio (v/v) were used for each pot. AM Fungal inoculums (15g) 5g. Of highly colonized root bits of host plant *Zea mays* L., and 10g of rhizospore soil contain hyphae, sporocarps and AMF spores approximately 180 - 200/25g soil. All the five AM fungi were cultured aseptically in separate earthen pots by using Maize (Zea may L.) as potential host. Host plant used for mass multiplication of all the five AM fungal species served as AM fungal inoculates. Host plants were maintained in the green house ofVGU, Jaipur. Physico-chemical characteristics of the soil used for the experimental pots. We have travelled different parts of the Districts of Rajasthan and scanned most important dominated AM Fungal strains, and they were isolated by wet sieving and decanting technique (gerdemann and nicolson, 1963) and identified by using identification of AM Fungi manual proposed by (Scenck, and Parez, 1990; Prasad and Rajesh, 1999; Wang and Liu , 2017). The control treatment was provided without any AM Fungal inoculums. All the experimental pots were arranged in randomized block design (RBD) in duplicates. Inoculation was placed just 5 cm below the surface of the growth media. Plants were watered on alternate days to maintain moisture level. Experimental pots were kept free of weeds irrigated properly. Observation was recorded at a period of 45 and 90 days intervals.

Experimental plants first harvest was done at 45 days after sowing and second harvest was done after 90 days after sowing. The harvested plants were subjected for analysis of growth parameter such as shoot length, root colonization, measure seed numbers per pod and yielding capacity.

1. Shoot length was measured by using a measuring tape or ruler and position it next to the shoot. It assured that the measuring device is aligned with the base of the shoot and extends vertically along its length.

2. Root colonization was assessed using the magnified intersection method, following the protocol outlined by McGonigle et al. in 1990. The root samples were carefully washed with water to remove excess soil, taking care not to damage the root structures. To prevent degradation, the cleaned root samples were then placed in a fixative solution, such as formalin or FAA (50% ethanol, 5% acetic acid), and allowed to soak for a specific duration, typically 24-48 hours.

For staining, a suitable staining solution was prepared based on the type of colonization being assessed. In this case, trypan blue was used to evaluate mycorrhizal colonization. After staining, the root samples were mounted on microscope slides using a suitable mounting medium like lactoglycerol. Each slide typically contained approximately 30 cm of roots, which were divided into about 20 pieces of approximately 1.5 cm each.The stained root samples were observed under a light microscope at an appropriate magnification. The extent of root colonization was assessed and quantified based on microscopic images. This involved visually estimating the percentage of root length colonized, counting the number of colonized root segments, or utilizing image analysis software for more precise measurements. All measurements were recorded, and statistical analysis was performed as needed. By comparing the levels of colonization between different samples or treatments, conclusions were drawn regarding the effectiveness of mycorrhizal colonization on plant roots.

Screening of an Efficient AM Fungi for Mustard Plant (*Brassica junceae)* on its growth : All the growth parameters were measured in duplicate. Mycorrhizal spore number /25g.ofrhizogenic soil were estimated. All

the five strains of AM Fungi were aseptically maintained in separate earthen pots by growing in viable host Maize *Zeamays L.* The percent root colonization was evaluated microscopically followed by clearing of roots in 10% KOH and staining with 0.05% try pan blue in lacto phenol according to method described by (Phillips and Hayman, 1970). The following formula was used to calculate their root colonization according to (Grovanneth and Mosse, 1980).

$$\text{Root colonization (\%)} = \frac{\text{Number of colonized segments}}{\text{Total number of segments}} \quad 100$$

Organic matter of the soil was analysed following the procedure of Walkley and Black (1934). Phosphorus content of shoots were determined calorimetrically by the Vanadomylbdate phosphoric yellow colour method of Jackson (1973).

3. Seed per pod : To measure the number of seeds per pod in mustard plants, mature pods were carefully selected. Representative pods were collected from different plants or areas of the mustard crop. The pods were opened by gently applying pressure or using a small knife to reveal the seeds inside. The number of seeds in each pod was then manually counted. The data, including the pod number and corresponding seed count, were recorded in tables. This process was repeated for multiple pods, ensuring a diverse sample. The average number of seeds per pod was calculated by summing the individual counts and dividing by the total number of pods measured.

4. Yielding capacity : To measure the yielding capacity of mustard plants, representative mustard plants were carefully selected from the crop. Factors such as plant health, growth stage, and uniformity were considered to ensure accurate results. The measurement area was defined, specifying a certain number of plants, a specific row, or a defined square meter area. The plants within the designated area were harvested by cutting them at the base, ensuring the collection of the entire above-ground biomass.

Extraneous material, such as leaves or stems not bearing pods, was removed from the harvested mustard plants. The plants were then placed in a well-ventilated and dry area to dry, allowing the moisture content to reduce and ensuring accurate yield measurements. Once dry, the seeds were separated from the pods, either through manual threshing or by using mechanical means such as a seed separator or threshing machine.

The collected seeds were weighed using a precise and calibrated scale. The weight of the seeds was divided by the area of measurement to calculate the yield. In cases where multiple plants were harvested, the seed weight was divided by the number of plants to determine the average yield per plant.

All the yield measurements were recorded, including details about the specific area measured, the number of plants, and the corresponding seed weight.

Results and Discussion

The table provided a comparison of different types of arbuscular mycorrhizal (AM) fungi and their effects on various plant growth parameters. The discussionsof the findings are given below.

From the Table-1, the results of an experiment that investigated the effects of different quantities of the *Glomus intraradices* fungal strain on plant growth and yield. The experiment measured parameters such as plant height increase, root colonization percentage, seeds per pod, and yield in kilograms per acre.The findings indicate that plant height increased as the quantity of the *Glomus intraradices* fungal strain increased. The tallest plants, reaching a height of 25 cm, were observed with 40 grams of the fungal strain. Conversely, the shortest plants, measuring 10 cm, were obtained when no fungal strain was applied. This suggests that the presence of *Glomus intraradices* promotes plant growth. Root colonization percentage also showed a positive correlation with the quantity of the fungal strain. As the quantity of the *Glomus intraradices* fungal strain increased, the root colonization percentage also increased. The highest colonization percentage of 81% was achieved with 70 grams of the fungal strain, indicating a greater level of root colonization by the beneficial fungus.

The number of seeds per pod ranged from 10 to 18 seeds, with variations observed across the different quantities of the fungal strain. Higher quantities of the fungal strain tended to be associated with a higher number of seeds per pod, although the relationship was not strictly linear.Yield per acre demonstrated variations based on the quantity of the fungal strain. The highest yield of 0.72 kg per acre was obtained with 40 grams of the fungal strain. The lowest yield of 0.41 kg per acre was observed with no fungal strain applied. These results suggest that the presence of *Glomus intraradices* can contribute to improved yield.

From the Table-2, The table presents the results of an experiment that examined the effects of different quantities of the *Glomus mosseae* fungal strain on plant growth and yield. The experiment measured parameters such as plant height increase, root colonization percentage, seeds per pod, and yield in kilograms per acre.

Table-1 : Comparative analysis of *Glomus intraradices* in mustard plant.

S. No.	*Glomusintraradices* Fungal strain quantity in gm	Plant height (increase in cm) 165-212 cm	Root colonization (in %)	seeds per pod (10 to 18)	YIELD (kg/acre) (1.5kg to 2.5kg) 0.618 gr/m^2
1.	0 g	10 cm	0%	8	0.41
2.	10 g	12 cm	25%	10	0.42 gm
3.	20 g	15 cm	28%	11	0.53
4.	30 g	20.3 cm	43%	13	0.65
5.	40 g	25 cm	54%	18	0.72
6.	50 g	23.5 cm	62%	17	0.51
7.	60 g	20.4 cm	76%	15	0.65
8.	70 g	19.6 cm	81%	11	0.45

Table-2 : Comparative analysis of *Glomus mosseae* in mustard plant.

S. No.	*Glomusmosseae* Fungal strain quantity in gm	Plant height (increase in cm) 165-212 cm	Root colonization (in %)	seeds per pod (10 to 18)	YIELD (kg/acre) (1.5kg to 2.5kg) 0.618 gr/m^2
1.	0 g	9.5 cm	0%	8	0.37
2.	10 g	11.5 cm	9%	10	0.44
3.	20 g	14.3 cm	23%	11	0.52
4.	30 g	17.3 cm	24%	13	0.66
5.	40 g	26 cm	36%	18	0.77
6.	50 g	25.5 cm	51%	17	0.53
7.	60 g	19.4 cm	62%	15	0.63
8.	70 g	18.6 cm	79%	11	0.46

Table-3 : Comparative analysis of *Glomus aggregatum* in mustard plant.

S. No.	*Glomusaggregatum* Fungal strain quantity in gm	Plant height (increase in cm) 165-212 cm	Root colonization (in %)	seeds per pod (10 to 18)	YIELD (kg/acre) (1.5kg to 2.5kg) 0.618 gr/m^2
1.	0 g	10 cm	0%	9	0.37
2.	10 g	10 cm	10%	10	0.42
3.	20 g	12 cm	25%	13	0.48
4.	30 g	15.3 cm	28%	17	0.52
5.	40 g	26 cm	43%	20	0.62
6.	50 g	22.5 cm	54%	16	0.59
7.	60 g	21.4 cm	62%	14	0.50
8.	70 g	17.6 cm	76%	11	0.45

The findings indicate that as the quantity of the *Glomus mosseae* fungal strain increased, there was a general trend of increased plant height. The tallest plants, reaching a height of 26 cm, were observed with 40 grams of the fungal strain, while the shortest plants, measuring 9.5 cm, were obtained when no fungal strain was applied. This suggests that the presence of Glomus mosseae promotes plant growth.

Root colonization percentage also showed a positive correlation with the quantity of the fungal strain. As the quantity of the Glomus mosseae fungal strain increased, the root colonization percentage also increased. The highest colonization percentage of 79% was achieved with 70 grams of the fungal strain, indicating a higher level of root colonization by the beneficial fungus.

The number of seeds per pod ranged from 10 to 18 seeds, with some variations observed across the different quantities of the fungal strain. However, there was no

Table-4 : Comparative analysis of *Funneliformismosseae* in mustard plant.

S. No.	*Funneliformismosseae* Fungal strain quantity in gm	Plant height (increase in cm) 165-212cm	Root colonization (in %)	seeds per pod (10 to 18)	YIELD (kg/acre) (1.5kg to 2.5kg) 0.618 gr/m^2
1.	0 g	13 cm	0%	10	0.40
2.	10 g	12 cm	10%	12	0.41
3.	20 g	15 cm	15%	13	0.50
4.	30 g	16.3 cm	27%	13	0.65
5.	40 g	24.1 cm	46%	18	0.75
6.	50 g	23 cm	55%	15	0.62
7.	60 g	22 cm	75%	13	0.56
8.	70 g	20 cm	80%	10	0.45

Table-5 : Comparative analysis of *Rhizophagus irregularis* in mustard plant.

S. No.	*Rhizophagus irregularis* Fungal strain quantity in gm	Plant height (increase in cm) 165-212 cm	Root colonization (in %)	seeds per pod (10 to 18)	YIELD (kg/acre) (1.5kg to 2.5kg) 0.618 gr/m^2
1.	0 g	12 cm	0%	12	0.42
2.	10 g	13 cm	15%	13	0.45
3.	20 g	15 cm	21%	15	0.49
4.	30 g	19 cm	27%	16	0.56
5.	40 g	24 cm	50%	19	0.65
6.	50 g	24 cm	59%	16	0.50
7.	60 g	23 cm	65%	12	0.65
8.	70 g	21.6 cm	79%	11	0.40

clear trend or consistent relationship between the quantity of the fungal strain and the number of seeds per pod.

Yield per acre demonstrated variations based on the quantity of the fungal strain. The highest yield of 0.77 kg per acre was obtained with 40 grams of the fungal strain. The lowest yield of 0.37 kg per acre was observed when no fungal strain was applied. These results suggest that the presence of Glomus mosseae can contribute to improved yield.

From the table-3, the results are determined as the effects of different quantities of the Glomus aggregatum fungal strain on plant growth and yield. The experiment measured parameters such as plant height increase, root colonization percentage, seeds per pod, and yield in kilograms per acre. The findings show that the presence of Glomus aggregatum had a positive impact on plant growth. As the quantity of the fungal strain increased, there was a general trend of increased plant height. The tallest plants, reaching a height of 26 cm, were observed with 40 grams of the fungal strain, while the shortest plants, measuring 10 cm, were obtained when no fungal strain was applied.

Root colonization percentage also showed a positive correlation with the quantity of the Glomus aggregatum fungal strain. As the quantity increased, the root colonization percentage also increased. The highest colonization percentage of 76% was achieved with 70 grams of the fungal strain, indicating a higher level of root colonization by the beneficial fungus.

The number of seeds per pod ranged from 10 to 20 seeds, with some variations observed across the different quantities of the fungal strain. However, there was no clear trend or consistent relationship between the quantity of the fungal strain and the number of seeds per pod.

Yield per acre demonstrated variations based on the quantity of the fungal strain. The highest yield of 0.62 kg per acre was obtained with 40 grams of the fungal strain, while the lowest yield of 0.37 kg per acre was observed when no fungal strain was applied.

Table-4. resulted that investigated the effects of different quantities of the Funneliformis mosseae fungal strain on plant growth and yield. The experiment measured parameters such as plant height increase, root

colonization percentage, seeds per pod, and yield in kilograms per acre.

The findings indicate that the presence of Funneliformis mosseae had a positive impact on plant growth. As the quantity of the fungal strain increased, there was a general trend of increased plant height. The tallest plants, reaching a height of 24.1 cm, were observed with 40 grams of the fungal strain, while the shortest plants, measuring 12 cm, were obtained with 10 grams of the fungal strain.

Root colonization percentage also showed a positive correlation with the quantity of Funneliformis mosseae. As the quantity increased, the root colonization percentage also increased. The highest colonization percentage of 80% was achieved with 70 grams of the fungal strain, indicating a higher level of root colonization by the beneficial fungus.

The number of seeds per pod ranged from 10 to 18 seeds, with some variations observed across the different quantities of the fungal strain. However, there was no clear trend or consistent relationship between the quantity of the fungal strain and the number of seeds per pod.

Yield per acre demonstrated variations based on the quantity of Funneliformis mosseae. The highest yield of 0.75 kg per acre was obtained with 40 grams of the fungal strain, while the lowest yield of 0.40 kg per acre was observed when no fungal strain was applied.

From the table-5, The provided table presents the results of an experiment that explored the effects of different quantities of the Rhizophagus irregularis fungal strain on plant growth and yield. The experiment measured parameters such as plant height increase, root colonization percentage, seeds per pod, and yield in kilograms per acre. The findings indicate that plant height increased as the quantity of the fungal strain increased. The tallest plants, reaching a height of 24 cm, were observed with 40 grams of the fungal strain. On the other hand, the shortest plants, measuring 12 cm, were obtained when no fungal strain was applied. This suggests that the presence of the Rhizophagus irregularis fungal strain promotes plant growth. Root colonization percentage also showed a positive correlation with the quantity of the fungal strain. As the quantity of the fungal strain increased, the root colonization percentage also increased. The highest colonization percentage of 79% was achieved with 70 grams of the fungal strain, indicating a greater level of root colonization by the beneficial fungus. The number of seeds per pod ranged from 11 to 19 seeds, showing slight variations across the different quantities of the fungal strain. There was no clear pattern indicating a direct relationship between the fungal strain quantity and the number of seeds per pod. Yield per acre demonstrated variations based on the quantity of the fungal strain. The highest yield of 0.65 kg per acre was obtained with both 40 grams and 60 grams of the fungal strain. The lowest yield of 0.40 kg per acre was observed with 70 grams of the fungal strain. These results suggest that there may be an optimal quantity of the fungal strain that maximizes yield

Conclusions

Based on the research, the following has been drawn, As the quantity of all five fungi strains increased from 0g to 70g, there was a general trend of increasing plant height in mustard plant. The plant height ranged from 12cm with 0g of fungal strain to approx 24cm with 40g and 50g of fungal strain. However, there was a slight decrease in plant height with 60g and 70g of fungal strain. The Root Colonization shows an increase in the quantity of fungal strain, there was an overall increase in root colonization. About seeds per Pod, The number of seeds per pod did not show a consistent pattern with the increase in fungal strain quantity. In this research the yield of the crops, measured in kg/acre, showed some variations with the increase in fungal strain quantity. The yield ranged from 0.40kg/acre with 70g of fungal strain to 0.65kg/acre with 5th and 7th treatment (40g and 60g of fungal strain, respectively). The initial treatment without the fungal strain had the lowest yield of 0.42kg/acre.

Overall, the results suggest that the presence of arbuscular mycorhhizal fungi had a positive impact on plant height, root colonization, and yield up to a certain point. However, beyond a certain quantity (60g and 70g), the positive effects seemed to diminish or even decrease slightly. Therefore, the optimal quantity of the fungal strain for achieving the best results in terms of plant growth and yield may lie within the range of 40g to 50g.

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Role of Rootstocks in Fruit Crops Improvement

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Abstract

Fruit crops constitute a significant part of the total agricultural produce and in horticultureits role as backbone to strengthen the sector. In fruit crops, rootstocks play very crucial role in control of tree size and vigour, fruit setting, yield, quality attributes, physiology, biochemistry, nutrient accumulation as well as insect pest and disease resistance over the scion. In a plant, a lower part provides the root system as the rootstock, and the top ground portion is called the scion. The rootstock-scion combination is selected based on desirable traits of scion varieties, rootstocks, and prevailing edaphic condition.For all tree fruits, incorporating resistances to critical diseases and pests will facilitate fruit production in a social environment demanding reduction in pesticide usage. Diseases caused by various Phytophthora species are important and can be catastrophic for all major tree fruit crops; breeding for resistance to Phytophthora has generally been successful. Identification of problems and prioritising breeding objectives based on those problems are essential first steps in a rootstock improvement program.In earlier time, this propagation technique of joining two plants by grafting or budding remains unclear especiallythe mechanism of transmission of physiological and biochemical traits from the rootstock to the desirable scion variety. Nevertheless, this propagation technique widely persisted in multiplication of several fruit crops. Impact of rootstock over the scion on fruit quality in terms of morphological traits and bio-chemical compositions is almost well established only in temperate fruit crops. By gene sequencing technique it was confirmed that genetic exchange exists between rootstock and scion variety through grafting joints but more exhaustive study is required for actual clarification. Impact of rootstocks for morphological, physiological and biochemical character over scion still remains unclear for other fruit crops like tropical and subtropical fruits.The present review summarizes the reported elite characters and discusses the role of rootstock over scion especially for those fruit cropswhich are commercially grown in India.

Key Words : *Horticulture, rootstock, fruit crop, traits.*

Introduction

Horticultural crops constitute a significant part of the total agricultural production and can play a vital role in solving nutritional problem of the people.Currently it is a major potential sector for increasing agricultural production, income generation, and nutritional security through export, employment generation, value addition, job opportunitiesand diversification. In addition to new major challenges, low productivity per unit area continues a problem in most of the horticultural crops, with climate change impacting the greater effect on fruit productivity. Biotic (causal agents of disease, insect, nematode, etc.), and abiotic (temperature, humidity, drought, wind, water logging, salinity, etc.) stresses are also challenges. Therefore, proper rootstock selection is one of the most important factors in orchard management because it affects the growth, nutrient accumulation, environmental tolerance, and fruit quality of scion varieties. Rootstocks enables scion varieties to express its genetic potential in terms of fruit quality and achieving real yield, modify architecture of plants, enhance nutrient and water use efficiency and express resistance and tolerance to different biotic and abiotic stresses.

Fruits and vegetables are known as protective food. It is scientifically established fact that fruits and vegetables are essential sources of phytonutrients and provide range of health benefits. World Health Organization (WHO) observed that lower levels of intake of fruits and vegetables are one among the 10 high risk factors of mortality (WHO, 2003; ICMR and NIN, 2019).India's diverse climate ensures availability of all varieties of fresh fruits & vegetables. It ranks second in fruits and vegetables production in the world, after China. As per National Horticulture Database (Second Advance Estimates) published by National Horticulture Board, during 2019-20, India produced 99.07 million metric tonnes of fruits and 191.77 million metric tonnes of vegetables. The area under cultivation of fruits stood at 6.66 million hectares while vegetables were cultivated at 10.35 million hectares.

For fulfilment of present requirement of fruits in a balanced amount to all citizens of the India it require just double the production in which the rootstocks could play their key roles for adoption of hi-tech horticulture technology in fruit production. Fruit crops have immense scope to generate lot of employment opportunities from production to consumption level of the produce. The

biggest incentive for the farmer is money and fruit crops provide more returns in terms of per unit area production, export value, value addition compared to other crops. After achieving the food security, nutritional security for the people of the country is yet to be needed hence considered on priority basis. Our nation producing fruits a lot but per capita availability is very poor than developed nations. We can fulfil our requirement by increasing the production as well as minimising the post-harvest losses of produce that provides tremendous scope for the growth of this industry.

Rootstocks have many advantages in fruit culture because it is resistant to many biotic and abiotic stresses, and have many beneficial effects on fruit yield and quality. In this way, it can be said that rootstocks has greater potential to minimise the above major problems at some extent. In spite of that, in India there has not been systematic effort made yet for proper utilization and multiplication of the rootstocks at farmer level (12).

In a grafted plant, the plant part of the combination that provides the root is called the root stock and the added piece is called the scion. Grafting involves the joining together of plant parts by means of tissue regeneration. When more than two parts are involved, the middle piece is called the inter-stock. The basic technique in grafting consists of placing cambial tissues of stock and scion in intimate association, so that the resulting callus tissue produced from stock and scion interlocks to form a living continuous connection. Stock cambium and scion cambium respond to being cut by forming masses of cells (callus tissues) that grow over the injured surfaces of the wounds. The union resulting from interlocking of the callus tissues is the basis of graftage. The performance of scion cultivar over stock or vice versa is known as stock scion relationships.

Effect of rootstocks on scion cultivars

Tree Size, shape and Vigour : The effect of rootstock on the size and vigour of a tree has been demonstrated in apple and citrus. In case of apple, rootstock classified as dwarf, semi dwarf vigorous and very vigorous rootstock based on their effect on scion cultivar. If a scion is drafted on dwarf rootstock the graft combination will be dwarf while the same cultivar grafted on vigorous rootstock would grow very vigorously. In citrus, Trifoliate orange is the most dwarfing rootstock for sweet oranges and grapefruit. Root stocks kalapady, Olour of mango has been found to impart dwarfness in the scion cultivars. *Psidiumpumilum* is dwarfing rootstock of guava. 'PusaSrijan' rootstock also imparts dwarfness in cv. 'Allahabad Safeda' (10).

Effect on juvenile period longevity : The time taken from plating to fruiting is called juvenile periodinfluenced by rootstocks. Precocity is reduction injuvenile period longevity of fruit crops. It is prominent problem in fruit crops. In general, vigorous rootstock results in vigorous growth of the scion, which leads to delay flower bud differentiation. The dwarfing rootstocks exhibit precocity and vigorous rootstocks delay in fruiting. Mandarin orange, when grafted on Jambheri rootstocks are precious than those grafted on sweet orange or sour orange or acid lime rootstocks (11).

Fruit setting and yield : The effect of rootstock on fruit setting and yield played significant role in many fruit crops. Under high density plantation yield increases per unit area in Guava, Apple, Mango, etc. (7).Trees on dwarfing rootstock may yield higher per unit area because more plants can be accommodated per unit area. Golden Delicious apple produced more fruit per tree than Gold Spur onM 7, MM 106 and M 26 rootstocks of apple.The production of flower and fruits set is directly influenced by rootstock in Persimmon (*Diospyrous kaki* cv. Hachiya). It produces more number of flowers when grafted on *D. lotus* but only few mature into fruits. Fruit set is very high when *D. kaki* is used as the rootstock(2). Acid limes budded on rough lemon found significant improvement in yield as compared to budded on troyercitrange, rangpur lime or its own rootstock (11). Sweet orange var. Sathugudi gave higher yield when budded on Kichili rootstock than others.

Fruit size and quality : Domestic pear seedlings (*Pyruscommunis*) are still the most acceptable rootstocks for pear cultivars in terms of vigour, hardiness, and compatibility. However, all pear trees on seedling roots are susceptible to fire blight.Rootstock Pyruscommunis did not show any symptom of physiological disorder black end in Bartlett Pear but*Pyruspyrifolia*exhibited this disorder and affected fruit quality. In case of citrus Sathugudi sweet orange produced large fruit when grafted on Gajanimma rootstocks, but the quality was poor while on its own roots they produced fruits with high juice content and quality (2) (4). Sweet orange exhibited the highest granulation when budded on rough lemon whereas granulation was very low on Cleopatra mandarin. Washington navel oranges are found largest on Troyer citrange and smallest on Cleopatra mandarin.In general, when sour orange, sweet orange and grapefruit rootstock are used for sweet orange, fruits are smooth, thin-skinned, juicy with excellent quality.

Ability tolerance of problematic soils : Screening of mango rootstocks to salinity has shown that the polyembryonic cultivars 'Olour' and 'Bappakai' could withstand higher level of salinity (10). Dubey *et. al.,* reported that 'Olour' as best salt tolerant rootstock compared to 'Kurukan' (5). Trifoliate orange is poorly

resisted excess salt whereas sweet oranges, sour orange, rangpur lime rootstocks moderately resist excess salts in the soil. Rootstock Myrobalan plum tolerates to excess moisture and boron than Marianna plum, peach, apricot or almond.

Hardiness : Apple rootstock, M-9 and M16 are resistant to winter injury. Grape rootstock 110R is a drought hardiness and tolerant to salinity (1).Rootstocks are found to impart winter hardiness to the susceptible scion variety. Rangpur lime tolerated winter injury when grapefruit budded on it.Sweet oranges and Mandarins on trifoliate orange stocks were reported as cold hardiness character. Trifoliate orange is the hardiest rootstock of citrus (3).

Disease resistance : Rootstocks also exhibit resistance variability in their response to different diseases and insect pests. Apple Rootstock MM 106, MM 104, MM 109 and MM 111 are resistant to wooly apple aphids. Myrobalan B is used as a rootstock for plum is resistant to bacterial canker. In case of citrus Rough lemon is tolerant many diseases like Tristeza, xyloporosis and exocortisbut susceptible to gummosis and nematode. Troyer citrange is tolerant of gummosis but susceptible to exocortis virus disease. Guava rootstock, Chinese guava (*Psidiumfriedrichsthalianum*) exhibits resistant to wilt diseases and nematodes (12).

Conclusions

A powerful root system, its wide and deep distribution in the soil and a persistent and adequate annual growth of absorbing roots are the principal prerequisites of abundant fruit bearing. Rootstocks play a crucial role in determining orchard efficiency in fruit crops. Combining the desirable attributes of two different plants by budding or grafting can produce different growth effects. The effect of rootstock on fruit quality in terms of physical traits and internal chemical compositions is well demonstrated in temperate fruit crops (Apple, Pears, Cherry etc.) as compared to tropical and subtropical fruit crops. Rootstocks are important from a horticultural point of view because they provide a basis for selecting the best graft combination for particular environmental conditions and high fruit quality. Selection of an appropriate graft combination is crucial for the production of crops because the rootstock interaction with scion influences water relations, leaf gas exchange, mineral uptake, plant size, flowering, fruit set, fruit quality and yield efficiency.

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Effect of Salinity Stress on Growth and Flowering of Tuberose

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Abstract

In the present study, the effect of different levels of saline irrigation water on growth and flowering in Tuberose was evaluated. Bulbs of tuberose variety Prajwal were planted in plastic pots filled with garden soil and irrigated with different levels of saline irrigation water (2,3,4,5 dSm^{-1}) along with control (best available water). Salinity tolerance was evaluated on the basis of various vegetative, reproductive, physiological and biochemical parameters. The data was subjected to analysis of variance. Different levels of salinity were found to reduce growth, flower production and biochemical parameters. Among the various levels of saline irrigation water, in addition to control, level 2dSm^{-1} was found to be better for various traits studied.

Key words : *Tuberose, salinity, growth and flowering.*

Introduction

Salinity is a major abiotic stress limiting growth and productivity of plants in many areas of the world due to increasing use of poor quality of water for irrigation and soil salinization. (Guptaand Huang, 2014). Salinity impairs plant growth and development *via* water stress, cytotoxicity due to excessive uptake of ions such as sodium (Na^+) and chloride (Cl^-), and nutritional imbalance. Additionally, salinity is typically accompanied by oxidative stress due to generation of reactive oxygen species (ROS) (Isayenkov, 2012). Plants vary greatly in their tolerance to saline water. Salinity tolerance of flowers crops is of increasing importance due to decreasing availability of high-quality irrigation water. It has been estimated that 100-350 kg of water are needed to produce 1 kg of plant dry matter, but it can vary with species and variety, cultivation system and plant growing season (Frornes *et al.,* 2007).The effect of water salinity on growth and development of ornamental plants, especially in bulbous plants, has been investigated to a much lesser extent than other crops in our country. Increasing the salt tolerance of crops-will allow the effective use of poor quality irrigation water. Currently, only few major determinant genetic traits of salt tolerance have been identified owing to low success in releasing of salt-tolerant crops for optimal use of salt contaminated water resources (Flowers 2004, Munns 2005).

Tuberose (*Polianthestuberosa Linn.),* native to Mexico, is an herbaceous, bulbous, perennial ornamental plant belonging to the family Agavacaeae. It is one of the most popular commercial flower crops in tropical and sub-tropical areas of the world including India. Tuberose is adorned with vernacular names like Rajanigandha (Hindi), Gulsaboo (Urdu), Nelasampengi (Telugu), Sugandharaja (Kannada), Nishigandha (Marathi), tuberoos (Dutch), tubereuse (French),tuberose (English, German) and andNargo (Spanish). Flowers are used as loose flowers, cut flowers & for extraction of concrete / absolute. Environmental conditions especially salinity and drought highly define its yield and quality. Several approaches have been developed for abiotic stress tolerance but important ornamental crops like tuberose are rarely tapped. Therefore, an attempt has been made to study the effect of saline stress on growth and flowering of tuberose.

Materials and Methods

A pot experiment was conducted in the research farm and laboratory of Division of Floriculture and Landscaping during 2019-20. Earthen potsfilled with approx 10kg soil were used for this experiment. Healthy and uniform sized bulbs were planted in April 2019. In this experiment, salinity treatments with the irrigation water of EC values of 0.7 (control), 2, 3, 4 and 5 dS/m were imposed in tuberose cultivar Prajwal. The various salinity levels were created by mixing the salts NaCl, $MgSO_4$ and $CaCl_2$.A four replication randomized complete block design was employed with a total of 20 plants for each treatment, with five plants in each replication. During summer season, weather was very hot and it was needed to irrigate the pots every 2 to 3 days interval. During rainy season, irrigation interval was 7 to 9 days and during rabi season, 10 to 12 days. Data was recorded from all the replications on various vegetative and flowering parameters. Relative water content, cell membrane injury of leaves, chlorophyll and proline content of leaves, Na and K content of leaves were measured. Immediately after harvest flowering stalks were weighed as fresh weight and dried in oven at 72°C for 72h for dry weight. Chlorophyll content was

determined by using a chlorophyll content meter (SPAD 502, Beijing, China). Proline content was determined according to Bates et al. (1973) method. To measure the RWC, six discs were taken from excised leaves of each plant, the discs were weighed (Fresh weight: FW), and were immersed in distilled water for 4 hours and weighed again (Turgid weight: TW) and then were dried at 70°C inside an oven for 24 hours (Dry weight: DW). RWC was calculated using the following equation (Whethereley, 1950):

$$RWC = (FW - DW)/(TW - DW) \times 100$$

Membrane stability index (MSI) was measured in leaves by the method described by Sairam *et al.,* 2002 and expressed in percentage per sample. 100 mg of leaf tissue was taken in test tubes, 10 ml of distill water was added. It was placed in water bath at 40 ° C for 30 minutes and then E.C. was measured. It was then placed in water bath at 100 ° C for 15 minutes and after cooling E.C. measured. The electrical conductivity was measured using Century water and soil analyser kit CMK 73 and MSI (%) was calculated using the following formula :

$$MSI\ (\%) = 1 \quad \frac{E.C.\ at\ 40\ C}{E.C.\ at\ 100\ C} \quad 100$$

The data was subjected to Analysis of Variance and means were compared at 5% level of significance.

Results and Discussion

Growth parameters : The effect of various levels of saline irrigation water on growth of tuberose is presented in Table-1. In the present study, after planting the earliest sprouting (11.5 days) was observed in T1 whereas the treatment T5 had delayed sprouting (14 days). There was no significant difference between treatments T1, T2 and T3. With the increase in salinity level, there was gradual decline in plant height of tuberose. Plants irrigated at (0.7 dS/m), which was the control had the longest plant height (83 cm) and the ones irrigated at 5 dS/m water had the shortest plants (75.25 cm). The increment of in EC levels inhibited the growth in plant height, probably due to the reduction of osmotic potential in root environment, which can cause physiological water deficit. It can also cause toxicity, through the specific action of the ions, especially Na+ and Cl^- , on the protoplasm (Munns, 2002). There were significant ($P<0.05$) differences in number of leaves of tuberose, in different concentrations of saline irrigation water. Plants irrigated at (0.7 dS/m), which was the control had the maximum number of leaves (20.75) and the ones irrigated at 4 dS/m water had the lowest number of leaves. (15.75). In treatment T2 and T3 equal number of leaves were observed. The leaf length and leaf width was also found to decrease with increasing concentration of salinity in irrigation water. Reduction in cell elongation and division in plant cell reduce their final size, resulting in decrease in plant height, number of leaves, leaf area and root growth as elucidated by earlier workers (Cabrera, 2003; Cassaniti *et al.* 2009). Niu et al. 2013 reported that plants subjected to salt stress had their leaf area reduced, due to the delay in leaf production, which decreases as the area available for photosynthesis and the effect is even more accentuated when the time of exposure to the stress is prolonged. Growth reduction in different ornamental plants due to salinity have been also reported in gladiolus (Ahir and Singh, 2017) in nerium (Banon *et al.,* 2005), in marigold (Valdez Aguilar et al., 2009), in gladiolus (Haouala and Sahli 2011, in gladiolus and heliconia (Cerquera et al., 2008) and in zinnia (Zivder *et al.,* 2011). This findings were consistent with those of Allkaverdiev et al. 2000 who studied the effects of water salinity on six heliconia genotypes and observed that EC higher than 0.8 dS/m negatively affected leaf production and plant growth causing losses related to size and to the desirable features in ornamental plants, such as colour of leaves and plant size, in all genotypes.

Flowering Parameters : The effect of various levels of saline irrigation water on various flowering parameters of tuberose is elucidated in Table-2. There were significant ($P<0.05$) differences in number of days for bud emergence, in different concentrations of saline irrigation water. Plants irrigated at (0.7 dS/m), which was the control had the earliest bud emergence (71.5 days) and the ones irrigated with 4 dS/m water took the longest time (79.75 days). Days to first floret opening also showed similar trend. Delay in flowering due to the specific mechanism that alter the growth stage of flowering have been known to occur due to multiple stresses (osmotic imbalance, nutritional deficit and cellular toxicity) exerted by salinity (Stanton *et al.,* 2000) .

Each increase in salinity level in irrigation water resulted in decrease in spike length of tuberose plants. Control plants had the maximum spike diameter which was significantly higher than all other treatments studied. There were no significant difference in tuberose plants with respect to rachis length in various levels of saline irrigation water. In this study, there was a reduction in number of florets per spike per plant with increasing salinity levels in the irrigation water. The highest number of florets per spike (28.75) was obtained from plants in the control and the lowest (22.25) among those irrigated at 4 dS/m. Besides, reduction in root biomass caused due to salinity has also been indicated as a factor impeding flowering by affecting energetic reserves (Van Zandt and Mopper, 2002). Saline water irrigation reduced crop growth and production in sensitive species (Volkmar *et al.,* 1998) due to negative effects on water and mineral relations, carbon assimilation and biomass partitioning.

Table-1 : Effect of various levels of saline irrigation water on growth parameters of Tuberose variety Prajwal.

Treatment	Days to sprouting	Plant height (cm)	No. of leaves	Leaf length (cm)	Leaf width (cm)
T_1	11.5	83	20.75	40.83	23.23
T_2	11.75	81.98	17	39.03	23.05
T_3	12.5	80.3	17	40.43	21.95
T_4	13.75	78.73	16.25	38.8	21.41
T_5	14	75.25	15.75	35.55	21.71
CD at 5%	1.55	3.99	2.36	2.93	N/A

(T1-0.7 dSm^{-1} (Control), T2-2 dSm^{-1}, T3-3 dSm^{-1}, T4-4 dSm^{-1}, T5-5 dSm^{-1})

Table-2 : Effect of various levels of saline irrigation water on flowering parameters of Tuberose variety Prajwal.

Treat-ment	Days to bud emerge nce	Days to 1st floret opening	Spike length (cm)	Spike diameter (cm)	Rachis length	No. of florets/ spike	Floret length	Floret diameter (mm)	Days to senesc ence in field	Vase life	Fresh weight of spike (g)	Dry weight of spike (g)
T_1	71.5	89	62.28	6.31	22.85	28.75	5.45	34.1	12.75	9.75	49.46	7.07
T_2	72.25	90	58.6	5.89	19.75	24.75	5.43	33.9	12.25	7.5	42.84	5.25
T_3	77	94.5	57.15	5.85	19.78	24.25	5.3	32.92	11.25	5.75	41.52	5.1
T_4	78	96	57.23	5.64	19.6	24	5.28	32.85	11.25	5.5	40.65	5.2
T_5	79.75	97.5	55.58	5.6	19.33	22.25	5.05	32.3	10.5	5.5	37.72	4.8
CD at 5%	2.74	2.72	4.28	0.3	N/A	3.45	N/A	N/A	N/A	1.15	5.84	1.14

(T1-0.7 dSm^{-1} (Control), T2-2 dSm^{-1}, T3-3 dSm^{-1}, T4-4 dSm^{-1}, T5-5 dSm^{-1})

Table-3 : Effect of various levels of saline irrigation water on physiological, biochemical and nutrient parameters of Tuberose variety Prajwal.

Treatment	MSI (%)	RWC (%)	Chlorophyll (SPAD)	Proline (g/g fresh weight)	Na^+ (%)	K^+ (%)
T_1	81.73	94.24	62.49	128.16	0.12	2.39
T_2	80.15	93.96	57.21	145.89	0.13	2.65
T_3	78.18	92.51	55.3	149.42	0.16	2.78
T_4	74.67	92.21	46.59	165.36	0.17	2.9
T_5	72.05	91.97	38.81	174.2	0.23	3.22
CD at 5%	4.8	1.54	8.09	4.11	0.04	0.45

(T1-0.7 dSm^{-1} (Control), T2-2 dSm^{-1}, T3-3 dSm^{-1}, T4-4 dSm^{-1}, T5-5 dSm^{-1})

Crop response to salinity depends on cultivar and growing conditions (e.g. Bass *et al.,* 1995; Sonneveld *et al.,* 1999). In the present study, there were no significant differences in floret length, floret diameter and days to senescence in field with respect to varying levels of saline irrigation water. The vase life (days) of harvested spikes was found to be significantly higher in control plants (0.7 dS/m). No significant difference were observed in T3, T4 and T5. The fresh weight of spike was significantly high in control plants (49.46 g)and decreased gradually. Similar trend was observed in dry weight of spike(g).

Physiological and Bio-chemical parameters : Table-3 shows the effect of different concentrations of saline irrigation water for above traits. Plants irrigated at (0.7 dS/m), which was control, had the highest chlorophyll content and the ones irrigated with 4 dS/m water had the lowest chlorophyll content. There were no significant ($P>0.05$) differences among T1, T2 and T3 in chlorophyll content of the tuberose plants. An increase in salinity level in irrigation water resulted in decrease in chlorophyll content of tuberose plants (Fig.-5). The second highest chlorophyll content was obtained from plants irrigated with 2 dS/m saline water. The results of the experiment are in agreement with those of Delperee (2003) who stated that the observations might be due to the increased thickness of leaves and compacted mesophyll cells of stressed leaves, consequently, more chloroplasts per unit area, as often is the case under stress conditions. Mamnouie (2006) also reported that the amount of salinity in soil after long irrigation interval with saline water increased and induced oxidative osmotic stress, which resulted in reduction of chlorophyll content in plants. High salinity could affect stroma volumes of chloroplasts and the protein bonds of green pigments, thus causing a decrease

in chlorophyll content in plants (Prakash, 2000).Relative water content (RWC) of leaves decreased in all water salinity treatments. Decrease in means of RWC in salinity level of 4 dS/m was more as compared to all other salinity levels.

In the present study, content of proline in leaves increased at higher stress levels. This increase was significant in most of the treatments (Table-3). To prevent water loss from the cells and protect the cellular proteins, plants accumulate many metabolites that are also known as "compatible solutes." These solutes do not inhibit the normal metabolic reactions. Frequently observed metabolites with an osmolyte function are sugars, mainly fructose and sucrose, sugar alcohols, and complex sugars like trehalose and fructans. In addition, charged metabolites like glycine betaine, proline, and ectoine are also accumulated. The accumulation of these osmolytes, facilitate the osmotic adjustment. Water moves from high water potential to low water potential side and accumulation of these osmolytes lowers the water potential inside the cell and prevents the intracellular water loss (Mahajan and Tuteja, 2005). Tuberose such as other plants creates physiological mechanisms of stress tolerance with production of proline. This compatible solute is found in high concentrations to protect cytoplasmic structures when plants are exposed to stresses (Salehi and Bahadoran, 2015). Similar results were reported by Jampeetong and Brix (2009) who reported increase in proline content and decrease in chlorophyll content of *Salvinianatans* L. under salinity stress condition. Na and K content in leaves increased with increasing salinity level in the irrigation water. This finding correlates with those of Munns (1993) who reported that Na content strongly increases in all plant tissues with increasing NaCl concentration in the nutrient solution.

Conclusions

Based on the findings of the above experiment, it can be concluded that tuberose is sensitive to saline irrigation water. Further investigations are needed to clarify the mechanism of tuberose sensitivity to environmental stresses at both molecular and ultrastructural levels.

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Dynamics of Tobacco Production in Andhra Pradesh

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Abstract

The present study was conducted to analyse the trends in area production and yield of FCV tobacco in Andhra Pradesh. The study found that production of FCV tobacco had higher growth rate than that of area and yield. The cost incurred on cultivation of FCV tobacco in the study area showed that human labour, harvesting and firewood cost was very high compared to that of other costs. The cost of cultivation was found to be highest among medium size farmers followed by small and marginal farmers. The cost A2 + Family labour was found to be highest among marginal farmers followed by small and medium farmers. Medium farmers had higher net income in the study area though the average cost incurred was high among medium farmers compared to other farmers. The study suggests that the concerned agencies should take necessary steps to provide alternative fuel material other than wood in order to preserve natural resources and reduce the cost incurred in curing process.

Introduction

Tobacco known as 'Golden Leaf' is one of the major commercial crops and plays an important role in the world's economy. It is considered as an international crop for being cultivated in 124 countries across the world [1]. The main product of tobacco crop is leaf which is used for consumption purpose, the principle alkaloid present in tobacco leaf is Nicotine. The tobacco is classified into two types, Flue cured Virginia (FCV) and non-Flue Cured Virginia tobacco (non FCV) based on the curing procedure of tobacco. FCV tobacco is more valuable than the non FCV tobacco because of its chemical properties and usage. FCV tobacco is also called as cigarette type of tobacco and is mainly used for cigarette manufacturing. China is largest producer of tobacco in the world with 2391 million kilograms followed by India and Brazil. In Brazil, tobacco production was found to be 744.20 thousand metric tons [3] and that of India was found to be 189 million kilo grams [3]. In India, FCV tobacco contributes to a share of 30 per cent of total tobacco production and 32 per cent of total area. Although, 13 states grow tobacco, major states are Andhra Pradesh, Gujarat, Karnataka, Uttar Pradesh and Bihar. Andhra Pradesh has an annual production of 121 million kg (2021-22) grown in an area of 66000 ha [2]. The present study was conducted to analyse the trends and cost of tobacco production in Andhra Pradesh.

Materials and Methods

The study was conducted for Prakasam district of Andhra Pradesh. The study required both primary and secondary data. Time series data regarding area, production and productivity of tobacco for the period 2001 to 2015 was collected from tobacco board while the primary data required for the study was collected through a pre-tested interview schedule.

Analytical Tools

(a) Variability, growth and trend

Absolute change = current year – Base year

Relative change = current year – Base year

Mean = $\bar{X}$ $\frac{x}{n}$

Current year : The mean value of final three years was considered to be current year

Base year : The mean value of initial three years was considered to be base year

Coefficient of variation : Mean standard deviation and coefficient of variation was used to estimate the variability in area, production and productivity of FCV tobacco in Prakasam district of Andhra Pradesh.

Standard deviation : $\sqrt{\frac{1}{n} \quad (X \quad \bar{X})^2}$

Co-efficient of Variation = $\frac{}{\bar{X}} * 100$

Estimation of trend : $Y \quad a \quad bt$

Simple growth rate : $GR \quad \frac{b}{\bar{Y}} * 100$

Compound Annual Growth Rate : Compound growth rate for area, production and productivity of FCV tobacco in Andhra Pradesh was estimated for time series data 2001-2015.

Compound growth rate in percentage

$$= (Anti \log b \quad 1) * 100$$

(b) Cost concepts : The costs incurred in cultivation of tobacco was assessed and the following cost concepts were used in the study,

CostA1 = All actual expenses incurred in the production (Casual hired labour, seedlings, manures, fertilizers, Plant Protection Chemicals, irrigation charges, interest on working capital, depreciation, land revenue, firewood charges, miscellaneous expenses)

Cost A2 = Cost A1+ Rent paid for leased in land

Cost B1 = Cost A2 + Interest on fixed capital excluding land

Cost B2 = Cost B1 + Rental value of owned land

Cost C1 = Cost B1 + Imputed value of family labour

Cost C2 = Cost B2 + Imputed value of family labour

Cost C3 = Cost C2 + 10 per cent of Cost C2 as managerial cost

Cost of production (Rs. per kg)

$$= \frac{\text{Total cost incurred in production (Rs.)} - \text{value of by} - \text{products (Rs.)}}{\text{Quantity of the main product (Quintals)}}$$

Depreciation was calculated by using straight line method, rental value of land was assumed to be 20 per cent of gross returns, interest on working capital was calculated at rate of 7 per cent per annum for half of the crop period (7 per cent was the prevailing interest for crop loan in the study area), interest on fixed capital was calculated at the rate of 10 per cent per annum for value of fixed assets excluding land and it is apportioned in proportion to the total area of crop.

(c) Profitability measures : Following income measures were calculated in the study,

Gross income = It was considered as the total value of main product and By-product

Returns over variable cost (RVC) = Gross income – Cost A_1

Farm business income= Gross income – Cost A_2

Family labour income = Gross income – Cost B_2

Net income = Gross income – Cost C_2

Returns to management RM = Gross income – Cost C_3

Returns per rupee (RPR) = Gross income per hectare / Cost C_2

Results and Discussion

The area under FCV tobacco was found to be increased by 4.01 per cent from 96.77 (The Base year) to 100.87 '000' ha (The current year) with the fluctuation of 18.10 per cent and annual growth of 0.31 (SGR) and 0.16 (CGR) per year in Andhra Pradesh during 2001 to 2015. The production was found to be increased by 31.98 per cent from 131.89 (The Base year) to 174.07 million kgs (The Current year) with the fluctuation of 18.46 per cent and annual growth of 1.90 (SGR) and 1.90 (CGR) per year. The yield of FCV tobacco witnessed an increase of 26.25 per cent from 1363.66 (The Base year) to 1721.66 kg/ha (The Current year) with the fluctuation of 11.39 per cent and annual growth of 1.82 (SGR) and 1.74 (CGR) per year (Table-1).

Costs and returns : The labour used in FCV tobacco cultivation was divided into human labour, bullock labour and machine labour. On an average 12 per cent of total labour cost was incurred on family labour, 66 per cent on hired labour, 2 per cent on bullock labour and 18 percent on machine labour (Fig.-2).

The operation wise cost incurred in FCV tobacco cultivation was estimated and the average cost incurred on land preparation was found to be14 per cent of the total operational cost. The average cost incurred on sowing

Table-1 : Variability and growth in area production and productivity of FCV tobacco.

Particulars	Area	Production	Yield
Base year	96.77	131.89	1363.66
Current year	100.82	174.07	1721.66
Relative change	4.01	31.98	26.25
Absolute change	4.04	42.17	358
SD	21.00	30.50	163.27
CV	18.10	18.46	11.39
Trend coefficient (b)	0.36	3.15*	26.16*
SGR	0.31	1.90	1.82
CAGR	0.16	1.90	1.74
t calculated	0.28	1.88	3.70*

*Indicates significance @ 5 per cent

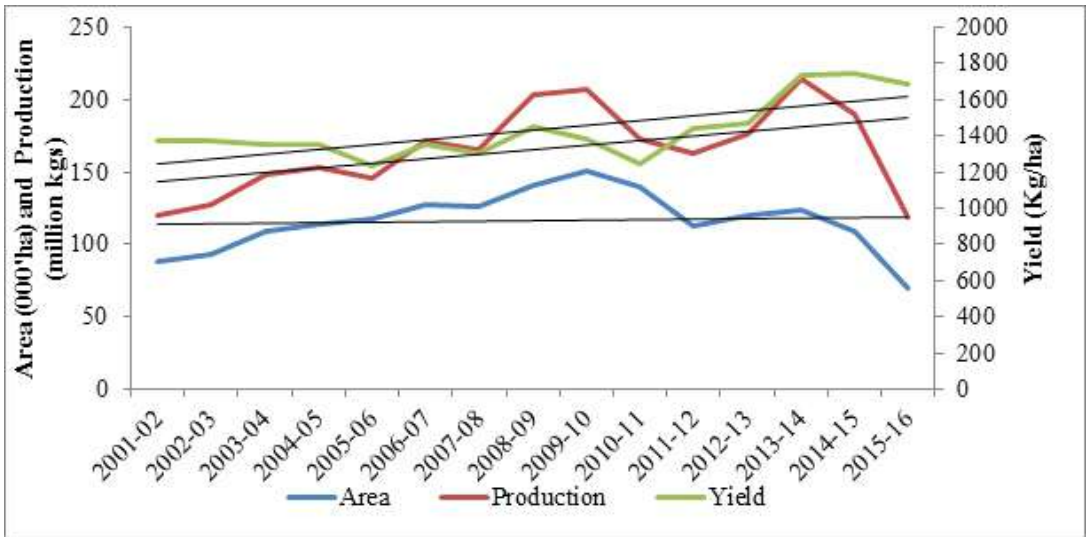

Fig.-1 : Trend in area, production and yield of FCV tobacco in AP during 2001-02 to 2015-16.

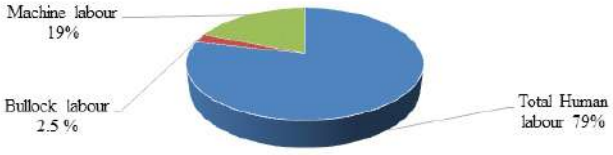

Fig-2 : Labour cost incurred in tobacco cultivation.

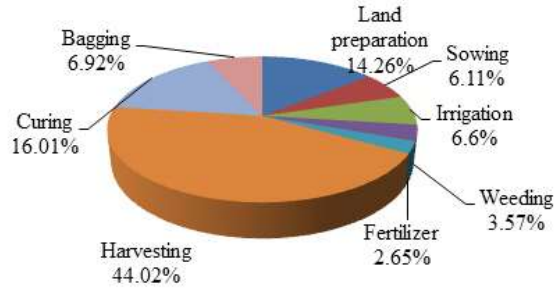

Fig-3 : Operation cost incurred in tobacco cultivation.

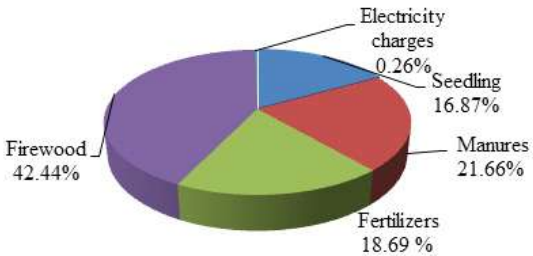

Fig-4 : Input cost incurred in cultivation of FCV tobacco.

and irrigation was found to be 6 per cent of total operational cost and that of on weeding, fertilizer application, harvesting, curing and bagging was found to be 4 per cent, 3 per cent, 44 per cent, 16 per cent and 7 per cent respectively (Fig.-3). The total input cost in the cultivation process was analysed and found that firewood accounted for 42 per cent of total input cost, followed by manures and fertilizers with 40 per cent of total input cost and remaining 17.13 per cent was incurred for seedling and electricity charges (Fig 4). The results obtained were similar to the study conducted by

It is evident from table-2 that Cost A_1, Cost A_2 and Cost B_1 were found to be 52 per cent each while Cost B_2, Cost C_1, Cost C_2 were found to be 88 percent, 56 percent, and 91 percent of total cost C_3. The sum of cost A_2 and family labour was found to be 54 percent of total cost. The total cost of marginal, small and medium farmers was found to be Rs 157715, Rs 157957 and Rs 159680 respectively. The average total cost of FCV cultivation was found to be Rs 158539. It was found that medium farmers incurred high cost in tobacco cultivation (Table-2).

The average yield of the study area was found to be 20.62 quintal per hectare and the average cost per quintal was found to be Rs 13629. The gross returns of FCV tobacco cultivation in the study area were found to be Rs 281037. The net returns over total variable cost, farm business income, farm labour income, net income, returns to management and net income over cost A_2 and family labour was found to be Rs 199207, Rs 199207, Rs 141580, Rs 134936, Rs 122529 and Rs 194565 respectively (Table-3).

Table-2 : Cost of cultivation of FCV Tobacco across size of farms. **Unit – Rs / ha**

Cost	Marginal	Small	Medium	Average
A1	80006.35 (51)	81308.54 (51)	83836.23 (52)	81830.33 (52)
A2	80006.35 (51)	81308.54 (51)	83836.23 (52)	81830.33 (52)
(Cost A2 + FL)	86511.35 (55)	86323.54 (55)	86238.23 (54)	86471.66 (54)
B1	83188.05 (53)	82849.14 (52)	84712.36 (53)	83249.22 (52)
B2	138854.25 (88)	138492.14 (88)	142025.32 (88)	139456.62 (88)
C1	89693.05 (57)	87864.14 (56)	87114.36 (56)	87890.55 (56)
C2	145359.25 (92)	143507.14 (91)	144427.32 (91)	144097.95 (91)
C3	157714.97 (100)	157857.18 (100)	159679.65 (100)	158539.53 (100)

Figures in parenthesis show the percentage to total cost C3.

Table-3 : Profitability of FCV tobacco across size of farms. **Unit – Rs / ha**

Particulars	Marginal	Small	Medium	Average
Average yield (q/ha)	20.35	20.45	21.07	20.62
Average price (Rs/q)	13677	13604.65	13600.60	13629.34
Gross return	278331	278215.23	286564.8	281037
Net returns over variable cost	198324.65	196906.66	202728.57	199206.67
Farm business income	198324.65	196906.66	202728.57	199206.67
Family labour income	139476.75	139723.06	144539.48	141580.38
Net income	132971.75	134708.06	142137.48	136939.05
Returns to management	118435.83	120357.31	127694.65	122529.26
Net income over cost A2 + FL	191819.65	191891.66	200326.57	194565.34

Conclusions

The study concludes that production of tobacco had higher growth rate than that of area and productivity. The human labour cost contributed majorly in the total labour cost because of on-going human labour prices. Harvesting cost was high because of manual harvesting in the study area. Curing plays a major role in tobacco cultivation leading to high cost of firewood. The study revealed that medium farmers incurred high cost of cultivation in FCV tobacco and also obtained higher net income. The study suggests that concerned agencies should take necessary steps to provide alternative fuel material other than wood with cheaper rates in order to reduce the cost of curing as well as deforestation.

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Effect of Integrated Nutrient Management on Growth, Yield and Economics of Papaya (*Carica papaya* L.)

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Abstract

A filed experiment was conducted during 2019-20 and 2020-21 on the seven farmers' field in Khargone (M.P.) to determine the effect of integrated nutrient management (INM) on growth, yield and economics of papaya. Treatments comprised T_1 Farmers' practice (200:250:100g NPK/plant/year) and T_2 INM (RDF 250:250:250g NPK/plant/year + 20 Kg FYM/ Plant + Azotobacter 20 g/plant + PSB 20 g/Plant). T_2 recorded significantly higher number of fruits/tree (38.07), fruit weight (1.062 g), yield/tree (40.442 kg) and yield/ha (1011.07 q). The maximum net return of Rs 329950/ ha and benefit cost ratio of 2.46 were recorded with treatment T_2. Whereas, the minimum net return of Rs 207573/ ha and benefit cost ratio of 2.09 were recorded in T_1.

Key words *: Integrated nutrient management, growth, papaya, yield.*

Introduction

Papaya (*Carica papaya* L.) of the family Caricaceae has come out most popular fruit crop in recent years because of the ease in cultivation, high returns, wide adaptability in different agro ecological conditions. Its attractive, delicious fruits have wide scope for value addition. In India, it is grown all over the country and is available round the year. It occupies an area of 138.40 thousand hectares with production of 5988.83 thousand MT with productivity of 43.27 MT/hectare (Anon., 2018). It is a rich source of carbohydrates, minerals and vitamins (carotene, riboflavin and vitamin A). Papaya has high amounts of photolytic enzyme, papain and alkaloid carpaine, which are of importance to pharmaceutical, tanning and silk industries (Chadha, 1992). For sustainable soil productivity, optimum and balanced soil biological activities are must, its disturbance will affect the nutrient transformation in soil. Soil organic matter and balanced microbial activities contribute to sustainable functioning of soil. Currently, intensification of production systems without adequate organic matter has deteriorated the soil health. Therefore, nutrient management is one of the key factors to improve the productivity. Continuous sole and erratic use of chemical fertilizer in imbalanced ratio leads to decline in soil fertility as well as nutrient uptake efficiency, resulting in either yield stagnation or its decline. The nutrition of papaya differs from other fruit crops because of its rapid growth, continuous flowering and production potential. The present investigation was undertaken with an objective of determining the effect of integrated nutrient management on growth, yield and economics of papaya cv. Red Lady 786.

Materials and Methods

The experiment was carried out on seven farmers' field in West Nimar region of M.P. during the year 2019-2020 and 2020-21. Treatments T_1 Farmers' practice is comprised (200:250:100g NPK/plant/year) and INM T_2 (RDF 250:250:250g NPK/plant/year + 20 Kg FYM/ Plant + Azotobacter 20 g/plant + PSB 20 g/Plant). Seedlings were transplanted in the field with spacing of 2 × 2 m. Recommended practices were followed. The yield parameters recorded were number of fruits/plant, average fruit weight, Fruit yield kg/plant, fruit yield q/ha. Cost of cultivation/ha, gross return/ha, net return/ha and BC ratio were worked out as per standard methods. Various parameters were compared as per paired "t" test of significance.

Results and Discussion

Growth parameters : Plant height, stem girth, petiole length and number of leaves per plant were significantly affected by the application of organic manures, inorganic fertilizers and bio fertilizers in combinations. It is evident from (table 1). Maximum plant height (186.41cm), stem girth (50.21cm), petiole length (43.68 cm) and number of leaves per plant (45.09) were recorded in T_2 (INM). Significantly lower plant height (175.32 cm), stem girth (45.25 cm), petiole length (40.56 cm) and number of leaves per plant (41.11) were recorded with T_1 (Farmers' practice). It may be attributed to continuous supply of nutrients from organic as well as inorganic sources and effect of bioactive substance released by application of bio fertilizers. Organic manures along with bio fertilizers also

Table-1 : Effect of integrated nutrient management on growth parameters of papaya.

Treatments	Plant height (cm)	Stem girth (cm)	Petiole length (cm)	Number of leaves/Plant
T_1	175.32	45.25	40.56	41.11
T_2	186.41	50.21	43.68	45.09
t-value	5.4819	3.4187	2.8273	3.7804

The means of T_1 and T_2 are significantly different at p = 0.05.

Table-2 : Effect of integrated nutrient management on yield parameters of papaya.

Treatments	Number of fruits/plant	Average weight of fruits (Kg)	Fruit yield/ plant (Kg)	Fruit yield/ hectare (q)
T_1	34.53	0.923	31.874	796.86
T_2	38.07	1.062	40.442	1011.07
t-value	4.1126	3.9065	15.4567	19.2965

The means of T_1 and T_2 are significantly different at p = 0.05.

Table-3 : Effect of integrated nutrient management on economics of papaya.

Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit Cost : ratio
T_1	190855	398429	207573	2.09
T2	226139	556089	329950	2.46

improve physio chemical conditions of soil, which ultimately resulted in increased plant height, stem girth petiole length and number leaves per plant. The similar result was reported by Shivakumar (2010), Suresh *et al.* (2010), Singh *et al.* (2010), Tandel *et al.* (2014) and Srinu *et al.* (2017) in papaya.

Yield parameters : The effect of integrated nutrient management on yield attributes such as the number of fruit per plant (38.07), average fruit weight (1.062 kg), fruit yield per plant (40.442 kg) and yield per hectare (1011.07 q) were higher with the application of RDF 250:250:250g NPK/plant/year + 20 Kg FYM/ Plant + Azotobacter 20g/plant + PSB 20g/Plant (T_2). However, T_1 recorded significantly lower number of fruit per plant (34.53), average fruit weight (0.923 kg), fruit yield per plant (31.874 kg) and yield per hectare (796.86 q). The significant response of bio-fertilizers, organic manure with inorganic fertilizers greatly influenced the yield attributes. Increase in fruit yield may be attributed to better availability as well as uptake of nutrients and enhanced source-sink relationship because of better movement of carbohydrates from the leaves to the fruits (Yadav *et al.*, 2011b). Higher yield response owing to application of organics ascribed to improved physical, chemical and biological properties of soil resulting in proper and timely supply of nutrients, which in turn led to robust crop growth and yield (Shivakumar, 2010). Decomposition of organic materials caused the release of appreciable quantities of CO_2, which got dissolved in water and form carbonic acid, which decomposed certain primary minerals and release nutrients and boost nutrient uptake (Suresh *et al.*, 2010). These results are in conformity with the findings of Shivaputra *et al.* (2004), Singh *et al.* (2010) and Tandel *et al.* (2017).

Economics : Economics of various treatments (Table 2) shows maximum net returns (Rs 329950) and B C ratio (2.46) in treatment T_2 (RDF 250:250:250g NPK/plant/year + 20 Kg FYM/ Plant + Azotobacter 20g/plant + PSB 20g/Plant). However, minimum net returns (Rs 207573) and low Benefit-Cost ratio (2.09) were recorded in T_1. These results are in conformity with the results reported by Yadav *et al.* (2011) and Srinu *et al.* (2017) in papaya.

Conclusions

The results of present experiment on integrated nutrient management of papaya cv. Red lady 786 revealed that the application of RDF 250:250:250g NPK/plant/year + 20 Kg FYM/ Plant + Azotobacter 20g/plant + PSB 20g/Plant was the most appropriate dose of integrated nutrient management for obtaining maximum growth, yield and net returns from papaya.

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Effect of Moringa Leaf Meal-Based Diet Feeding on Behaviour in Growing Deccani Sheep

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Abstract

Present investigation has been carried out on Eighteen growing Deccani sheep of uniform body weight (14.22 kg) were reared in intensive farming at LFC, Rajendranagar Hyderabad to investigate the impact of feeding Moringa leaf meal on feeding behaviour and intake and digestibility in Deccani sheep. The animals were divided randomly into three groups (three males and females in each) taking into consideration the group averages of body weights in all 3 groups were as uniform as possible. Three experimental diets were prepared using 100 percent groundnut cake (T1), 75% groundnut cake+ 25% *Moringa oliefera* leaf meal (T2) and 50% groundnut cake+ 50 % *M. oliefera* leaf meal (T3) as protein source in the concentrate mixture and offered @ 1% of body weight along with *ad libitum* green fodder. Time spent and percentage of total time spent on eating and sleeping were significantly (P<0.01) higher in T2 (50.0 ±0.78 and 18.33±1.75) group lambs than T3 (47.91±1.69 and 22.5±0.68) and T1(46.25±0.78 and 26.26±0.48) group lambs and no significant difference was noticed between T1 and T3 group lambs. More time spent in eating in T2 group indicate that the Moringa based diet (25%) was relatively more palatable than the other two groups.

Key words : *Chemical composition, digestibility, feeding behavior, Moringa oleifera.*

Introduction

India is the largest producer of Moringa (Radovich *et. al.*, 2011), with an annual production of 1.1 to 1.3 million tons of fruits pods and an average green leaf fodder yield up to 120 tons/ha/year (Sagbo *et. al.*, 2006). The advantage of using moringa as a protein source are numerous and include the fact that it is a perinial plant that can be harvested several times in one growing season and also has the potential to reduce feed cost of livestock ration. Due to its potential benefits it is popularly known as “Miracle Tree”.

Over the past decade a progressive decline in the global sheep population was observed, and in 2008 the universal flock size was estimated at 1000 million sheep. This decline could be ascribed to seasonal droughts, unpredictable weather patterns, diminishing land resources and an unstable economy with fluctuating meat prices. The global trend in animal production is a systematic transition from small-scale extensive production to large-scale intensive production systems (Venkatata Raju. N *et al* 2015).

Feeding behavioural studies are useful in the palatability and choice of feed for the sheep and the acceptability of feed is probably one of the prime parameters for ascertaining utility of the non-conventional feed resource.

Utilization of fodder trees and shrubs could be a potential strategy for increasing the quality and availability of feeds for resource-limited livestock farmers during the dry season. The trees provide a good and cheaper source of protein and micronutrients (Moyo *et al.,* 2012a). In recent years, there has been increased research on alternative protein sources from forage trees and shrubs that can be fed to sheep. In recent years, attention has been given to the use of moringa leaf meal (MLM) as a protein source and feed component in animal production especially in goats (Sarwatt *et al.,* 2002; Asaolu *et al.,* 2010). There are many advantages of using moringa foliage as protein source including the fact that it is a perennial plant that can be harvested several times in one growing season. The leaves can be fed fresh or dried with little effect on intake. Dried moringa leaf can be stored for longer periods

In India, there is scarce work on effect of feeding Moringa leves on feeding behavior and dry matter digestibility in sheep. Keeping in view of above points, the present investigation has been carried out to investigate the impact of feeding Moringa leaves on feeding behavior and dry matter digestibility.

Materials and Methods

Eighteen growing Deccani sheep of uniform body weight (14.22 kg) were reared in intensive farming at LFC,

Table-1 : Chemical Composition of feed ingredient and Moringa leaves (% DM Basis).

Constituent	De-oiled rice bran	Red gram chunni	Ground nut cake (De-oiled)	Cotton seed cake	Moringa Leaves	Para Grass
Dry matter	91.67	92.26	95.68	92.42	92.12	55.21
Crude Protein	13.54	13.87	34.03	24.45	24.39	6.48
Ether Extract	0.76	2.37	0.78	8.58	6.67	1.58
Crude Fiber	15.14	31.89	5.34	26.83	5.57	18.49
Total Ash	12.88	3.68	12.78	5.42	12.66	6.67
Acid Insoluble Ash	5.83	0.23	6.69	0.40	0.27	4.35
Total Phosphorus	1.92	0.72	0.75	0.98	0.65	0.10
Calcium	0.20	0.41	0.60	0.66	2.07	0.35
Neutral Detergent Fibre	24.10	18.60	26.28	34.60	38.84	68.70
Acid Detergent Fibre	11.50	15.17	22.3	20.20	12.94	42.3

Table-2 : Effect of feeding Moringa based diets on behavioural traits of Deccani lambs under Intensive farming system.

Behavioural Traits	Control T_1		T_2		T_3	
	Time Spent (Min)	% Total Time	Time Spent (Min)	% Total Time	Time Spent (Min)	% Total Time
Eating	114 ± 1.87	46.25 ± 0.78	120 ± 1.87	50 ± 0.78	115 ± 4.06	47.91 ± 1.69
Drinking Water	5 ± 0.37	2.8 ± 0.16	6 ± 0.37	2.5 ± 0.16	5 ± 0.45	2.8 ± 0.19
Ruminating	40 ± 4.47	16.16 ± 0.78	48 ± 1.87	20 ± 0.93	45 ± 2.24	18.75 ± 0.72
Standing	20 ± 2.00	8.33 ± 0.83	22 ± 1.87	9.16 ± 0.78	21 ± 2.45	8.75 ± 1.02
Sleeping	61 ± 2.92	26.26 ± 0.48	44 ± 1.16	18.33 ± 1.75	54 ± 4.2	22.5 ± 0.68
SEM	19.111	7.666	19.544	8.144	18.857	7.778
p-value	1.00	0.72	0.89	0.93	0.68	0.87

Rajendranagar Hyderabad and randomly allotted to three treatment groups with six lambs in each group (6 x 3) and reared in intensive farming.Three experimental diets were prepared using 100 percent groundnut cake (T1), 75% groundnut cake+ 25% *Moringa oliefera* leaf meal (T2) and 50% groundnut cake+ 50% *Moringa oliefera* leaf meal (T3) as protein source in the concentrate mixture and offered @ 1% of body weight along with *ad libitum* green fodder.

Behavioural recording was done by direct visual observation of lambs using a stopwatch for five days each for four hours from 8.00 AM-12.00 noon after refreshing of daily feed. The recorded activities were eating, ruminating, drinking, standing and sleeping as per the procedures of Fraser and Broom (1990).

Analytical Methods : The proximate analysis of feeds was performed as per the procedures described by AOAC (2005).

Statistical analyses : Statistical analysis of the data was carried out in accordance with Snedecor and Cochran (1994). Analysis of variance was used to test the significance of variance and the treatment means tested for significance by Duncans new multiple range F test (Duncan,1995).

Results and Discussion

Chemical composition of experimental diets : The chemical composition of the feed ingredients used in experiment i.e DORB, Red gram chunni, DGNC, CSC, dried leaves of Moringa, Para grass is presented in Table1. Proximate composition of feed ingredients and Moringa leaves used in the present study are shown in Table-1. The data indicated that the crude protein content of *Moringa oleifera* was 24.39%, this makes the Moringa leaves to be a good potential source of supplementary protein in animal diets. This level of crude protein content is of particular nutritional significance as it may meet animal's protein and energy requirements and boost the immune system against diseases. Moringa is reported to have high quality protein which is easily digested and that is influenced by the quality of its amino acids (Babeker and Bdalbagi, 2015). The acceptability of feed is probably one of the prime parameters for ascertaining utility of the non-conventional feed resource.

Feeding behaviour : Time spent and percentage of total time spent on eating and sleeping were significantly ($P<0.01$) higher in T2 group lambs than T3 and T1 group lambs and no significant difference was noticed between T1 and T3 group lambs. The percentage of time spent for

ruminating was less than the time spent for eating in the present study. Time spent in eating and percentage of time spent in eating in T2 group indicates that the Moringa based diet (25%) was relatively more palatable. The literature on feeding behaviour with Moringa based diets are scanty in sheep. However, the present findings are disagreement with Abijoude et al. (2000) in sheep Nasrullah et al. (2013) in goats.

Conclusions

Moringa oliefera had a crude protein content of 24.39% on DB basis. Hence, it could be considered as an alternative proetein source for sheep feeding and dry matter intake was significantly higher in T2 group where as the sheep, more time spent in eating, ruminating, sleeping and dry matter intake, digestibility coefficients (%) suggests feeding of Moringa leaves 25% (T2) replacement in -intensive system of rearing and Moringa feeding can help small and medium scale farmers overcome shortages of good quality feeds and therefore sustain and improve their productivity. The result of the this study recorded that the supplementation of *Moringa oleifera* leaves 25%-in small ruminants shows boosting for all the parameter without any adverse effect and high protein content. However more research is needed to assure these finding.

There was no significant difference in feeding behaviour traits among lambs fed on different experimental diets in intensive farming system. More time spent in eating in T2 group indicate that the Moringa based diet (25%) was relatively more palatable than the other two groups.

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Storage Behaviour of Potato Cultivars under Ambient Conditions in Semi-Arid Region

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Abstract

Potatoes, the humble tuberous crops, have played a pivotal role in the culinary and agricultural landscapes for centuries. These versatile vegetables are not only a dietary staple for millions worldwide but also a fascinating subject of scientific inquiry. Several studies have reported the storage behaviour of potato cultivars under ambient conditions in Semi-Arid Region and provided valuable insights into the optimal conditions for its growth and development. This study was carried out at research farm of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University- Hisar, India during *rabi* season of the year 2021-22. Among all varieties, the Kufri Bahar shows minimum loss in weight (24.06 %), minimum decay loss (11.43 %), minimum sprouting loss (50.40 %) and Kufri Lima resulted maximum total marketable tuber yield (374.4 q/ha) and Kufri Neelkanth resulted maximum (582.21 q/ha) biological yield and with spacing 60×20 cm with whole tuber maximum total marketable tuber yield (373 q/ha) and resulted maximum (583.9 q/ha). The experiment was conducted with factorial randomised block design with three replications. Based on this study, the aforementioned treatments can be exploited for sustainable potato production.

Key words : *Potato, varieties, storage yield and loss.*

Introduction

Potato (*Solanum tuberosum* L.) belongs to family Solanaceae is one of the most important among vegetable crops grown throughout India. This crop gives an exceptionally high yield (30-40 t/ha) and produces more edible energy and protein per unit area and time than many other crops. Besides, potato generates a higher yield as compared to the other crops; therefore, it is one of the most prominent crops to eliminate hunger and poverty at global level. However, the crop possesses huge potential concerning yield and nutrition, enhancement of the potato production is major concern due to increasing global population. Devoid of genetics, various agronomic practices in potato production affects its yield to a greater extent. Among all the production practices, spacing and planting material highly affects the yield.

Potato plant is very sensitive to climate factors such as temperature and day length, which exert a considerable influence on its growth and development. A temperature of 15- 20°C is optimum for sprouting and emergence of tubers. Maximum tuberization taken place a mean temperature of about 20°C. Soil has great influence on yield and quality of the potato tubers. Visual rating for appearance showed that the tubers of potato cultivars remained firm up to 105 days even at room temperature (Mehta *et al.,* 2006). The size of potato tuber significantly influenced the days to start shrivelling as the large sized tubers shrivelled earlier than the small sized tubers (Nipa *et al.,* 2013). Weight loss up to 10% was considered acceptable because of no visible shrivelling of tubers, but at higher weight loss, shrivelling took place, which reduced the market value of table potatoes (Mehta and Ezekiel, 2010).

Potato tubers must be stored properly in order to ensure a consistent supply in the market. This necessitates the monitoring of tuber quality at harvest as well as in storage. Many factors influence the storage behaviour of potato tubers. Weight losses and chemical composition of stored tubers are influenced by meteorological circumstances, physiological age of the seed tuber, variety and soil type during the growth period, as well as agronomic factors such as leaf death before maturity and harvest date (Firman and Allen, 2007). Farmers have also been reported to lose up to 40% of their stored tubers within three months of storage due to poor storage conditions. Postharvest losses from spotting are represented by a loss of quantity and quality due to pathological, physiological and mechanical damage to potatoes (Oladoye *et al.,* 2013).

Visible rating of firmness showed shrivelled condition of heaped potatoes after 90 days of storage. Tuber weight loss more than 10% reduces the marketability of potatoes because of their shrivelled appearance (Booth and Shaw, 1981). Weight loss up to 10% was considered acceptable because of no visible shrivelling of tubers, but at higher weight loss, shrivelling took place, which reduced the market value of table potatoes (Mehta and Ezekiel, 2010). Increase in production mostly results in glut and several post-harvest problems in storage. The storage losses to which the

potato is subjected include respiration, transpiration or water loss, sprouting after breaking dormancy, decaying and damage caused by pests.

Good quality seed is almost universally considered a requirement for high productivity in all potato production systems. Much of the yield gap currently constraining productivity is attributed to the poor quality of seed. Potato seed sector development is thus a major concern of governments, researchers, development agencies and civil society organizations (Forbes *et al.,* 2020).

Materials and Methods

The present study was carried out at Vegetable Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experimental site is situated at 29°10"N latitude and 75°46"E longitude with 215.2 m above mean sea level in north-west part of India. The treatments comprising of three potato varieties; **(V_1):-** Kufri Neelkanth, **(V_2):-** Kufri Bahar and **(V_3):-** Kufri Lima **(V_3)** and four different spacing; **(S_1):-** 60×10 cm with cut tuber, **(S_2):-** 60×15 cm with cut tuber, **(S_3):-** 60×20 cm with cut tuber and **(S_4):-** 60×20 cm with whole tuber were laid out in a randomized block design (factorial) with three replications keeping gross plot size 4.8 x 3.6 m^2 net plot size 3.6 x 3.0 m^2. Tubers of 2.5-3.0 cm diameter disease free certified seed tubers were used and recommended package of practices for potato FYM @ 20 tonne/ha + 150: 100: 120 kg/ha was used. At the last ploughing, the whole quantity of FYM @ 20 tonnes per hectare was incorporated in the soil. In addition to this half quantity of nitrogen and full phosphorus and potassium were applied in rows about 4-5 cm away from seed tubers and remaining quantity of nitrogen was top dressed in furrow at the time of earthing up. The data recorded during study for various parameters was statistically analyzed with the help of OPSTAT available at CCS HAU, Hisar, website.

The mean weekly maximum temperature ranged between 17.1 to 32.0 ºC and minimum between 5.2 to 19.6 ºC and relative humidity ranged between 88 to 97 per cent. Field soil belongs to inceptisol order and sandy loam texture with 55% sand, 34% silt and 11% clay. Field soil contain organic carbon (0.44 %), available nitrogen (128 kg/ha), medium phosphorus (28.5 kg/ha) and available potassium (378 kg/ha), the fertility status of the experimental area was poor. Field soil is also little bit alkaline having pH value of 7.9. The month wise total precipitation, average maximum & amp; minimum temperature, relative humidity, sunshine hours and evaporation of experimental site of the crop seasons are depicted in Table-1.

Results and Discussion

The physiological loss in weight in different potato varieties and under different plant spacings increased with increased storage period as shown in Table 2. Throughout the 90-days storage period, data on physiological weight loss were collected at 15 days intervals and reported as a cumulative percentage. The physiological weight loss increased significantly as storage time extended from the beginning to the end of the experiment. The physiological loss in weight was significantly influenced by different varieties at 90 days of storage while plant spacing had no significant effect. The interaction of different plants spacing and varieties for all the treatments differed non-significantly. Among potato varieties, the variety Kufri Bahar showed the minimum cumulative physiological loss in weight (24.06 %) in comparison to Kufri Lima (26.04%) and Kufri Neelkanth (28.36 %) on 90th day of storage under ambient conditions. The different plant spacings using whole and cut tuber had no significant effect on physiological loss in weight during storage. Verma *et al.* (1974) found that the storage of potato tubers at ambient room temperature leads to severe loss in their weight and quality during hot summer months. Other reasons might be the higher transpiration losses, membrane permeability, delay in periderm formation, changes in specific gravity, organic acid contents and sugars & amino acids which may be attributed to the weight loss. Patel *et al*. (2012) reported that the variation among varieties with reference to physiological loss in weight might be attributed to the genetic factors.

At intervals of 15 days during storage, the loss from potato tuber decay on a weight basis was recorded in cumulative percentage. The decaying loss in weight was significantly influenced due to effect of different varieties at 90 days of storage but with comparison to varied plant spacings using whole or cut tuber for planting did not produce a noticeable result.

The decay loss was found lower at start of storage, while it increased with increasing storage period (Table 3) because the susceptibility of potato tubers to different disease-causing organisms and the pests attack during storage, which got enough time to multiply with increasing storage period leads to decay loss. The results are in accordance with the findings of Malik *et al*. (2008) and Brar and Rana (2016). Kufri Bahar showed minimum decay loss as compared to Kufri Neelkanth and Kufri Lima. Significant difference in decay loss was recorded among varieties which might be due to their genetic makeup. Similar results were also reported by Chandra *et al*. (2017). However, different plant spacings using cut or whole tubers had no effect on decay loss of the potato tubers.

The sprouting behavior of potato was studied on weight basis during storage under ambient conditions and

Table-1 : Monthly actual weather parameters of the experimental site during 2021-22.

Season	T max (°C)	T min (°C)	RH (%)	Sunshine (hours)	Rainfall (mm)	Evaporation (mm)
October	32.0	19.6	88	7.3	3.2	3.2
November	27.9	9.9	90	5.5	0.0	1.8
December	21.3	6.3	95	5.0	0.0	1.3
January	17.1	5.2	97	3.9	10.4	1.0
February	22.7	6.8	93	7.2	10.9	2.1
March	25.9	12.4	92	6.1	95.2	3.1

Tmax- maximum temperature, Tmin- minimum temperature, RH-relative humidity.

Table-2 : Effect of plant spacing using cut seed tuber of different potato varieties on physiological loss (%) on weight basis during storage under ambient conditions.

Plant spacing	Varieties	Storage period (days)					
		15	30	45	60	75	90
60×10 cm with cut tuber	K. Neelkanth	5.27	10.37	13.36	16.23	22.18	27.42
	K. Bahar	4.70	8.07	13.30	16.22	19.14	24.56
	K. Lima	4.52	9.88	12.30	16.42	22.18	25.79
Mean		4.83	9.44	12.99	16.29	21.17	25.92
60×15 cm with cut tuber	K. Neelkanth	5.27	10.87	14.52	16.72	23.42	28.33
	K. Bahar	4.75	8.25	10.52	15.74	18.19	21.26
	K. Lima	4.67	8.85	11.82	15.57	22.18	27.02
Mean		4.89	9.32	12.28	16.01	21.26	25.54
60×20 cm with cut tuber	K. Neelkanth	6.33	10.43	14.00	16.63	22.10	27.00
	K. Bahar	4.40	7.88	10.65	13.67	19.55	25.23
	K. Lima	4.55	8.22	11.33	15.55	21.38	27.20
Mean		5.09	8.84	11.99	15.28	21.01	26.48
60×20 cm with whole tuber	K. Neelkanth	6.62	10.23	13.37	17.07	25.83	30.70
	K. Bahar	4.20	7.63	11.47	15.27	20.96	25.21
	K. Lima	4.40	8.72	11.08	16.34	19.15	24.13
Mean		5.07	8.86	11.97	16.23	21.98	26.68
Mean of Variety	K. Neelkanth	5.87	10.48	13.81	16.66	23.38	28.36
	K. Bahar	4.51	7.96	11.48	15.22	19.46	24.06
	K. Lima	4.53	8.92	11.63	15.97	21.22	26.04
		CD at 5%					
Variety		0.55	0.79	0.98	0.64	1.80	2.18
Spacing		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Variety × Spacing		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

expressed in cumulative percentage. The data related to sprouting loss (%) on weight basis has been presented in Table 4. The sprouting loss was significantly influenced by different potato varieties and non-significantly influenced with different plant spacing.

It is evident from the table as the storage period was increased, the percentage of sprouting increased considerably. Sprouting started on 45th day of storage in all treatments and the highest sprouting loss was recorded on 90th day of storage. All the varieties with respect to sprouting per cent differed significantly from each other. Kufri Bahar showed minimum sprouting loss (50.40 %) which was significantly lower as compared to other varieties and Kufri Neelkanth showed the maximum sprouting per cent (62.45 %) after 90 days storage. The interaction between different plant spacing and variety for sprouting per cent was found non-significant for all the treatment combinations. The sprouting loss was found highest at 90 days of storage, however, up to 30 days of storage no tuber was sprouting. The reason might be due to release of dormancy in tubers with time. The results are in conformity with the findings of Gupta *et al.* (2015), Brar and Rana (2016) and Sudha *et al.* (2017).

The data demonstrated that different plant spacing and varieties of potato had significant impact on the marketable yield and biological yield (q/ha). The

Table-3 : Effect of plant spacing using cut seed tuber of different potato varieties on decay loss (%) on weight basis during storage under ambient conditions.

Plant spacing	Varieties	Storage period (days)					
		15	30	45	60	75	90
60×10 cm with cut tuber	K. Neelkanth	0.00	0.00	0.58	5.35	8.49	14.00
	K. Bahar	0.00	0.00	0.64	4.11	6.40	10.75
	K. Lima	0.00	0.00	1.83	5.30	7.99	13.06
Mean		0.00	0.00	1.02	4.92	7.63	12.60
60×15 cm with cut tuber	K. Neelkanth	0.00	0.00	1.07	4.78	7.66	14.21
	K. Bahar	0.00	0.00	1.72	5.02	7.83	11.60
	K. Lima	0.00	0.00	1.23	5.03	7.58	12.26
Mean		0.00	0.00	1.34	4.94	7.69	12.69
60×20 cm with cut tuber	K. Neelkanth	0.00	0.00	1.38	5.67	8.83	14.34
	K. Bahar	0.00	0.00	0.95	4.45	6.74	11.30
	K. Lima	0.00	0.00	0.80	5.17	7.35	12.52
Mean		0.00	0.00	1.04	5.10	7.64	12.72
60×20 cm with whole tuber	K. Neelkanth	0.00	0.00	2.53	6.28	8.08	13.89
	K. Bahar	0.00	0.00	0.27	4.65	7.71	12.07
	K. Lima	0.00	0.00	0.87	3.95	7.44	12.40
Mean		0.00	0.00	1.22	4.96	7.74	12.79
Mean of Variety	K. Neelkanth	0.00	0.00	1.39	5.52	8.26	14.11
	K. Bahar	0.00	0.00	0.89	4.56	7.17	11.43
	K. Lima	0.00	0.00	1.18	4.86	7.56	12.56
		CD at 5%					
Variety		0.00	0.00	0.15	0.41	0.22	0.45
Spacing		0.00	N.S.	N.S.	N.S.	N.S.	N.S.
Variety × Spacing		0.00	N.S.	N.S.	N.S.	N.S.	N.S.

Table-4 : Effect of plant spacing using cut seed tuber of different potato varieties on sprouting loss (%) on weight basis during storage under ambient conditions.

Plant spacing	Varieties	Storage period (days)					
		15	30	45	60	75	90
60×10 cm with cut tuber	K. Neelkanth	0.00	0.00	12.95	27.12	46.15	62.55
	K. Bahar	0.00	0.00	11.00	24.21	38.85	50.50
	K. Lima	0.00	0.00	10.85	24.25	43.00	55.20
Mean		0.00	0.00	11.60	25.19	42.67	56.08
60×15 cm with cut tuber	K. Neelkanth	0.00	0.00	12.84	29.45	45.02	63.45
	K. Bahar	0.00	0.00	10.42	20.14	40.45	48.66
	K. Lima	0.00	0.00	10.78	25.45	42.45	53.22
Mean			0.00	11.35	25.01	42.64	55.11
60×20 cm with cut tuber	K. Neelkanth	0.00	0.00	13.52	28.45	47.12	61.78
	K. Bahar	0.00	0.00	10.65	22.50	39.12	52.44
	K. Lima	0.00	0.00	11.02	24.38	42.88	55.33
Mean		0.00	0.00	11.73	25.11	43.04	56.52
60×20 cm with whole tuber	K. Neelkanth	0.00	0.00	13.58	28.45	47.00	62.00
	K. Bahar	0.00	0.00	10.00	21.85	39.45	50.00
	K. Lima	0.00	0.00	11.50	24.75	40.45	55.67
Mean		0.00	0.00	11.69	25.02	42.30	55.89
Mean of Variety	K. Neelkanth	0.00	0.00	13.22	28.37	46.32	62.45
	K. Bahar	0.00	0.00	10.52	22.18	39.47	50.40
	K. Lima	0.00	0.00	11.04	24.71	42.20	54.86
		CD at 5%					
Variety		0.00	0.00	0.85	2.88	3.78	4.22
Spacing		0.00	N.S.	N.S.	N.S.	N.S.	N.S.
Variety × Spacing		0.00	N.S.	N.S.	N.S.	N.S.	N.S.

Table-5 : Effect of plant spacing using cut seed tuber of different potato varieties on marketable tuber yield and biological yield (q/ha).

Plant spacing	Marketable tuber yield (q/ha)	Biological yield (q/ha)
S_1	363.6	568.8
S_2	349.9	548.8
S_3	323.4	506.0
S_4	373.0	583.9
SEm +	6.75	12.58
CD at 5%	19.94	26.25
Varieties		
V_1	354.3	582.2
V_2	328.7	520.5
V_3	374.4	552.8
SEm +	5.85	10.89
CD at 5%	17.27	22.74

marketable tuber yield and biological yield for different plant spacing were recorded in the range of (323.4 to 373.0 q/ha) and (506.0 to 583.9 q/ha). The maximum total marketable tuber yield and biological yield (373.0 & 583.9 q/ha) were noticed with plant spacing 60×20 cm using whole tuber for planting, which was significantly higher as compared to other spacing, marketable yield except 60×10 cm spacing (363.6 q/ha) using cut tuber for planting, while the minimum tuber yield and biological yield (323.4 & 506.0 q/ha) were recorded with cut tuber planting at 60×20 cm spacing. It might be due to better plant stands resulted higher yield of all size tubers, whereas, under closer spacing this may be due to more plant population per unit area ultimately increases yield of medium size tubers. This may be due to that under wider spacing and whole tuber planting there was a proper growth and development of the plant resulted more yield of large size tubers, while under closer spacing using cut tuber there was higher plant population per unit area which increases the yield of all size tuber. The present findings were also confirmed the results of Malik *et al.* (2002) and Birhanu *et al.* (2018) reported that the yield per plant and tuber yield per hectare were higher with whole tubers planting as compared to cut tubers.

Among the potato varieties, Kufri Lima resulted maximum total marketable tuber yield (374.4 q/ha) which was significantly higher as compared to other varieties and the minimum total marketable tuber yield (328.7 q/ha) was recorded in Kufri Bahar. The biological yield varied between from 520.5 to 582.2 q/ha. Significantly maximum (582.21 q/ha) biological yield was observed in Kufri Neelkanth as compared to other varieties. The maximum tuber yield in Kufri Neelkanth may be due to better growth parameters which resulted higher yield. Kufri Lima produced more number of large size tuber because of their genetic behaviour resulted higher marketable and biological yield. The varietal difference in potato varieties with respect to tuber yield, marketable yield as well as biological yield was also noticed by Yadav *et al*. (2022). The present findings are in accordance of results reported by Abrha *et al.* (2014), Lal *et al*. (1981), Birhanu *et al.* (2018) and Qasim *et al.* (2013). The interaction effect between different plant spacings and potato varieties was found non-significant for marketable yield as well as biological yield. This may be due to that all varieties respond equally to different spacings using whole or cut tuber for planting.

Conclusions

In conclusion, the study on the storage behaviour of potato cultivars in a semi-arid region under ambient conditions underscores the significance of understanding and addressing the unique challenges posed by this specific environment. The variability observed among cultivars highlights the need for targeted selection to enhance resilience in the face of high temperatures and low humidity. Practical solutions, such as tailored storage technologies and management practices, are crucial for mitigating post-harvest losses and ensuring the availability of quality potatoes. While the findings contribute valuable insights, further research and innovation remain essential for the sustainable cultivation and storage of potatoes in semi-arid regions. The present study adds up the knowledge in previous works carried out worldwide and provides an approachable practice to enhance the yield of potato. Present study may benefits the farmers and growers at global level.

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Inoculation Effect of PGPR and Biopesticide on Growth and Yield Of Broccoli (*Brassica Oleracea* L. Var. *Italica*)

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Abstract

The present investigation was conducted to know the effect of PGPR and biopesticides on performances of Broccoli (*Brassica Oleracea L. Var. italica*). The experiment laid out in CRD comprised of 7 different treatment combinations and replicated four times. The treatments were *viz.,* T1 (Absolute control),T2 (Application of chemical pesticides), T3 (Inoculation of PGPR) ,T4 (Application of *Trichoderma*), T5 (Inoculation of PGPR + Neem cake),T6 (Application of *Trichoderma* +Neem cake), T7 (Inoculation of PGP +*Trichoderma* + Neem cake). Results indicated that combined Inoculation of PGPR +*Trichoderma* + Neem cake gave significantly highest growth attributes viz. number of leaves per plant(26.75)There was no incidence of aphids, reduced number of damage leaves per plant was observed in T7- Inoculation of PGP +*Trichoderma* + Neem cake (mean value 0.41) as compared to other treatments and maximum(2.16damaged leaves/plant)was observed in T1-control. Application of PGPR+ *Trichoderma* + Neem Cake showed significantly highest fruit weight in broccoli (331.66g/fruit) as compared to other treatments. PGPR along with *Trichoderma* and Neem Cake treatment showed superior effect on broccoli which proved the best treatment combination with respect to yield and biocontrol effect.

Key words : *Broccoli, PGPR, Trichoderma, neem cake.*

Introduction

Broccoli (*Brassica Oleracea L. Var. italica*) is a vegetable from Italy and an entirely new arrival in India (Brahma *et al.* 2010; Saha *et al.* 2010). In recent years commercial broccoli cultivation has become increasing in India due to its higher nutritional value, palatability, short growing duration, high productivity, and good market potential (Brahma *et al.* 2010). The tender green bud, thick fleshy floral stalk, and the secondary heads are eaten raw as cooked salad or steam. It is low in calories, free of fat, low in sodium, has high vitamin amounts (A, B1, B2, B5, B6, C, and E) and minerals (Ca, Mg, Zn, and Fe) (Beecher 1994; Decoteau 2000). This also contains antioxidant known as glucosinolates, which are active cancer chemoprevention agents (Farnham *et al*. 2004).

The broccoli plant resembles cauliflower morphologically and is known as 'Hari gobi', in the local language. Broccoli and cauliflower production worldwide is 24.2 million tonnes (Ujjwal Vivak *et.al*. 2020) Broccoli is cultivated commercially in Himachal Pradesh, Jammu and Kashmir, Uttrakhand, Uttar Pradesh, Maharastra and Nilgiris hills in Tamil Nadu. In India, broccoli cultivation has evidently gained popularity among farmer over the past few years due to increasing demand in cosmopolitan cities and awareness their high nutritional values (Brahma *et al*. 2010; Saha *et al.* 2010).

Area under Broccoli crop cultivation is very limited and the crop productivity is very low, which is due to lack of knowledge on giving proper fertilization. At the same time the demand for vegetable crops is increasing day by day. Research is required to improve the yield of broccoli along with sustainability and certain biological agents should be applied either alone or in combination with synthetic fertilizers to increase their output and growth performances. The use of microbial inoculants at the seedling stage may prove to be a promising approach. Several symbionts like *Rhizobium*, *Trichoderma viride* a known biocontrol agent and phosphorus solubilising bacteria (PSB) like *Pseudomonas fluorescens* can be implemented for cole crop cultivation. There are several reports of *Trichoderma* and *Pseudomonas* mediated growth promotion and development of seedlings of several vegetable crops like cauliflower, tomato, chlli etc. Therefore the present experiment is planned to be carried out with the objectives evaluate the inoculation effect of PGPR along with biopesticide on growth and yield of broccoli.

Materials and Methods

The present investigation was carried out in the rabi season in 2019-20 at the Department of Agricultural Microbiology in College of Agriculture Raipur, Chhattisgarh. The experiment was laid out in a completely randomized design with four replications comprising of seven treatments, *viz.,*T1 (Absolute control),T2 (Application of chemical pesticides), T3 (Inoculation of PGPR) ,T4 (Application of *Trichoderma*), T5 (Inoculation

of PGPR + Neem cake),T6 (Application of *Trichoderma* +Neem cake), T7(Inoculation of PGPR +*Trichoderma* + Neem cake). Broccoli (*Brassica Oleracea L. Var. italica*) seeds of variety Green magic were obtained from horticulture nursery, IGKV and germinated in a tray containing cocopeat

Seedling transplanting, application of biofertilizer and after care : Nearby College of Agriculture, Raipur Surface soils were randomly collected from a depth of 6 inches (15cm) and thoroughly mixed together to create a composite sample. Each pot had a well balanced mix of soil, sand, and compost in 1:1:1 proportion. Soil samples collected were retained in a polythene bag for physicochemical and microbial analysis, so labeled and stored correctly.

PGPR includes composite culture of *Azotobactor*, PSB and *Azospirillum.* Isolates were obtained from the microbiology repository of Department of Agricultural Microbiology, College of Agriculture, Raipur. PGPR inoculation was given as seedling root dip at sowing and as soil treatment @ 5g per pot at time of initiation of flowering. *Trichoderma* used in 100g/liter of water for seedling treatment while transplanting and 5g /pot as soil treatment at time of initiation of flowering. Neem cake were applied as soil treatment as basal before taking crop. @5g per pot. All pots were provided with uniform irrigation, as and when required. The plants were planted at a spacing of 45 cm each way. Observations of plants with broccoli were recorded at regular interval. The fruits were manually harvested at marketable size. The harvest fruits were weighed immediately after each harvest and subjected to further observations. Survival percentage was recorded.

Survival percentage : The germination in each treatment was recorded at 15 days after transplanting. Number of seedlings were counted and expressed as survival percentage.

$$\text{Survival (\%)} = \frac{\text{Total number of seedlings survived}}{\text{Total no. of seedlings sown}} \quad 100$$

The effect of different treatments were observed under different parameters like number of leaf/plant at 15,30,45,60 days after transplanting and at harvest. Observations were recorded on incidence of insect/pests (aphids) in leaves, damaged leaves. Weight of curd,biomass accumulation, were also recorded at harvest. Four plants were randomly selected, and labelled for each treatment and replication to study the plant growth and yield characteristics. All of the observations were reported from those plants.

Enumeration of microbial population in rhizosphere soil of broccoli after harvest : Rhizosphere soil samples from different treatments were collected after completion of experiment for enumeration of *Azotobacter, Azospirillum* and PSB. Enumeration was done by serial dilution and plating technique. Plating was done using Jensen's media, okon's media and Pikovskaya's media for *Azotobacter, Azospirillum* and PSB respectively. The plates were incubated at 28^0C in the incubator. Plating of each samples was done in duplicate and mean values were worked out for each samples. One control was also incorporated with each set of plating. After counting of colonies, the populations were expressed as cfu g-1 of dry soil using following formula (Schmidt and Caldwell, 1967).

Number of *Azotobacter, Azospirillum*/ PSB per gram of oven dry soil :

$$\frac{\text{No. of colony forming units (CFU)} \quad \text{dilution}}{\text{Dry wt. of 1 g moist soil} \quad \text{aliquot taken}}$$

Dehydrogenase activity : Taking a 1g soil sample and adding Triphenyl Tetrazolium Chloride solution and distilled water to it. The tube are then sealed to remove any trapped oxygen and incubatd at 37^0C for 24 hrs. After incubation ,methanol is added and the tubes are shaken and allowed to stand. Colorimeter reading are taken in supernatant. The amount of TPF formed is calculated using a standard curve drawn in the range of 10 mg to 90 µg TPF g1soil h^{-1} (Klein *et al*., 1971).

The data were analyzed statistically using ANOVA for completely randomized design (CRD). The substantial difference was measured at 5% significance point by F-test. (Panse and Shukhatme, 1978).

Results and Discussion

Survival percentage and shoot and root biomass : Data in Table-1 showed significant highest survival percentage in broccoli (100%) was recorded in treatment T7 (Inoculation of PGPR + *Trichoderma* + Neem Cake) and the minimum percentage was recorded in T1(Absolute control)and T2 (Application of chemical pesticides) (83.33%). Similar results were obtained by R. Rawat *et al., (*2018).

In broccoli, significantly maximum shoot dry weight (7.85g/plant) was recorded in T7 at harvest (Inoculation of PGPR + *Trichoderma* + Neem Cake) followed by T3 and T5 (Inoculation of PGPR and PGPR + Neem cake) (7.72and 7.80 g/plant). Similarly maximum root dry weight (3.23 g/plant)was recorded in T7 (Inoculation of PGPR + *Trichoderma* + Neem Cake) whereas the minimum shoot dry weight (5.57g/plant) and the minimum root dry weight in (2.32g/plant) found in T1.Similar result obtained by Tnwar Anju *et al.* (2013)

Table-1 : Efficacy of PGPR and biopesticides on survival and growth parameter of broccoli.

Treatments	Treatment details	Survival (%)	Shoot DW (g/plant)	Root DW (g/plant)
T_1	Control	83.33	5.57^{d}	2.32^{c}
T_2	Chemical pesticides	83.33	6.47^{c}	2.55^{bc}
T_3	PGPR	91.66	7.72^{ab}	3.05^{ab}
T_4	*Trichoderma*	91.66	7.27^{b}	2.88^{ab}
T_5	PGPR + Neem cake	91.66	7.80^{ab}	3.07^{a}
T_6	*Trichoderma* + Neem cake	91.66	7.67^{ab}	2.95^{ab}
T_7	PGPR + *Trichoderma* + Neem cake	100	7.85^{a}	3.23^{a}
	CD (0.05)	-	0.568	0.495

Table-2 : Effect of PGPR and Biopesticides on incidence of insect/ pests in Broccoli.

Treatments	Treatment details	Damaged leaves per plant	No. of Aphids in leaves	No. of clean leaves/plant
T_1	Control	2.16	18.25	20.25
T_2	Chemical pesticides	1.00	1.92	22.25
T_3	PGPR	1.33	8.92	26.00
T_4	*Trichoderma*	0.75	3.42	23.25
T_5	PGPR + Neem cake	0.66	2.33	26.25
T_6	*Trichoderma* + Neem cake	0.58	1.33	23.50
T_7	PGPR +*Trichoderma* + Neem cake	0.41	0.75	26.75

Table-3 : Efficacy of PGPR and biopesticides on characteristics of broccoli.

Treatments	Treatment details	Total No. of curds from 4 plants	Weight/ Curd (g)
T_1	Control	2	250.08^{d}
T_2	Chemical pesticides	2	270.81^{cd}
T_3	PGPR	3	293.16^{bc}
T_4	*Trichoderma*	3	283.83^{bc}
T_5	PGPR + Neem cake	3	307.83^{ab}
T_6	*Trichoderma* + Neem cake	3	288.55^{bc}
T_7	PGPR + *Trichoderma* + Neem cake	4	331.66^{a}
	CD (0.05)	-	28.88

Number of clean leaves, damaged leaves and incidence of aphids in leaves per plant : Table-2 showed the number of clean leaves in broccoli. The maximum number of leaves per plant of broccoli in 26.75 was reported under T7(Inoculation of PGPR + *Trichoderma* +Neem Cake) while minimum number of leaves 20.25 per plant was recorded in under T1(Absolute control). Wheareas in T1 (Absolute control) the maximum damaged leaves per plant were reported in broccoli at 2.16. T7 (Inoculation of PGPR + *Trichoderma* +Neem Cak) was reported as the minimum damaged leaves per plant at 0.41. The maximum incidence of aphids in leaves per plant was observed in treatment T1 (Absolute Control) 18.25, while the minimum incidence of aphids was recorded T7 (Inoculation of PGPR + *Trichoderma* + Neem Cake) i.e.; 0.75.

Fruit yield / plant (g) : The maximum number of fruits from four plants in broccoli was recorded(4) in T7, where The maximum number of fruits from four plants were 03 in T6, T5, T4 and T3 and the minimum number of fruit (2) observed in T1 and T2 (Table-3).

In broccoli the treatment T7 (Inoculation of PGPR +*Trichoderma* +Neem cake) recorded the maximum fruit yield (331.66g / fruit) which was at par with T5 (307.83g/ fruit) followed by T3 (293.16g) and T6 (288.55g). The minimum fruit yield/plant was recorded in treatment T1 (Absolute control) (250.08g) (Table-3).

Table-4 : Effect of PGPR and biopesticides on dehydrogenage activity of rhizosphere soil.

Treatments	Treatment details	Dehydrogenage activity of composite rhizosphere soil sample µgTPF/g soil/h
T_1	Control	12.09[d]
T_2	Chemical pesticides	13.26[d]
T_3	PGPR	26.21[ab]
T_4	*Trichoderma*	23.34[c]
T_5	PGPR + Neem cake	26.88[a]
T_6	*Trichoderma* + Neem cake	24.28[bc]
T_7	PGPR + *Trichoderma* + Neem cake	27.54[a]
	CD (0.05)	2.433

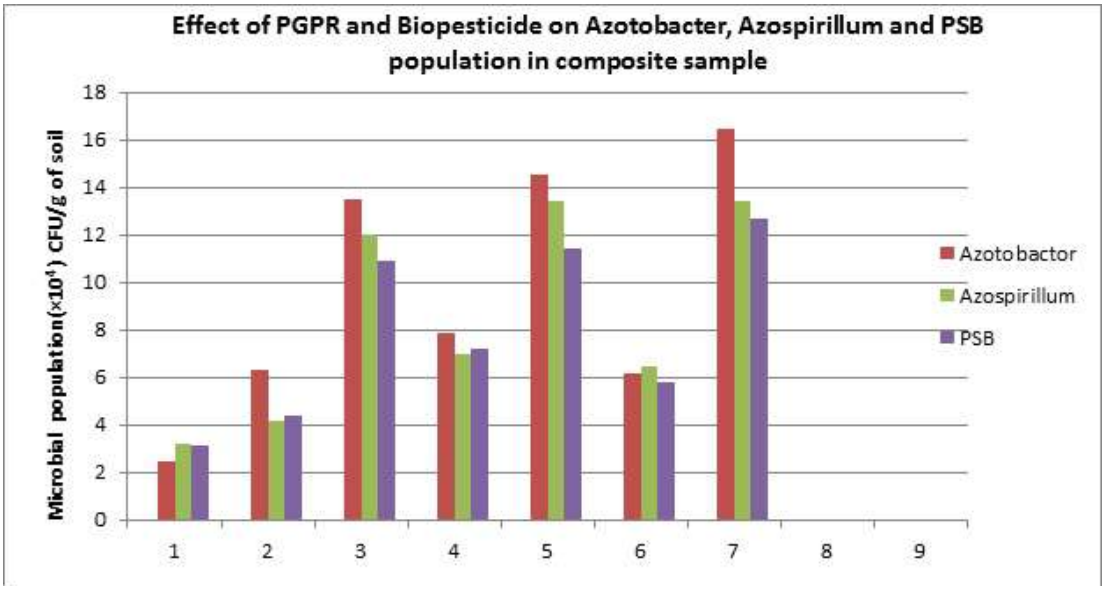

Fig.-1 : *Azotobacter, Azospirillum* and PSB population in broccoli rhizosphere as affected by treatments.

***Azotobacter, Azospirillum* and PSB population in rhizosphere soil of broccoli crop :** Figure-1 indicated population density of microbes in soil in different treatments. *Azotobacter* population density was ranged in between $2.42\times10^4$to 16.48×10^4 /g in broccoli rhizosphere soil among treatments. The *Azotobacter* population was recorded significantly maximum *i.e.* 16.48×10^4 in T7 (Inoculation of PGPR+ *Trichoderma* +Neem cake). The minimum *Azotobacter* population *i.e.* 2.42×10^4 was found in T1 (Absolute control).

Azospirillum population density was observed in between 3.20×10^4 to 13.40×10^4 /g of soil among treatments. The minimum population density was found in T1 *i.e.* 3.20×10^4 /g of soil. The *Azospirillum* population was recorded significantly maximum *i.e.* 13.40×10^4 in T7 (Inoculation of PGPR+ *Trichoderma* +Neem cake). Similarly the PSB population was recorded significantly maximum *i.e.* 12.69×10^4 in T7 (Inoculation of PGPR+ *Trichoderma* +Neem cake). The minimum PSB population *i.e.* 3.11×10^4 was found in T1 (Absolut control).

Dehydrogenase activity : Inoculation with *Azotobacter, Azospirillum* and PSB treatments also showed maximum dehydrogenase activity in rhizosphere soils of broccoli. The data on the effect of different treatments on dehydrogenase activity (DHA) in rhizosphere soils of pot grown broccoli were presented in (Table 4). At 60 DAT the dehydrogenase activity was increased due to application of *Azotobacter*, *Azospirillun* and PSB isolates in combination and being maximum in T7. Above observations were in close agreement with Nowark (1996) and Wyszkowska and Kucharski (2004) who claimed that dehydrogenase activity is a reflection of the biological status of soil.

Conclusions

Taking into account input cost, it can be concluded that inoculation of PGPR and biopesticides has proven to be the best treatments with regard to the growth performance, fruit yield of broccoli besides it was effective in reducing insect/pests. The findings, however, are representative and further repeated experimentation is needed to arrive at more reliable results and to ensure the

long term growth success of broccoli to inoculation response.

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Efficacy of Different Fungicides and Plant Extracts against Curvularia Leaf Spot of Sponge Gourd (*Luffa cylendrica* (L.) Rox.)

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Abstract

Sponge gourd [*Luffa cylendrica* (L.) Rox] popularly known as in Hindi Ghiya, Tori, Nenua. It belong to the family Cucurbitaceae.The pathogen was tested by 7 Fungicide and 3 plant extract *In-Vitro* and *In-Vivo. In-Vitro* condition tested 7 fungicide and three plant extract. Among the tested fungicide namely Chlorothalonil, Propineb and Mancozeb were found most effective which inhibited the growth of the pathogen completely and inhibition exhibited 100 % Tulsi was the least effective plant extract which showed 37.89mm fungal growth with 57.9 percent inhibition over control. *In-Vivo* condition 7 fungicide and one plant extract were tested in the year 2020-21 and 2021-22. Among the tested fungicide Cholorothalonil and Propineb was most effective fungicide which was showed mean minimum disease incidence (14.36 and 21.20%) and maximum mean yield 154.07 and 137.94 q/ha respectively. Next order of superiorly fungicide were Mancozeb, and Hexaconazole which were showed the mean disease incidence (24.14 and 25.57) and mean yield 134.72 and 130.55q/ha respectively. Among the tested plant extract Neem was least effective which showed 70.31 Percent mean disease incidence and minimum 68.20 q/ha mean yield.

Key words: *Sponge gourd, Curvularia, fungicide.*

Introduction

Sponge gourd [*Luffa cylendrica* (L.) Rox] popularly known as in Hindi Ghiya, Tori, Nenua. It belong to the family Cucurbitaceae. It rather difficult to assign which occuracy in indigenous area of *Luffa species*. They have alone history of cultivation in the tropical country of Asia and Africa Sharma and Arora (2016).

Among the two cultivated species *Luffa acutangula* (Ridge and Ribbed gourd) and *Luffa cylendrica* (Sponge gourd) and two wild species *Luffa graveolens* and *Luffa echinata* chromosome counts in the all species were found to be the same (2n=26) and comparative morphology of the wild and cultivated species and chromosome paiving in inter specific hybrid. Dutt and Roy(1969).

Sponge gourd commercially it is produce in countries like China, Korea, Japan, India, and Central America In India it is largely grown in Karnatka, Andhra Pradesh, Madhya Pradesh and Maharashtra states. Bal *et al.*, (2004), Oboh and Aluyor (2009).The sponge gourd crop is known to suffer from a viral, nematode, fungal and bacterial disease. The fungal disease considered to be the major factor responsible for reducing the yield.

Materials and Methods

Evaluation of fungicides and plant extracts under *In-vitro* condition : The efficacy of 7 fungicides and 3 plant extracts against the pathogen *In-Vitro* was tested by "Poison Food Technique" as suggested by Schmitz, 1930 using PDA medium. The fungicides namely *viz.,* Propineb, Chlorothalonil, Mancozeb, Hexaconazole, Copper oxychloride, Copper hydraoxide, Azoxystrobin and three botanical extract (0.05%) were tested *In-Vitro* condition with C.R.D. design with 3 replication and without fungicides plate was mention as control. Plant extracts of the botanicals, Neem, Calotropis and Tulsi were prepared by crushing their leaves and bulb (100g each) in 100ml of sterilized distilled water. The extracts were then filtered through a muslin cloth and centrifuged for 30 minute at 5000 rpm. The extract were sterilized by passing them through a Millipore filter (0.22um pore size) using a swimmy filter adopter. The materials were dried at room temperature (25±2^{0}C) for 6 hours to remove the traces of water. Subsequently 0.5% concentration of the extracts of each botanical was used for bio-assay test by poison food technique. The per cent inhibition over control was calculated by the formula (Bliss, 1934) as given below :

$$\text{Percent inhibition over control} = \frac{C \quad T}{C} \quad 100$$

Where, C = Growth of fungus in control

T = Growth of fungus in treatment

Evaluation of fungicides and plant extracts under *In-vivo* condition : In order to find out a suitable fungicide and plant extract which was found effective *In-Vitro* condition. The effective fungicides, and plant extracts were assessed in field trail during *Kharif* season 2020-21

and 2021-22. A highly susceptible field with known history of Curvularia leaf spot of Sponge gourd was selected. The Sponge gourd variety ("Pusa Chikani") was sowing in 5X5m plot size in Randomized Block Design with four replications. The nine fungicides *Viz,* Propineb, Chlorothalonil, Mancozeb, Hexaconazole, Copper oxychloride, Copper hydraoxide, Azoxystrobin and one plant extract Neem were used as spray. For recording the disease incidence, forty randomly selected plants per plot were examined and the disease incidence in percentage was transformed in to angles and analyzed statistically. Yield was estimated on plot basis without the border rows in the q/ha.

Results and Discussion

Evaluation of fungicides and plant extracts under *In-vitro* condition : Seven fungicides and three plant extracts belonging to different groups were tested against the pathogen under laboratory conditions The screening of the best and effective fungicides was done on the basis of the inhibitory effect of the fungicides on the growth of the fungus by the agar plate method After 10 days of incubation the average diameter of fungal colonies were noted in the poured plates containing different fungicides are presented in Table-1.

The result presented in its Table-1 and corresponding histogram (Fig.-1) indicate that all the fungicide were significantly superior over the control in inhibition the growth of pathogen *In-Vitro.* Among the tested fungicides Chlorothalonil, Propineb and Mancozeb were the most effective fungicide which are showed minimum (00.00) fungal growth each and they completely inhibited growth of pathogen (100%).The Hexaconazole and Copper oxycloride was the next best effective fungicide which showed the Average fungal growth 12.00 and 14.50 mm respectively and its percent inhibition zone was 86.66 and 83.88. Both the fungicide were statically at par with each other The Copper hydroxide and Azoxystrobin was the next best effective fungicide which showed the average fungal growth 24.70 and 27.00 mm respectively and its percent inhibition zone were 72.55 and 70.00. Both the fungicide was statically different from each other. Among the tested plant extracts the Neem and Calotropis was also effective which showed the fungal growth 30.50 and 33.00mm and inhibition percent

Table-1 : Effect of different fungicides and plant extract on the growth of Cuevularia lunata *In-vitro* at 28+1°C after 10 days.

S. No.	Fungicides	Dose (%)	Ave. Diameter of fungal growth (mm)	Percent inhibition over control
1.	Chlorothalonil	0.20	00.00	100.00
2.	Propineb	0.20	00.00	100.00
3.	Mancozeb	0.20	00.00	100.00
4.	Hexaconazole	0.20	12.00	86.66
5.	Copper oxycloride	0.20	14.50	83.88
6.	Copper hydroxide	0.20	24.70	72.55
7.	Azoxystrobin	0.20	27.00	70.00
8.	Neem	0.5	30.50	66.11
9.	Calotropis	0.5	33.00	63.33
10.	Tulsi	0.5	37.89	57.9
11.	Control	-	90.00	-
	CD at 5% level		2.57	

Table-2 : Effect of different fungicide and plant extract against Curvularia lunata *In-vivo* condition.

S. No.	Name of fungicides	Dose (%)	Average disease incidence 2020-21	Average disease incidence 2021-22	Mean disease incidence	Average Yield (q/ha) 2020-21	Average Yield (q/ha) 2021-22	Mean Yield (q/ha)
1.	Chlorothalonil	0.25	12.35	16.37	14.36	162.50	145.65	154.07
2.	Propineb	0.25	18.54	23.87	21.20	140.35	135.54	137.94
3.	Mancozeb	0.25	22.42	25.86	24.14	136.23	133.21	134.72
4.	Hexaconazole	0.25	24.15	27.00	25.57	134.25	126.85	130.55
5.	Copper oxycloride	0.25	42.85	49.35	46.1	102.42	118.63	110.52
6.	Copper hydroxide	0.25	54.36	57.25	55.80	86.32	84.34	85.33
7.	Azoxystrobin	0.25	60.85	64.46	62.65	79.87	71.64	75.75
8.	Neem	0.5	69.35	71.28	70.31	70.65	65.75	68.20
9.	Control	-	85.26	86.28	85.77	54.96	52.95	53.95
	C.D.		4.35	4.56	4.21	3.46	3.67	3.74

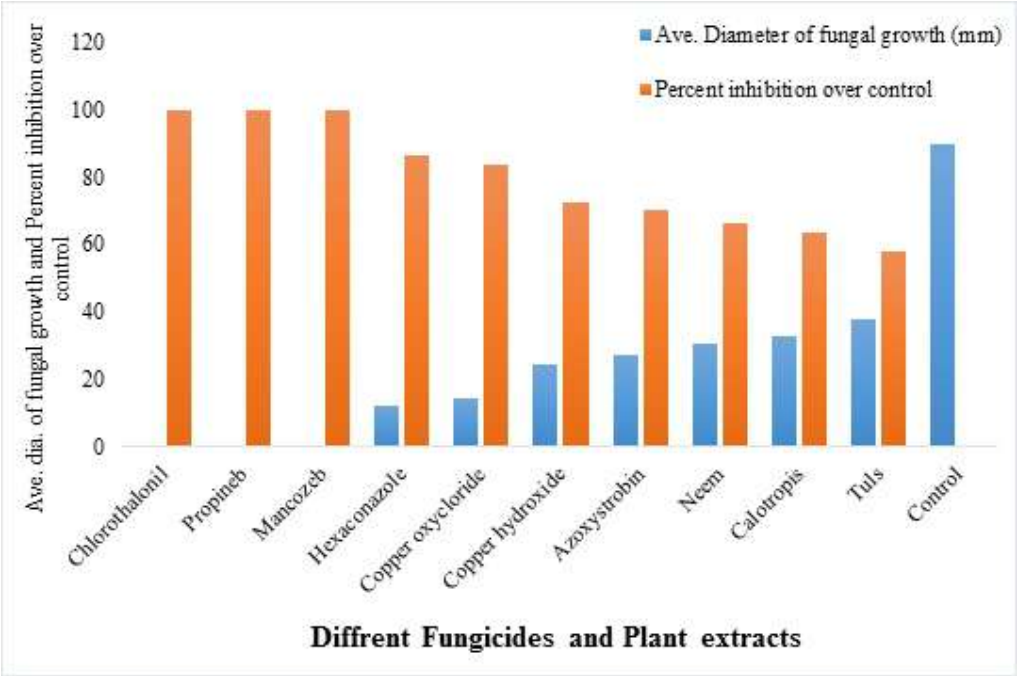

Fig.-1 : Effect of different fungicides and plant extract on the growth of *Cuevularia lunata In-Vitro* at 28+1°C after 10 days.

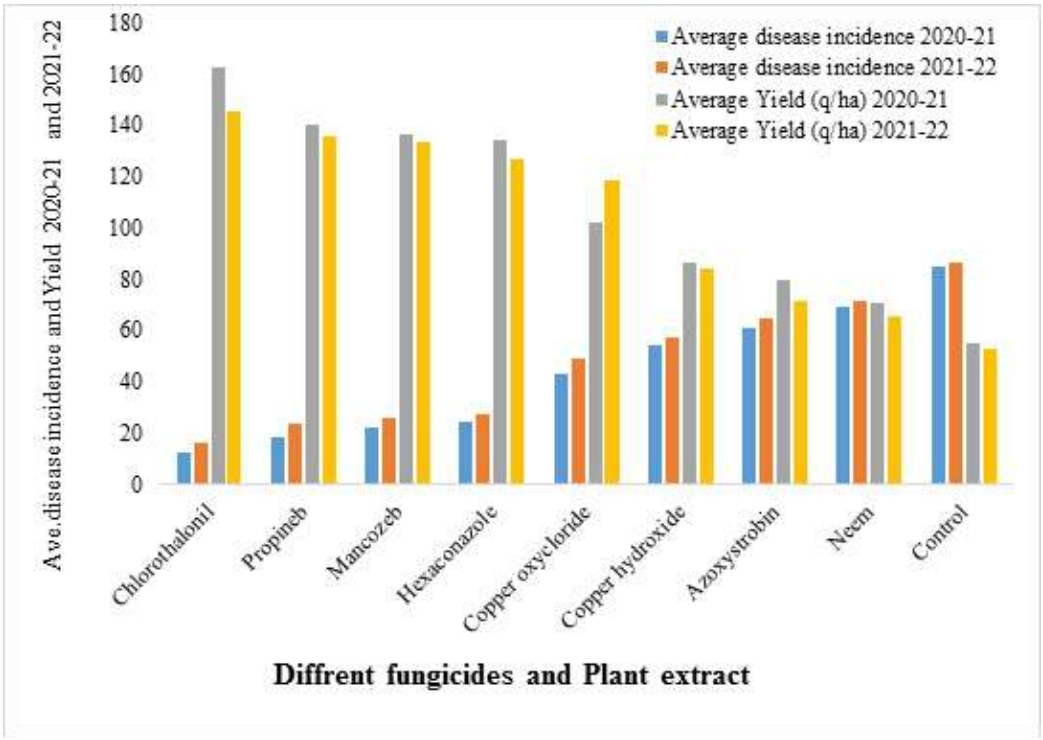

Fig.-2 : Effect of different fungicide and plant extract against *Curvularia lunata In-Vivo* condition.

was 66.11 and 63.33%. Thease were also statically at par with each other. The least effective plant extract was was Tulsi with average fungal growth 37.89 and percent inhibition over control 57.9 percent. This finding are in close agreement with the observation of Godage and Patil, 1977 on Curvularia leaf spot of Cotton.

Efficacy of different fungicides and plant extracts against Curvularia leaf spot of Sponge gourd under *In-Vivo* condition : The seven fungicides *viz,* Propineb, Chlorothalonil, Mancozeb, Hexaconazole, Copper oxychloride, Copper hydraoxide, Azoxystrobin and one plant extract Neem were used as spray. For recording the

disease incidence, four randomly selected plants per plot were examined and the disease incidence in percent and yield under field condition during the crop season (2020-21 and 2021-22). The disease incidence and yield recorded were summarized in Table-2.

The results are presented in Table-2 and corresponding histogram (Fig-2) of field trail with seven fungicides and one plant extract indicate their effectiveness in managing the disease. In the year 2020-21 spraying of fungicide Chlorothalonil (12.35%) at the interval of 15 days was most effective in minimizing the disease incidence and increasing the yield 162.50q/ha. The next effective fungicide was Propineb, Mancozeb and Hexaconazole which showed (18.54, 22.42 and 24.15) percent disease incidence and (140.35, 136.23 and 134.25 q/ha) yield. These were statically at par with each others. The next order of superiority fungicide Copper oxycloride (42.85), Copper hydroxide (54.36) and Azoxystrobin (60.85) present disease incidence and yield was (102.42), (86.32) and (79.87) q/ha respectively. The Neem provide to be least effective plant extract which showed (69.35) present disease incidence and decreasing the yield (70.65).

In the year 2021-22 Chlorothalonil was most effective fungicide which showed (16.37) present disease incidence and (145.65 q/ha) yield. The next best effective fungicide was Propineb, Mancozeb and Hexaconazole (23.87, 25.86 and 27.00 %) disease incidence and (135.54, 133.21 and 126.85 q/ha) yield. And these were statically at par with each other. Next order of superiority fungicide Copper oxycloride (49.35), Copper hydroxide (57.25) and Azoxystrobin (64.46) present disease incidence and corresponding yield was (118.63, 84.34 and 71.64 q/ha) respectively. The least effective plant extract Neem was (71.28%) disease incidence and yield was (65.75 q/ha). Our finding with the close agreement with the finding of Yashwant *et al.*2012 on Curvularia leaf spot of Okra and Singh *et al.* 1997 on Brinjal crop.

Conclusions

The present study demonstrated that the safest chemical are used for the managing the disease of Curvularia leaf spot of Sponge gourd *In-Vivo* condition. The minimum average mean disease incidence 14.36 with maximum mean yield 154.07 q/ha. was recorded with the application of Chlorothalonil followed by Propineb and Mancozeb which showed 21.20 and 24.14 mean average disease incidence with the corresponding yield was 137.54 and 134.72 q/ha. Among the tested plant extract Neem was least effective which showed the 70.31 mean average disease incidence with minimum average mean yield 68.20q/ha was recorded.

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Effect of Fertility Levels on Spectral Reflectance NIR and Red Reflectant by Maize Canopy

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Abstract

The field experiment was conducted at VNMKV Parbhani for two years during 2007-08 and 2008-09 which comes under semi-arid tropics with annual rainfall ranging from 700 to 900 mm. Very clear distinction in spectral behaviour of maize canopy was noticed between 50 to 65 DAS (Grand Growth period). While under nutrient stress condition, plants were found to have lower NIR reflectance and high red reflectance compared to nutrient supplied crop. The capability of discrimination of nutrient stress vs. nutrient applied crop was centralized between 45 to 65 DAS (grand growth period of maize). Among the various four spectral bands available with Optometry Ground Truth Radiometer band 3 and band 4 i.e. red wavelength and NIR wavelength bands were used. The data collected on spectral radiance in band 3 and band 4 during 2007-08 and 2008-09 are converted into reflectance and the observations are depicted. growth period the red reflectance was decreased because of increasing chlorophyll content while NIR reflectance was increased due to increased leaf area and vigour of crop.

Key words : *NIR and Red Reflectant.*

Introduction

Observations of spectral reflectance were taken during day time at 11 to 1 pm in bright sunshine hours. Spectral reflectance of leaves is influenced by plant pigment and leaf structure. Nutrient concentration in the soil influences the pigment concentration in the leaf. In the present study the spectral reflectance by maize canopy was studied under varying levels of fertility. The varied fertility levels were maintained to create varied chlorophyll concentration in the leaves.

The Red wavelength (0.62 to 0.68 µm) reflectance was more till the maize attained 55 day thereafter the Red wavelength absorption increased by maize canopy up to 67 DAS. Again as growth proceeded beyond 67 DAS and 78 DAS. The Red reflectance started increasing and it was maximum at 89 DAS and 99 DAS, respectively. This sigmoid behavior of graph confirm the hypothesis that red wavelength is absorbed more if chlorophyll concentration is more and as chlorophyll concentration decreases the Red wavelength absorption also decreases. In the present study in early growth stage, crop exposed low leaf area, less chlorophyll concentration and high soil area surface red absorption was less and reflectance was more. As leaf area and concentration of chlorophyll increased with advancement of crop growth, red reflectance was lowered down and absorption was increased. It is also noticed that all fertilizers level treatment curves behaves in a similar way. However, there was relatively more absorption of red wavelength by treatment F_5 and less absorption of red wavelength by F_0. This might be because of F_5 treatment provided balanced supply of nutrients and F_0 was devoid of these nutrients. The maximum absorption was between 55-76 days after sowing in both years. In a previous sub-head 4.5, it is recorded that the chlorophyll concentration was increased in the maize leaves during 55 to 76 and 66 to 87 days after sowing in both year and later on it was decreased which was responsible for sigmoid behavior of spectral reflectance curve. Absorption of Red wavelength in leaf is highly depending upon chlorophyll concentration and plant healthiness.

Figure shows the NIR reflectance as influenced by various fertility levels. The NIR reflectance shows almost a opposite mirror print of Red reflectance. The NIR wavelength reflectance was lower up to 55 days after sowing and 66 days after sowing, thereafter it increased and reached at peak between 60 to 70 days after sowing and 70 to 80 days after sowing. Further the NIR reflectance was more in F_5 treatment and it was low in F_0 treatment in both years.

Summerisingly, the result presented showed that in early growth of maize up to 67 days after sowing, the red reflectance was maximumand NIR reflectance was minimum. After this growth period the red reflectance was decreased because of increasing chlorophyll content while NIR reflectance was increased due to increased leaf area and vigour of crop. Further, in early stage of crop the spectral reflectance was dominated by soil and during grand growth period of maize leaf canopy dominates the soil. The results presented and discussed above are closely related with the observation drawn by Curran *et al.*, (1995), Petkar (2004) and Patil*et al.*, (2008) and Patil*et al.*, (2007).

Table : Effect of growth period on red wavelength.

	30 DAS	55 DAS	67 DAS	76 DAS	89 DAS
F_0	2.4	2.8	1.2	2.4	2.8
F_1	2.9	3.2	0.641	2.9	3
F_2	2.8	3.4	0.523	2.89	3.6
F_3	2.7	3.3	0.453	3.1	3.5
F_4	2.9	3.2	0.343	2.5	3.4
F_5	3	3.1	0.289	2.6	3.3

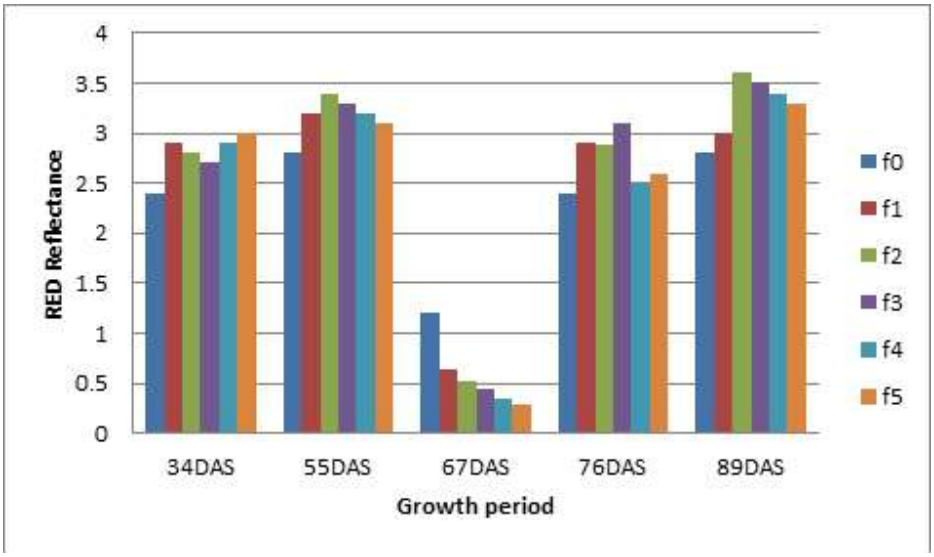
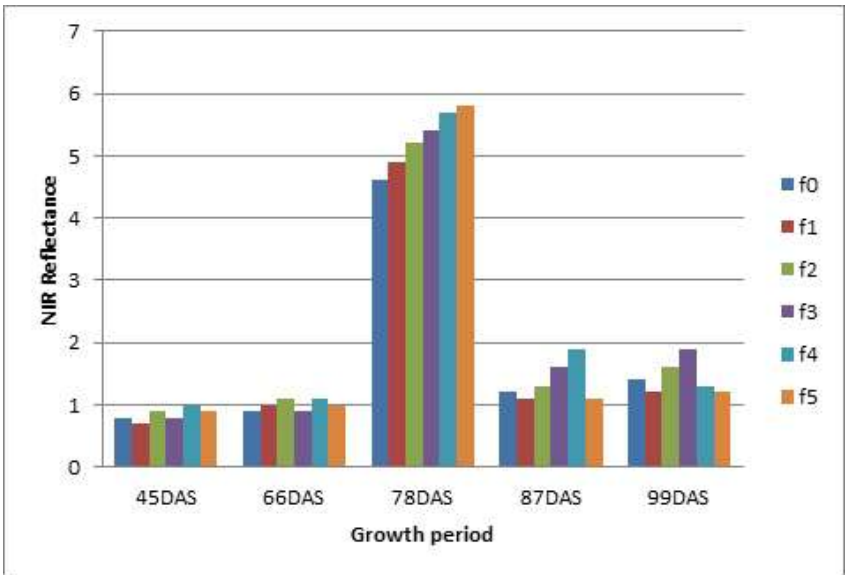


Table : Effect of growth period on NIR Reflectance.

	30 DAS	55 DAS	67 DAS	76 DAS	89 DAS
F_0	0.8	0.9	4.6	1.2	1.4
F_1	0.7	1	4.9	1.1	1.2
F_2	0.9	1.1	5.2	1.3	1.6
F_3	0.8	0.9	5.4	1.6	1.9
F_4	1	1.1	5.7	1.9	1.3
F_5	0.9	1	5.8	1.1	1.2



The capability of discrimination of nutrient stress vs. nutrient applied crop was centralized between 45 to 65 DAS (grand growth period of maize). Among the various four spectral bands available with Optometry Ground Truth Radiometer band 3 and band 4 i.e. red wavelength and NIR wavelength bands were used. The data collected on spectral radiance in band 3 and band 4 during 2007-08 and 2008-09 are converted into reflectance and the observations are depicted. growth period the red reflectance was decreased because of increasing chlorophyll content while NIR reflectance was increased due to increased leaf area and vigour of crop.

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Changes of chlorophyll a and b concentration with different fertility levels in maize

Effect of Fertility Levels on Spectral Reflectance NIR and Red Reflectant by Maize Canopy

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Abstract

The field experiment were conducted at Parbhani for two years during 2007-08 and 2008-09 which comes under semi-arid tropics with annual rainfall ranging from 700 to 900 mm. Chlorophyll was the most important independent factor affecting spectral reflectance. On an average for chlorophyll 'a' was from 0.18 to 0.70 and 0.20 to 0.63 and chlorophyll 'b' concentration of maize increase from 0.18 to 0.61 mg g^{-1} and 0.17 to 0.59 mg g^{-1} and in 73 and 78 days then it was decrease. However total Chlorophyll 0.96 mg g^{-1}. Further, only nitrogen fertilization contributed significantly to total chlorophyll production followed by the additional P+S+Zn+Fe fertilization (Treatment 5). With each additional nutrient application (from treatment F_1 to F_5) that was increase in chlorophyll content in maize.

Key words : *Chlorophyll 'a' , Chlorophyll 'b'*

Introduction

Among the various pigments that influence the spectral signature of vegetation chlorophyll. It contributes more than 70% to spectral reflectance and hence in the present investigation efforts were made to find out the effect of nutrient application on chlorophyll 'a', chlorophyll 'b' and total chlorophyll and to study the relationship between chlorophyll concentration and spectral reflectance for two consecutive years 2007-08 and 2008-09.

Materials and Methods

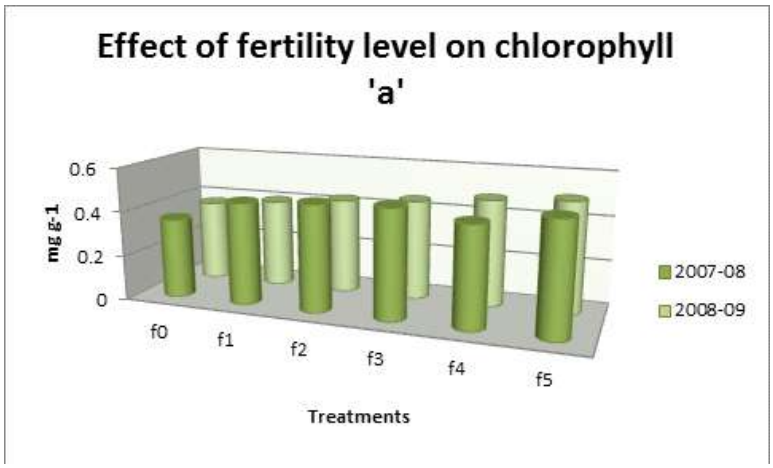
A field experiment on maize comprising of six fertility levels viz., F_0 No fertilizer application, F_1 :Only N 150 kg N ha^{-1}, F_2 :N + P (150 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1}), F_3 : N + P + S (150 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1}), F_4 : N + P + S + Zn (150 kg N ha^{-1} + 50 kg P_2O_5 ha^{-1} + 30 kg S ha^{-1} + 20 kg $ZnS0_4$ ha^{-1}) and F_5 :N + p+ S + Zn + Fe (150 kg N ha^{-1} + 50 kg P_20_5 ha^{-1} + 30 kg S ha^{-1} + 20 kg $ZnS0_4$ ha^{-1} + 2 % Fe foliar spray at 2 stages) replicated four times replicated four times were laid out during late kharif of 2007-08 and 2008-09. The observation on plant height, number of leaves, LAI, biomass and cob yield production and spectral reflectance were recorded. Chlorophyll 'a', 'b', total chlorophyll, was determined.

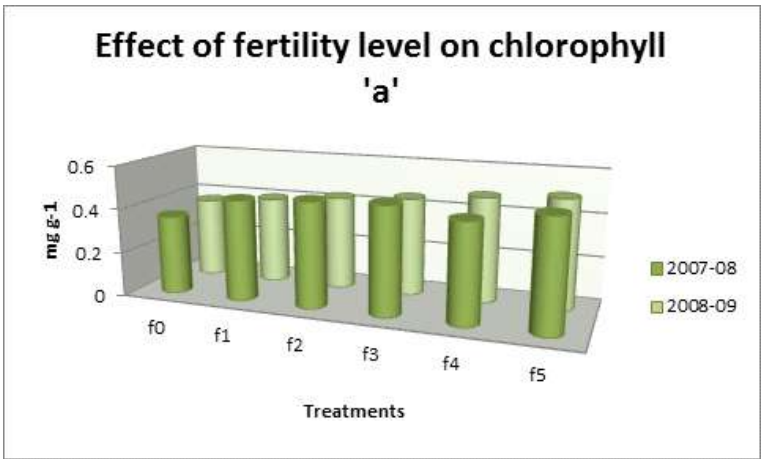
Effect of fertility levels on chlorophyll 'a' : The periodical observations of chlorophyll 'a' concentration recorded on various dates under varied fertility level treatment during 2007-08 and 2008-09 are presented in table . On average chlorophyll 'a' concentration of maize was found to be increased with growth of maize crop up to 73 days after sowing and 78 days after sowing in 2007-08 and 2008-09, respectively. Thereafter there was decrease in chlorophyll 'a' concentration. The increase was from 0.18 to 0.61 mg g^{-1} and 0.17 to 0.59 mg g^{-1}. It was further noted that the application of nitrogen over no nitrogen (Treatment F_1) enhanced the chlorophyll content at all growth stages. The role of nitrogen in chlorophyll synthesis is of vital importance. Nitrogen enhances the chlorophyll concentration in plants. Similar to nitrogen (F_5) treatment i.e. spraying of 2% iron increased the chlorophyll concentration in the leaves. The pooled mean showed lowest chlorophyll 'a' content 0.36 mg g^{-1} in control treatment. While, highest chlorophyll content 0.50 mg g^{-1} was observed in the treatment receiving complete nutrient package (F_5). Similer finding noted by Bodkhe, A.B. and Patil V.D. (2008) and Dixit, R.S. (1987).

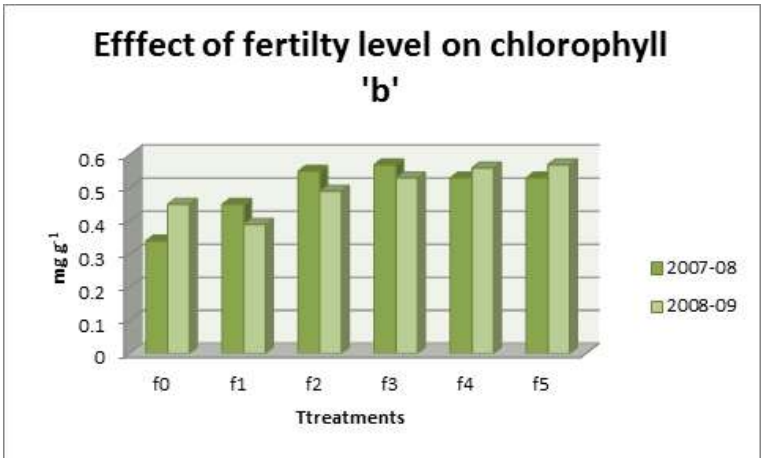
Effect of fertility levels on chlorophyll 'b' : On an average chlorophyll 'b' concentration of maize was found to be increased with growth of maize crop up to 73 and 78 days after sowing in 2007-08 and 2008-09, respectively. Thereafter there was decrease in chlorophyll 'b' concentration till 103 DAS and 108 DAS in the respective years. The increase was from 0.18 to 0.70 and 0.20 to 0.63 in first two observations. At various growth stages and under various fertility levels chlorophyll 'b' showed a similar pattern as that of chlorophyll 'a'. However, on chlorophyll 'b' concentration was relatively more than chlorophyll 'a'. Blackburn, G.A. (1998) and Costa, C. (1991) observe the same finding.

Effect of fertility levels on total chlorophyll : The data on total chlorophyll content in maize leaves are presented in Table are depicted in Figure. The data indicated that chlorophyll concentration in maize leaves ranged from

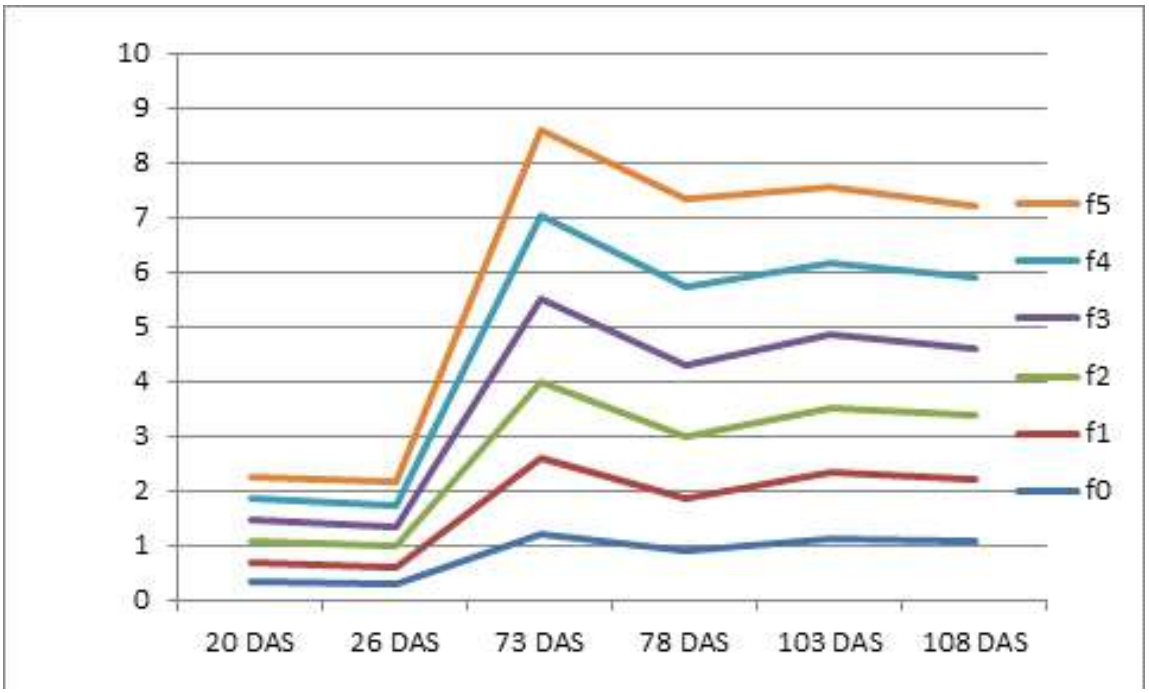
	Effect Of fertility level on chlorophyll 'a'		Effect Of fertility level on chlorophyll 'a'	
	2007-08	2008-09	2007-08	2008-09
f0	0.36	0.37	0.34	0.45
f1	0.46	0.4	0.45	0.39
f2	0.48	0.43	0.55	0.49
f3	0.49	0.45	0.57	0.53
f4	0.45	0.48	0.53	0.56
f5	0.5	0.5	0.53	0.57







	Total chlorophyll concentration as influenced by fertility levels 2007-08					
	20 DAS	**26 DAS**	**73 DAS**	**78 DAS**	**103 DAS**	**108 DAS**
f0	0.31	0.29	1.21	0.89	1.11	1.08
f1	0.38	0.32	1.37	0.97	1.2	1.11
f2	0.39	0.35	1.42	1.14	1.21	1.19
f3	0.39	0.38	1.51	1.27	1.31	1.23
f4	0.36	0.4	1.53	1.47	1.31	1.27
f5	0.42	0.42	1.56	1.61	1.41	1.33



0.37 to 1.28 mg g^{-1} with an average 1.00 mg g^{-1} in 2007-08 similarly in 2008-09 it was ranged from 0.36 to 1.20 mg $g^{-1}$with an average of 0.92 mg g^{-1}, respectively. Further, only nitrogen fertilization contributed significantly to total chlorophyll production followed by the additional P+S+Zn+Fe fertilization (Treatment 5). With each additional nutrient application (from treatment F_1 to F_5) that was increase in chlorophyll content in maize.

Chlorophyll concentration of the leaves influences the leaf biochemical properties and biochemical interactions are the result of molecular / atomic composition of the leaf. In turn they are responsible for color changes resulting from differences in pigment concentration. In this whole chain nitrogen, sulphur, and iron play important role. In the present study chlorophyll 'a', chlorophyll 'b' and total chlorophyll was found to be influenced by the application of essential plant nutrients particularly nitrogen, sulphur, and iron. With the advancement of growth up to silk formation (73 to 78 DAS) of maize the chlorophyll concentration in the leaves was increased. Patil and Malewar (1994) reported similar findings in cotton crop. Similarly, Gausman *et.al.* (1973) showed the role of nitrogen in chlorophyll synthesis.

Conclusions

The chlorophyll concentration of the leaf was increased with the advancement of growth of maize and with various fertility levels. Each additional nutrient found superior in increasing the leaf chlorophyll content except phosphorus.

The various growth parameters of maize viz., chlorophyll 'a', chlorophyll 'b', total chlorophyll and plant nutrient concentration were improved significantly due to application of 150 kg N, 50 kg P_2O_5, 50 kg k_2O,30 kg S, 20 kg $ZnSO_4$ per hectare and two foliar spraying of 2% iron.

The predominance of chlorophyll in the plant tissue compared with the other pigments and the strong positive relationship between chlorophyll 'b' resulting in concurrent increases of both pigments suggests that the chlorophylls had a greater influence on spectral reflectance than the accessory pigments.

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Natural Enemies of Insect-Fauna Diversity in Ecosystem of Bharsar, Uttarakhand

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Abstract

Natural enemies of insect-fauna are highly diversified in the mid-hill's region of Bharsar. The first-time efforts were taken to record the biodiversity of natural enemies of insect-fauna in the Garhwal Himalayas (Bharsar) Uttarakhand. The total 38 different species of natural enemies were identified from 8 different orders *viz,* Coleoptera, Hemiptera, Neuroptera, Dictyoptera, Hymenopetra, Odonata, Diptera and Dermaptera. The Maximum number of natural enemies of insect were found from Diptera order (13), followed by Coleoptera (7), Odonata (5), Hymenoptera (4), Dictyoptera (4), Dermaptera (3), Neuroptera (1) and Hemiptera (1). The collected species were identified by taxonomic keys and from Forest Research Institute, Dehradun. This study would help to understand the presence of natural enemies of insect pest and for pest management techniques. All the insects that were found were classified according to their morphological attributes and need to be further studied on the genetic or DNA level.

Key words : *Biodiversity, natural enemies, insect-fauna, Garhwal Himalayas.*

Introduction

Arthropod diversity in agricultural environments is often said to grow as a result of organic farming (Smukler *et al.,* 2010). The majority of agro-ecosystems have a high degree of disturbance and regular activities like ploughing, planting, applying fertilizers and pesticides, irrigation and harvesting can alter the ecosystem's normal operating parameters. The extensive use of organic insecticides over the past few decades has been the main cause of the decline in insect populations (Rekha *et al.,* 2021). The entomofauna is the most successful and dominant group in the planet. This is because to their tiny size, stable habits, fertility, aerial respiration, variety of food sources and protective gear among other factors (Prakhar *et al.,* 2021).

Ecosystems are strongly dependent on insect activity. Insects are essential for maintaining the health of ecosystems, recycling nutrients, pollinating plants, dispersing seeds, preserving soil fertility, managing populations of other species and serving as a key food source for other taxa (Majer, 1987). Natural enemies of insects offer a potential but understudied approach to controlling insect pests in agriculture system.

Bharsar is around 57 km south-east of the district (Pauri Garhwal). The climate is temperate evergreen forest with moderate summers, ample precipitation and harsh protracted winters. The region's unique temperature, precipitation and relative humidity as well as its elevation range and proximity to the Himalayas are responsible for a diverse insect species. In the local dialect, "Bharsar" means "the region rich in natural wealth" (Bisht and Sharma, 2014) which reflects the availability of various insects in the overall research area. This great diversity created an ideal habitat for the growth of several sorts of insect fauna. So, the overall current estimate shows that out of nearly 63,760 species of insect species in India, about 21,166 species are endemic (ZSI, 2012).

Materials and Methods

Study area : A survey was carried out in six different locations of Bharsar *i.e.,* Tiggadu, Floriculture, Organic, MAP, Vegetable and Fruit Block. The study area is located between 28°53'24" and 31°27'50" N latitude and 77°34'27" to 81°02'22" E longitude, with elevations ranging from 1975 to 2290 m s l (GPS Mobile App Geographical Information System) (Fig.-1).

Materials : The equipment and accessories that were used to capture the insects included an insect collection net, a setup board, insect killing bottles, forceps, hand lens, entomological pins, small hair brush, ethyl acetate, microscope, phone camera for photographs, insect preservation boxes, etc.

Identification and Classification : Microscope was used to analyze the distinctive morphological characteristics of several specimens. Morphological characters of Natural enemies were studied under the microscope and categorized into different orders and families by employing of a taxonomic key by taking the help of different insect taxonomy books, review/ research paper,

Fig.-1 : Google MAP of Bharsar, Pauri, Uttarakhand.

articles, apps, government biodiversity websites, *etc*. (Atwal and Dhaliwal, 2015; Gibb, 2015; Godfray, 2002; Gullan, 2005; Zack *et al.,* 2011; Yamawaki, 2011; Tschnikel, 2002; Villar *et al.,* 2022; Shubhan and Shah, 2016; Saleh *et al.,* 2017; Sharma, 2017; Hagerty, 2001; Rekha *et al.,* 2021) Some of the insect fauna obtained during the research were submitted to the Division of Plant Protection, Forest Research Institute, Dehradun for further identification and taxonomic confirmation.

Results and Discussion

During the survey 38 insect species were found that are natural enemies of many other insects. Seven natural enemies were found of coleoptera order that were *Palaeoneda auriculata, Coccinella septempunctata, Propylea japonica, Coccinella* sp*., Anatis* sp., *Calvia punctata, Agonum* sp. One insect was found of hemiptera order that was *Emesaya* sp., one from neuropteran order *i.e., Chrysoperla* sp., four insects from the order dictyoptera *i.e., Statillia maculate, Tenodera aridifolia, Brunneria* sp and *Statillia* sp*.,* four insects were from the hymenoptera order that are *Evania* sp, *Vespa basalis, Cotesia glomerata and Crematogaster sp.,* five insects were found from odonatan order that are *Anotogaster sieboldii, Sympetrum* sp., *Anax* sp., *Ischnura* sp. and *Ischnura* sp., thirteen insects were found from the diptera order *Chrysotoxum* sp., *Eristalis* sp., *Melanostoma* sp., *Sphaerophoria scripta, Dasysyrphus* sp., *Melanostoma* sp., *Chrysotoxum* sp*., Chrysopilus* sp., *Tachina* sp., *Tachina* sp., *Eristalis* sp*., Eutolmus* sp. and *Promachus* sp. and three insects found from dermaptera order *Chelisoches* sp., *Chelisoches* sp., *Forficula* sp.

Maximum number of insects that were found are feeds on aphids. There is maximum abundance of aphids at the Bharsar region which make it more diverse for their natural enemies as well. Sharma *et al.,* (2017) studied that total 65 predatory coccinellids have been found to be associated with different sucking pests of agricultural crops and wild flora. Their diversity varied with the agro-climatic conditions. Beetles namely *Coccinella septempunctata* Linnaeus, *Hippodamia variegata* (Goeze) and *Cheilomenes sexmaculata* (Fabricius) were the most common and widely distributed in all the agro-climatic zones of the state. Rekha *et al.,* (2021) found 3 predators from Ramnagar, Uttarakhand. Bhatt *et al.,* (2018) found 5 species of predators belonging to order Coleoptera, Diptera, Hemiptera and Dictyoptera.

Conclusions

The overall result of the present investigation was that there was total 38 different species of natural enemies of class Insecta were found which showed that there is abundance of natural enemies of insect pest in Bharsar, (Pauri Garhwal) Uttarakhand. In this study it was observed that maximum number of natural enemies were of aphids as there is abundance of aphids in Bharsar. These insects were identified on their morphological characteristics and can be identified on the other scientific techniques like DNA barcoding, to investigate the insects in this area for the promotion of biodiversity conservation and management of habitats.

Table-1 : Natural enemies of insect fauna found in Bharsar, Pauri.

S. No.	Name	Family	Order	Preys
1.	*Palaeoneda auriculata*	Coccinelidae	Coleoptera	Aphids
2.	*Coccinella septempunctata*	Coccinelidae	Coleoptera	Aphids
3.	*Propylea japonica*	Coccinelidae	Coleoptera	Aphids
4.	*Coccinella* sp.	Coccinelidae	Coleoptera	Aphids
5.	*Anatis* sp.	Coccinelidae	Coleoptera	Aphids
6.	*Calvia punctata*	Coccinelidae	Coleoptera	Aphids
7.	*Agonum* sp.	Carabidae	Coleoptera	Aphids, Spring tail
8.	*Emesaya* sp.	Reduviidae	Hemiptera	Small invertebrates
9.	*Chrysoperla* sp.	Chrysopidae	Neuroptera	Aphids, soft bodied insect
10.	*Statillia maculate*	Mantidae	Dictyoptera	Other arthropods
11.	*Tenodera aridifolia*	Mantidae	Dictyoptera	Other arthropods
12.	*Brunneria* sp.	Mantidae	Dictyoptera	Other arthropods
13.	*Statillia* sp.	Mantidae	Dictyoptera	Other arthropods
14.	*Evania* sp.	Evaniidae	Hymenoptera	Cockroach
15.	*Vespa basalis*	Vespidae	Hymenoptera	Insects, Honey bees
16.	*Cotesia glomerata*	Braconidae	Hymenoptera	Cabbage butterfly
17.	*Crematogaster* sp.	Formicidae	Hymenoptera	Mealworm, pupae
18.	*Anotogaster sieboldii*	Cordulegastridae	Odonata	Small insects
19.	*Sympetrum* sp.	Libellulidae	Odonata	Small insects
20.	*Anax* sp.	Aeshnidae	Odonata	Small insects
21.	*Ischnura* sp.	Coenagrionidae	Odonata	Small insects
22.	*Ischnura* sp.	Coenagrionidae	Odonata	Small insects
23.	*Chrysotoxum* sp.	Syrphidae	Diptera	Aphids
24.	*Eristalis* sp.	Syrphidae	Diptera	Aphids
25.	*Melanostoma* sp.	Syrphidae	Diptera	Aphids
26.	*Sphaerophoria scripta*	Syrphidae	Diptera	Aphids
27.	*Dasysyrphus* sp.	Syrphidae	Diptera	Aphids
28.	*Melanostoma* sp.	Syrphidae	Diptera	Aphids
29.	*Chrysotoxum* sp.	Syrphidae	Diptera	Aphids
30.	*Chrysopilus* sp.	Rhagionidae	Diptera	Aphids
31.	*Tachina* sp.	Tachinidae	Diptera	Aphids
32.	*Tachina* sp.	Tachinidae	Diptera	Aphids
33.	*Eristalis* sp.	Syrphidae	Diptera	Aphids
34.	*Eutolmus* sp.	Asilidae	Diptera	Flies, beetles, bees, ants and many other small insects
35.	*Promachus* sp.	Asilidae	Diptera	Flies, beetles, bees, ants and many other small insects
36.	*Chelisoches* sp.	Chelisochidae	Dermaptera	Aphids, mealy bugs, small insects
37.	*Chelisoches* sp.	Chelisochidae	Dermaptera	Aphids, mealy bugs, small insects
38.	*Forficula* sp.	Forficulidae	Dermaptera	Aphids, mealy bugs, small insects

			
1. *Palaeoneda auriculata*	**2. *Coccinella septempunctata***	**3. *Propylea japonica***	**4. *Coccinella* sp.**
			
5. *Anatis* sp.	**6. *Calvia punctata***	**7. *Agonum* sp.**	**8. *Emesaya* sp.**
			
9. *Chrysoperla* sp.	**10. *Statillia maculate***	**11. *Tenodera aridifolia***	**12. *Brunneria* sp.**
			
13. *Statillia* sp.	**14. *Evania* sp.**	**15. *Vespa basalis***	**16. *Cotesia glomerata***
			
17. *Crematogaster* sp.	**18. *Anotogaster sieboldii***	**19. *Sympetrum* sp.**	**20. *Anax* sp.**

			
21. *Ischnura* sp.	**22. *Ischnura* sp.**	**23. *Chrysotoxum* sp.**	**24. *Eristalis* sp.**
			
25. *Melanostoma* sp.	**26. *Sphaerophoria scripta***	**27. *Dasysyrphus* sp.**	**28. *Melanostoma* sp.**
			
29. *Chrysotoxum* sp.	**30. *Chrysopilus* sp.**	**31. *Tachina* sp.**	**32. *Tachina* sp.**

			
33. *Eristalis* sp.	**34. *Eutolmus* sp.**	**35. *Promachus* sp.**	**36. *Chelisoches* sp.**

	
37. *Chelisoches* sp.	**38. *Forficula* sp.**

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Evaluating Indian Garlic Accessions using Multivariate Analysis Based on Agro-Morphological Traits

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Abstract

To assess the genetic diversity of Indian garlic accessions, cluster analysis using Ward's method was used which classified 25 genotypes into 6 clusters. The highest intra-cluster distance was observed in cluster I revealed that genotypes within the same cluster were quite diverse while cluster IV showed highest inter cluster distance. The inter cluster distances were observed to be higher than intra-cluster distances, suggesting presence of high genetic diversity between the lines of any two clusters than the lines present within the cluster. The maximum contribution towards the genetic divergence was exhibited by bulbils per plant. A total of 92.93 % variation was explained by the first six significant principal components in which plant height (PC1 and PC2) followed by clove polar diameter (PC3), leaf length (PC4), cloves per bulb (PC5) and pseudo stem length (PC6) were observed as the maximum contributors towards genetic divergence revealed great potentiality of improving agronomic characters in garlic.

Key words : *Cluster analysis, character contribution, PCA, NHRDF.*

Introduction

Garlic (*Allium sativum* L.), an asexually propogated crop and member of family Amaryllidaceae (Allen, 2009) is an important spice crop and is the second most widely cultivated *Allium* after onion throughout the world. The primary centre of origin of garlic is Central Asia (India, Afganistan, West China, Russia) whereas, Mediterranean region is considered as its secondary habitat (Brewster, 1994). The most probable wild progenitor of garlic is *Allium longicuspis* Regel (Vvedensky, 1944).

Garlic has been considered as 'Nectar of life' in Ayurveda as it is richest source of S reducing blood lipids cholesterol, having anticancerous and antiscorbutic effects. It also contains carbohydrates, sugars, dietary fibres, fat, protein, thiamine, riboflavin, niacin, vitamin C, calcium, and essential oils which impart strong flavour. The chief constituents of oil are diallyl disulphide, diallyl trisulphide, allyl-propyl disulphide and a small quantity of diethyl disulphide and diallyl polysulphide. Diallyl disulphide is known to possess the true garlic odour.

Globally, China being key producer of garlic in the world with 70% of total production followed by India where it is mainly grown as short-day plant. However, long day varieties need photoperiod of more than 13 hrs. with 20-25 °C for bulbing. Hence Jammu and Kashmir, Himachal Pradesh and Uttarakhand being temperate areas are most suitable for long day garlic cultivars (Geetika et al., 2017). Early sowing, longer photoperiod and higher temperature plays key role in quality garlic production (Atif *et al.,* 2020).

The major constraints in garlic production are lack of availability of improved varieties for commercial cultivation, processing and export. Consequently, farmers are restricted to use garlic landraces inferior in yield, prone to most of the diseases and insects. Because of lack of systematic study to improve this crop, very little information is available on genetic diversity, and contribution of characters for bulb yield. This study was therefore, conducted with the objective of assessing the genetic diversity using morpho-agronomic traits among 25 garlic accessions.

Materials and Methods

The study involving 25 garlic accessions collected both within and outside the State (Table-1) was undertaken at Vegetable Farm, CSK HPKV, Palampur during 2018 at an elevation of 1290 m above mean sea level with 32^0 6' N latitude and 76^0 3' E longitude. Agroclimatically, the location represents mid hill zone of H.P with high rainfall of 2500 mm annually, of which 80 per cent is received during June to September. The soil is acidic in nature with pH ranging from 5.0 to 5.6 and soil texture is silty clay loam. Mean temperature during the crop season varied from 13.5 to 25.8 ^{0}C while relative humidity varied from 52 to 84.36 %. Each experimental plot consisted of 4 rows each of 0.6 m length, accommodating 6 plants per row. The observations were recorded on 10 randomly selected competitive plants from each entry per plot in each replication for 17 quantitative traits namely, plant height (PH), leaves per plant (LPP), leaf length (LL), leaf width at middle portion (LWMP), pseudo stem length (PSL),

pseudo stem diameter (PSD), bulb polar diameter (BPD), bulb equatorial diameter (BED), cloves per bulb (CPB), clove weight (CW), clove length (CL), clove polar diameter (CPD), clove equatorial diameter, total soluble solids (TSS), bulbils per plant (BPP) and bulb yield per plant (BYPP). Data was analysed using Ward's Cluster Analysis and Principal Component Analysis (PCA) procedures of statistical software XLSTAT (Anonymous, 2015).

Results and Discussion

Cluster analysis : Using clustering analysis method, 25 genotypes of garlic were grouped into six clusters based on genetic distance calculated on 16 agro-morphological quantitative traits (Fig.-1). Cluster V, II, VI, I and III contained 7, 5, 5, 4 and 3 genotypes, respectively and the remaining cluster viz., cluster IV was solitary, containing a single genotype. The results of the present investigation are in conformity with the findings of Sabir et al. (2017) who conducted diversity studies involving 27 garlic genotypes and categorized the genotypes into 6 clusters each comprising of 8, 6, 6, 4, 2 and 1 genotypes.

The highest intra-cluster distance was observed in cluster I (17.55) followed by cluster VI (16.32), cluster V (11.49), cluster II (10.95) and cluster III (9.24). The highest intra-cluster distances observed in the studies revealed that genotypes within the same cluster were quite diverse, hence selection of parents within cluster would be more effective. On the other hand, the highest inter cluster distance was observed between cluster IV and cluster V (166.66) followed by cluster IV and cluster VI (154.0), cluster III and cluster IV (101.40), cluster I and cluster IV (82.99), cluster II and cluster IV (80.82), cluster I and cluster V (45.96), cluster II and cluster V (34.33), cluster I and cluster VI (33.87), cluster III and V (31.69), cluster II and VI (29.48), cluster I and cluster III (23.52), cluster III and cluster VI (21.80), cluster V and cluster VI (20.70), cluster I and cluster II (20.61) and cluster II and cluster III (17.22). Islam et al. (2017) also observed the same trend in which genotypes were categorized into 4 and 6 clusters, respectively with variable inter and intra-cluster distances. This grouping will helpful to breeder to select trait specific genotypes for further selection and development of variety.

The inter cluster distances were observed to be higher than intra-cluster distances, suggesting presence of high genetic diversity between the lines of any two clusters than the lines present within the cluster. Hence, crossing between genotypes belonging to these clusters may result in generating diversity, which could be exploited in garlic improvement. The grouping pattern of the genotypes suggested no parallelisms between genetic divergence and geographical distribution of genotypes. Shashidhar and Dharmatti (2005), Singh et al. (2012 b), Mohammadi et al. (2014) and Sandhu et al. (2014) also reported the same results that genetic diversity was independent of geographical region in similarity with this investigation.

The cluster means showed great diversity for 16 quantitative traits of garlic accessions (Table-2). Cluster I was found best for the traits, plant height and leaves per plant; cluster II for leaf length and bulbils per plant; cluster III for pseudo stem length and TSS; cluster IV for bulb yield per plant, bulb yield per plot, clove weight, clove length, clove polar diameter, clove equatorial diameter, bulb polar diameter, bulb equatorial diameter and leaf width at middle portion; cluster V for pseudo stem diameter and cluster VI for cloves per bulb.

Character contribution : The maximum contribution towards the genetic divergence (Table-3) was exhibited by bulbils per plant (40.33 %), leaf length (12.67 %), plant height (10.67 %), bulb yield per plant (6.67 %), pseudo stem length (6.33 %), clove polar diameter (6.0 %), cloves per bulb (4.0 %), clove equatorial diameter (3.33 %), bulb equatorial diameter (3.33%), leaf width at middle portion (2.67 %), clove weight (2.33 %) and clove length (1.33 %). No contribution towards genetic divergence was exhibited by leaves per plant and pseudo stem diameter, while lowest contribution towards the genetic divergence was exhibited by bulb yield per plot (0.67 %), bulb polar diameter (0.67 %) and TSS (0.33%).

Principal Component Analysis : Principal component analysis (PCA) helps in identifying the most relevant characters that can be used as descriptors by explaining as much of total variation in the original set of variables as possible with a few components as possible and reducing the dimension of the problem. The characters contributing more to the divergence gave greater emphasis for deciding on the cluster for the purpose of further selection and the choice of parents for hybridization.

A total of 85.67 % variation was explained by the first four significant principal components (Table-4 and Fig.-2). The results are in agreement with the findings of Panthee et al. (2006) who reported that 86.0 % of the total genetic variation was captured by first four principal components. The first principal component (PC1**)** was the most important and explained 57.68 % of total variance which was mainly contributed by plant height (0.54), bulb equatorial diameter (0.44), leaf length (0.37), bulb yield per plant (0.36), clove polar diameter (0.29), bulb polar diameter (0.25), clove equatorial diameter (0.23) and pseudo stem length (0.11). The principal component (PC2) contributed 14.78 per cent to the total variance which was mainly contributed by plant height (0.54), pseudo stem length (0.45), cloves per bulb (0.24), TSS (0.15) and leaf length (0.15). The principal component

Table-1 : Garlic accessions collected within and outside the State.

Genotypes	Coding	Source
Yamuna Safed-1	G-9	NHRDF, Karnal (Haryana)
Yamuna Safed-2	G-12	NHRDF, Karnal (Haryana)
Yamuna Safed-3	G-8	NHRDF, Karnal (Haryana)
Yamuna Safed-4	G-2	NHRDF, Karnal (Haryana)
Yamuna Safed-5	G-5	NHRDF, Karnal (Haryana)
Yamuna Safed-8	G-13	NHRDF, Karnal (Haryana)
Yamuna Safed-9	G-1	NHRDF, Karnal (Haryana)
Agrifound Parvati	G-11	NHRDF, Karnal (Haryana)
Agrifound Parvati-2	G-10	NHRDF, Karnal (Haryana)
Agrifound White	G-7	NHRDF, Karnal (Haryana)
GHC-1	G-3	CSK HPKV, Palampur
Leda Local Selection	G-4	Local Collection (HP)
Bijni Local Selection	G-6	Local Collection (HP)
Nerchowk Local Selection	G-14	Local Collection (HP)
Mahadev Local Selection	G-15	Local Collection (HP)
Kangra Local Selection	G-16	Local Collection (HP)
Kanaid Local Selection	G-17	Local Collection (HP)
Gheru Local Selection	G-18	Local Collection (HP)
Chambi Local Selection	G-19	Local Collection (HP)
Biara Local Selection	G-20	Local Collection (HP)
Kasharala Local Selection	G-21	Local Collection (HP)
Jhungi Local Selection	G-22	Local Collection (HP)
Chakar Local Selection	G-23	Local Collection (HP)
Pungh Local Selection	G-24	Local Collection (HP)
Badraina Local Selection	G-25	Local Collection (HP)

Table-2 : Cluster means of six clusters for 16 quantitative traits in garlic accessions.

Traits	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI
Plant height (cm)	58.71	51.12	57.28	57.85	40.38	52.17
Leaves per plant	8.97	8.69	8.01	8.93	7.65	7.56
Leaf length (cm)	35.81	35.99	34.01	35.10	24.69	32.42
Leaf width at middle portion (cm)	1.46	1.29	1.21	2.70	0.90	1.29
Pseudo stem length (cm)	23.55	18.77	27.77	16.54	17.41	25.00
Pseudo stem diameter (cm)	1.23	1.30	1.37	2.31	0.89	1.03
Bulb polar diameter (mm)	35.60	33.67	35.11	41.04	28.24	30.64
Bulb equatorial diameter (mm)	39.76	40.95	38.03	50.86	27.89	32.47
Cloves per bulb	12.73	10.0	9.08	6.53	10.31	14.03
Clove weight (g)	2.26	2.84	2.57	5.36	1.78	1.50
Clove length (cm)	3.99	3.84	3.74	5.56	3.38	3.38
Clove polar diameter (mm)	31.19	27.13	28.48	46.75	23.80	23.77
Clove equatorial diameter (mm)	14.63	16.67	17.99	29.93	12.18	11.35
Bulb yield per plant (g)	27.36	28.08	22.65	38.07	18.08	19.30
Bulb yield per plot (kg)	0.65	0.67	0.54	0.91	0.43	0.46
TSS (0b)	39.82	39.06	43.31	33.99	42.17	41.21
Bulbils per plant	0.00	3.63	3.72	0.0	3.00	3.38

Table-3 : Relative contribution (%) of individual trait to genetic divergence.

Trait	No. of times ranked first	Contribution (%)
1. Plant height	32	10.67
2. Leaves per plant	0	0.00
3. Leaf length (cm)	38	12.67
4. Leaf width at middle portion	8	2.67
5. Pseudo stem length (cm)	19	6.33
6. Pseudo stem diameter (cm)	0	0.00
7. Bulb polar diameter (mm)	2	0.67
8. Bulb equatorial diameter	10	3.33
9. Cloves per bulb	12	4.00
10. Clove weight (g)	7	2.33
11. Clove length (cm)	4	1.33
12. Clove polar diameter (mm)	18	6.00
13. Clove equatorial diameter (mm)	10	3.33
14. Bulb yield per plant (g)	18	6.67
15. Bulb yield per plot (kg)	2	0.67
16. TSS (°b)	1	0.33
17. Bulbils per plant	121	40.33

Table-4 : Eigen vectors of first six principal components for different traits.

Variable	Eigen vector					
	PC1	PC2	PC3	PC4	PC5	PC6
Eigen values (Root)	6.68	5.40	2.12	1.69	1.38	1.17
Variation (%)	57.68	14.78	7.24	5.96	3.99	3.26
Cumulative variation (%)	57.68	72.46	79.70	85.67	89.66	92.93
Plant height	0.54	0.54	-0.25	-0.33	-0.13	-0.34
Leaves per plant	0.03	-0.02	-0.01	0.02	0.03	-0.00
Leaf length (cm)	0.37	0.15	0.08	0.86	-0.13	-0.04
Leaf width at middle portion (cm)	0.21	-0.01	0.01	0.02	-0.01	-0.00
Pseudo stem length (cm)	0.11	0.45	0.54	-0.05	0.23	0.46
Pseudo stem diameter (cm)	0.01	-0.01	-0.00	-0.01	-0.00	0.00
Bulb polar diameter (mm)	0.25	-0.05	0.09	-0.16	-0.16	-0.06
Bulb equatorial diameter (mm)	0.44	-0.18	-0.21	-0.08	0.11	0.42
Cloves per bulb	-0.00	0.24	0.04	-0.05	0.72	-0.11
Clove weight (g)	0.04	-0.07	-0.01	0.00	-0.08	0.03
Clove length (cm)	0.02	-0.04	0.01	0.01	-0.01	-0.02
Clove polar diameter (mm)	0.29	-0.38	0.63	-0.06	0.17	-0.46
Clove equatorial diameter (mm)	0.23	-0.31	0.09	-0.22	-0.40	0.12
Bulb yield per plant (g)	0.36	-0.29	-0.16	0.00	0.41	0.33
Bulb yield per plot (kg)	0.00	-0.00	-0.00	0.00	0.01	0.00
TSS (°b)	-0.08	0.15	0.36	-0.19	-0.10	0.27
Bulbils per plant	-0.04	0.05	0.01	0.05	-0.08	0.21

(PC3) contributed 7.24 % to total variance through clove polar diameter (0.63), pseudo stem length (0.54) and TSS (0.36).

The principal component (PC4) contributed 5.96 % to the total variance through leaf length (0.86). However, the remaining principal components (PC5 and PC6) contributed 3.99 and 3.26 per cent, respectively to the total variation through cloves per bulb, bulb yield per plant, pseudo stem length, clove polar diameter (PC5) and pseudo stem length, bulb equatorial diameter, bulb yield per plant, TSS and bulbils per plant (PC6). The results are in confirmation with the findings of Sharma et al. (2018) who reported that more than 75 % of the total genetic variation in the experimental material evaluated was explained by first four principal components.

Evaluation of garlic accessions has significant value with regard to its record, preparation of catalogue, classification as per traits and primary understanding of

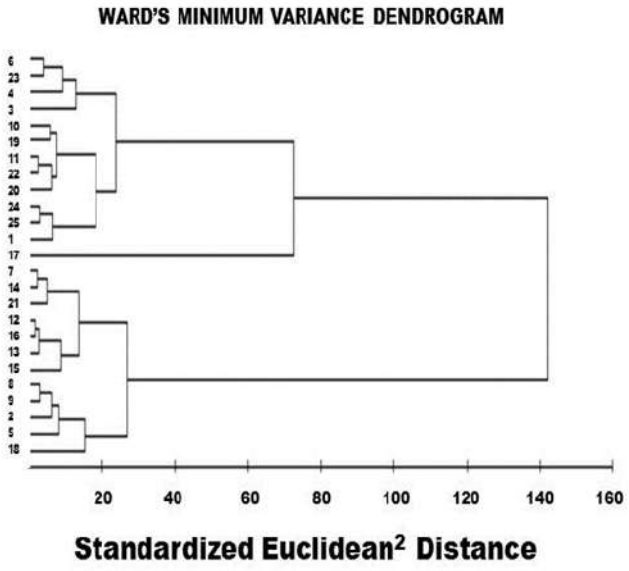

Fig.-1 : Dendrogram generated by Ward's method of cluster analysis showing 6 clusters.

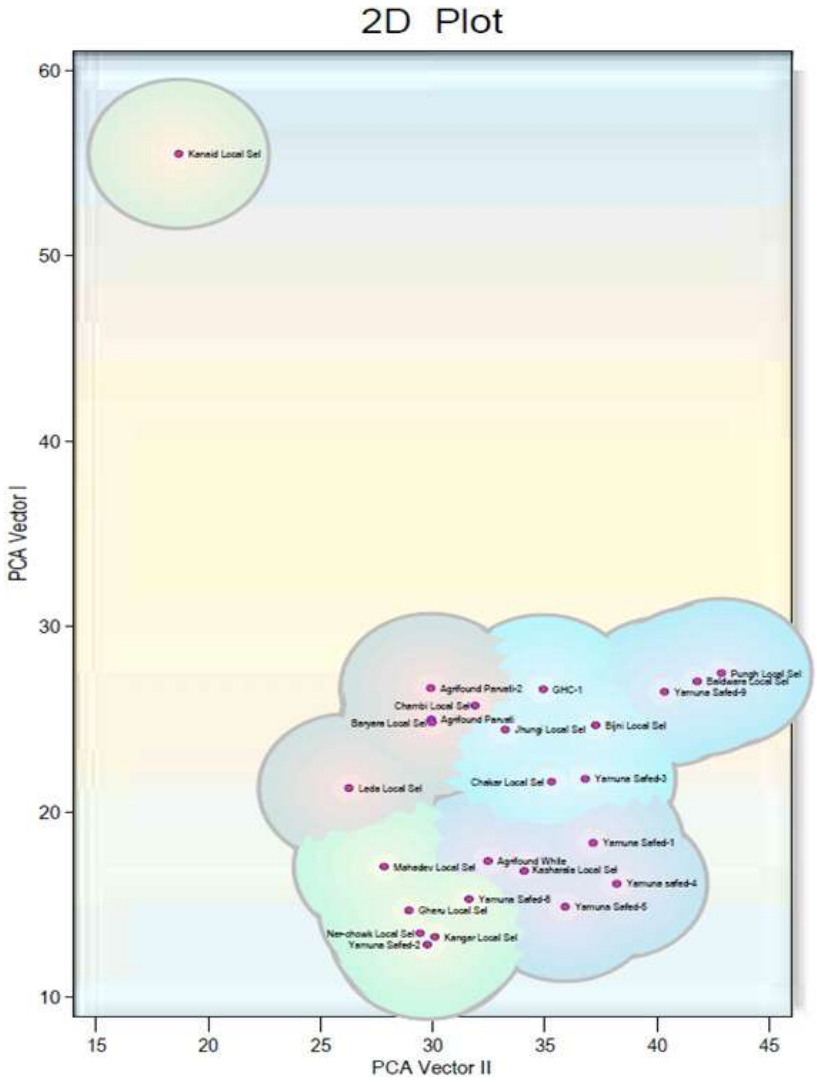

Fig.-2 : PCA 2-D plot depicting diversity among 25 garlic accessions falling in 6 clusters.

breeder to carry advance research. Based on cluster and Principal Component Analysis (PCA), selection of diverse parents among the cultivated/wild types and utilization of germplasm by using conventional and biotechnological approaches now appeared to be a need of hour. This study also acts as a base material for the formulation of a core group of Indian garlic gene pool for subsequent exploitation. Morphological evaluation in this study signified huge diversity which can be utilized and can prove helpful for planning advanced breeding program in future for improvement of garlic accession for economy production.

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Performance of Growth and Yield of Wheat to Application of N and K Fertilizer under Irrigated Condition

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Abstract

An experiment in the field was carried out during *rabi* 2022-23 at at C Dhani 400, Jhorarnali, Sirsa, Haryana to find out the "effect of nitrogen and potassium levels on productivity of wheat (*Triticum aestivum* L.)". The twelve treatment combinations *i.e.* four nitrogen levels (0, 75, 150 and 225 kg N ha^{-1}) and three potassium levels (0, 40 and 80 kg K_2O ha^{-1}) were involved in trial. The experiment was laid out in factorial randomized block design with three replications. All the nitrogen levels, application of 225 kg N ha^{-1} significantly increased growth parameters *i.e.* plant height, dry matter accumulation and number of tillers at CRI, tillering and at harvest stages, yield attributes *i.e.* spike length, number of spikelet $spike^{-1}$ and number of grains $spike^{-1}$ and yield (grain and straw) over 0 and 75 kg N ha^{-1}, but remained at par with 150 kg N ha^{-1}. Application of 80 kg P_2O_5 ha^{-1} was recorded significantly higher growth parameters *i.e.* plant height, dry matter accumulation and number of tillers at CRI, tillering and at harvest stages, yield attributes *i.e.* spike length, number of spikelet $spike^{-1}$ and number of grains $spike^{-1}$ and yield (grain and straw) as compared to rest of the treatments.

Key words : *Wheat, yield, nitrogen, potassium.*

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world grown in 122 countries. In India it is most staple and second most important crop after rice, which contributes nearly one third of the total food grain production. Due to its wide adaptability it can be grown under various agroclimatic conditions. Wheat is second only to rice as a source of calories. The approximate chemical composition of the wheat kernel is starch, 63-71%; protein, 10-15%; water, 8-17%; cellulose, 2-3%; fat, 1.5-2%; sugar, 2-3%; and mineral matter, 1.5-2%. In India, wheat is cultivated extensively in North-Western and Central zones. Improvement in its productivity has played a key role in making the country self-sufficient in food grain. However, in the past decade, a general slowdown in further increase in the productivity of wheat has been noticed, which is undesirable with building population pressure.

As per data from ministry of agriculture, the Wheat production during 2022-23 in the country is estimated at 112.18 million tonnes which is higher by 4.44 million tonnes than the production achieved during 2021-22. Major wheat-growing states in India are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar and Gujarat. The area, production and productivity of wheat in Rajasthan was 2.58 Mha, 10.095 Mt and 3913 kg ha^{-1}, respectively (Anonymous, 2022).

In India, important reason of low productivity of wheat is poor soil fertility. To realize the full yield potential crop must be nourished with adequate and balanced nutrition. Indian soils are becoming poor in soil fertility, 90% soils are deficit in N, 80% in P, 50% in K, 41% in S, 48% in Zn, 33% in B, 12% in Fe and 13% in Mo (Rattan 2013). Level of organic matter is also declining in soil. Plant nutrition plays an important role in growth and productivity of a crop. As wheat crop is highly responsive to applied nutrients through various sources, proper soil fertility management is important for optimizing the productivity of this crop. Among various nutrients, nitrogen is required by wheat crop in large amount and usually supplied through outside sources like fertilizers and manures as most of the soils in wheat growing areas are deficient in nitrogen.

Nitrogen is the nutrient with the highest potential for limiting profitable wheat production since N is a constituent of chlorophyll the green pigment allowing plants to convert solar energy into carbohydrate. Nitrogen supply to plant influence the amount of protein, protoplasm and chlorophyll formed and intern this influence cell size, leaf area and photosynthetic activity. Insufficient nitrogen result in lighter green color, reduced tillering and disturbance of normal cell growth and a decrease in the rate and extent of protein synthesis. Nitrogen deficiency during reproductive phase of wheat adversely affects spikelet formation, floret formation, kernel filling and result in reduced grain protein. Hence, application of fertilizer nitrogen results in higher biomass yields and protein yield and concentration in plant tissue is commonly increased. Increasing nitrogen supply

generally improves kernel integrity and strength, resulting in better milling properties of the grain. Wheat protein is high in glutamic acid and proline, whereas lysine, threonine, methionine, and cystine concentrations are lower than those recommended by the World Health Organization (Singh *et al*., 2016).

In wheat, potassium application is not regularly practiced, but plays equally important role as nitrogen and phosphorus in plants for their growth and development. By introduction of high yielding varieties and hybrids during green revolution and with the progressive intensification of agriculture, the soils are getting depleted in potassium reserve at a faster rate. As a consequence, potassium deficiency is becoming one of the major constraints in crop production, especially in coarse textured soils. Even in fine textured soils the available fraction is low compared to total K in them, crops do respond to K fertilization in soils with high available K. Excessive usage of fertilizers leads to the leaching of nutrients from the soil and contributes to environmental pollution, without corresponding increases in yield. Potassium fixed with in soil and not easily meet to crop. Although most agricultural soils have large amounts of K, these are immobilized and mostly become unavailable. Hence, very limited concentration of K is available to plants. Although K deficiency is not as wide spread as that of nitrogen and phosphorus, many soils which were initially rich in K become deficit in due course due to heavy utilization by crops and inadequate K application, runoff, leaching and soil erosion (Sheng and Huang, 2002).

Materials and Methods

A field experiment was conducted during *rabi* 2022-23 at C Dhani 400, Jhorarnali, Sirsa, Haryana which is situated in South-Eastern part of Rajasthan at an altitude of 201.58 metre above mean sea level with 29° 51' N latitude and 75° 03' E longitude. The climate of this region is typically subtropical steppe climate. The soil of the experimental field was loamy sand in texture, slightly alkaline in reaction (8.2), low in organic carbon (0.15%), available nitrogen (124.8 kg ha^{-1}) and medium in available phosphorus (18.5 kg ha^{-1}), available potassium (178.4 kg ha^{-1}). The twelve treatment combinations *i.e.* four nitrogen levels (0, 75, 150 and 225 kg N ha^{-1}) and three potassium levels (0, 40 and 80 kg K_2O ha^{-1}) were involved in trial. The experiment was laid out in factorial randomized block design with three replications. The application of nitrogen and potassium was given as per treatment, phosphorus (60 kg P_2O_5 ha^{-1}) applied as basal dose.

To bring the field into good tilth for proper germination and establishment of the crop, field should be cross cultivated with tractor drawn cultivator. The field was cleaned by removing stubbles and debris from the field manually. One harrowing followed by planking was done for preparation of field. First irrigation was given 21 days after sowing, followed by successive five irrigations at different critical growth stages *viz.,* 45, 67, 85, 100 and 112 DAS. To minimize the crop weed competition, pre-emergence herbicide Pendimethalin was applied @ 1.0 kg ha^{-1}.

The plant height was measured from the ground to the tip of the main shoot on five randomly selected plants from each plot at CRI, tillering and at harvest stages to the tip of the upper spikelet of main ear (excluding awns). The average plant height was calculated and expressed in cm**.** Plants of 0.5 m row length from the sample rows of each gross plot were uprooted at CRI, tillering and at harvest stages. The root portion was removed, and the plants were separated into little pieces before being placed in a perforated labelled brown paper bag and dried in the sunlight first, then in the thermostatically controlled oven at 60°C ± 2°C. The drying process was repeated until a steady weight was reached, and the mean dry matter accumulation g 0.5 m^{-1} row length was calculated. At CRI, tillering and at harvest stages, the number of effective tillers was counted from one-metre row length in three locations over the net plot area. The average of the three values is given as the number of effective tillers per m^{-1} row length. The length of spike was measured from five randomly selected ears at the time of crop harvest, and averaged to express in cm. The five randomly selected productive spikes were selected and number of spikelets were counted, averaged and expressed as number of spikelets $spike^{-1}$. Five spikes were randomly selected from net plot, threshed and the total number grain was counted and average was taken as number of grain $spike^{-1}$. The net plot crop was harvested, threshed and winnowed.

The grains harvested from each net plot were sun dried for 2-3 days to attain 10 per cent moisture and then the weight of grains net $plot^{-1}$ area was recorded and expressed in q ha^{-1}. The straw yield from each net plot was sun dried for 4 to 6 days and weighed. Straw yield q ha^{-1} was computed from straw yield of each net plot. It is the ratio of economic yield (grain yield) to biological yield, and worked out by following formula (Donald and Hamblin, 1976) expressed in percentage. The Gomaz and Gomaz (1984) paper's technique was used to conduct the statistical analysis.

Results and Discussion

Effect of nitrogen levels

Growth parameters : A perusal of data from Table-1 shows that plant height, dry matter accumulation and number of tillers at CRI, tillering and at harvest stages was

Table-1 : Effect of nitrogen and potassium levels on growth parameters of wheat at different stages.

Treatments	Growth pamaters								
	Plant population (number m^{-1} row length)	Plant height (cm)			Dry matter accumulation (g m^{-1} row length)			Tillers density (Tillers m^{-2})	
		CRI	Tillering	Harvest	CRI	Tillering	Harvest	CRI	Tillering	Harvest
Nitrogen levels										
0 kg ha^{-1}	23.7	9.98	25.94	60.48	16.4	52.9	184.4	142.5	175.7	199.5
75 kg ha^{-1}	24.0	12.35	33.35	68.31	19.5	64.9	222.3	185.2	237.5	266.0
150 kg ha^{-1}	24.5	15.73	36.43	69.98	23.7	72.3	236.9	190.0	261.2	304.0
225 kg ha^{-1}	24.6	16.15	37.26	74.10	23.2	74.0	242.1	194.7	266.0	313.5
S.Em ±	0.42	0.30	1.18	2.57	0.23	1.2	3.6	2.22	2.39	3.66
C.D. (P = 0.05)	NS	0.91	3.51	5.17	0.70	3.60	10.79	6.59	7.12	10.88
Potassium levels										
0 kg ha^{-1}	22.0	8.93	23.21	54.11	15.8	50.9	177.3	127.5	178.5	157.2
40 kg ha^{-1}	24.0	11.05	29.84	60.12	18.7	62.4	213.7	162.7	238.0	212.5
80 kg ha^{-1}	24.2	13.18	33.34	62.60	20.2	69.5	227.8	170.0	280.5	233.7
S.Em ±	0.40	0.29	1.14	0.55	0.23	1.16	3.49	2.15	3.54	2.32
C.D. (P = 0.05)	NS	0.87	3.36	1.62	0.69	3.5	10.48	6.32	10.42	6.82

Table-2 : Effect of nitrogen and potassium levels on yield parameters and yield of wheat at different stages.

Treatments	Yield attributes			Yield (q ha^{-1})		Harvest index (%)
	Spike length (cm)	Number of spikelet $spike^{-1}$	Number of grains $spike^{-1}$	Grain	Straw	
Nitrogen levels						
0 kg ha^{-1}	6.84	17.10	27.55	22.23	34.58	39.13
75 kg ha^{-1}	9.12	20.90	31.35	36.53	49.90	42.27
150 kg ha^{-1}	9.22	22.80	33.25	37.81	51.61	42.28
225 kg ha^{-1}	9.31	23.75	34.20	39.62	53.39	42.60
S.Em ±	0.05	0.78	0.50	0.76	1.44	1.26
C.D. (P = 0.05)	0.14	2.30	1.51	2.26	4.29	NS
Potassium levels						
0 kg ha^{-1}	6.12	15.30	24.65	19.89	30.94	39.13
40 kg ha^{-1}	8.06	19.04	28.05	31.38	42.65	42.26
80 kg ha^{-1}	8.25	21.28	29.75	33.83	47.77	41.46
S.Em ±	0.05	0.75	0.49	0.74	1.40	1.03
C.D. (P = 0.05)	0.14	2.20	1.45	2.17	4.11	NS

recorded significantly higher with application of 225 kg N ha^{-1} as compared to 0 and 75 kg N ha^{-1}, but remained at par with 150 kg N ha^{-1}. Plant population was not differed with application of nitrogen. This might be due to one of the important macronutrients needed for the development and growth of wheat plants is nitrogen. It is essential for the production of proteins and chlorophyll, both of which are necessary for photosynthesis and plant development. Saeed *et al.* (2013) was also observed that the application of nitrogen significantly increased growth in wheat crop. These outcomes are also consistent with those of Sharma *et al.* (2015), Jat *et al.* (2017), Sharma *et al.* (2018) and Singh *et al.* (2019).

Yield attributes : The data in Table-2 show that application of 225 kg N ha^{-1} significantly increased yield attributes *i.e.* spike length, number of spikelet $spike^{-1}$ and number of grains $spike^{-1}$ of wheat over 0 and 75 kg N ha^{-1} and remained at par with 150 kg N ha^{-1}. An increase in tillers brought on by nitrogen application may account for the improvement in yield characteristics. A larger output of flowers that later developed into spikelets may have resulted from increased meristematic activity, tissue differentiation (from somatic to reproductive), and the generation of floral precursors after nitrogen injection. The increase in yield caused by the application of nitrogen may be attributable to the cumulative effect of an increase in the number of productive tillers, spikelets $spike^{-1}$ and grains $spike^{-1}$. The same outcomes were also noted by Saeed *et al.* (2013), Sharma *et al.* (2015), Jat *et al.* (2017), Kumar *et al.* (2018), Sharma *et al.* (2018) and Singh *et al.* (2019).

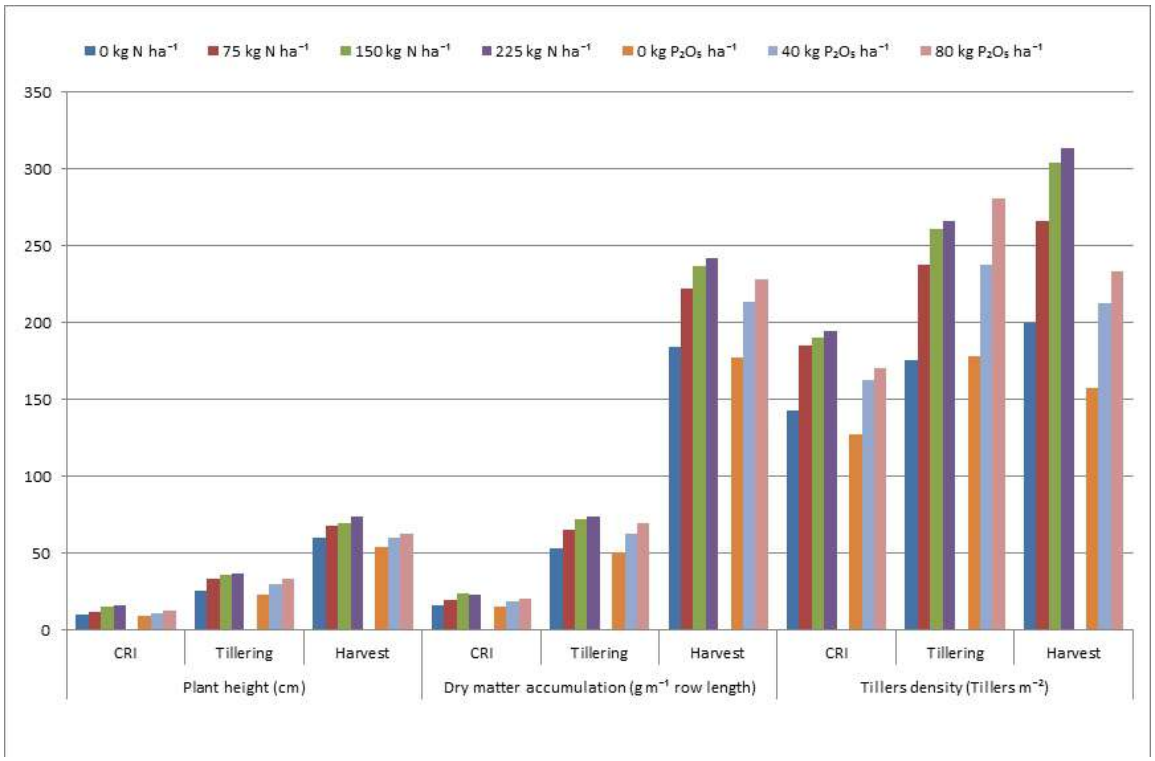

Fig.-1 : Effect of nitrogen and potassium levels on growth parameters of wheat at different stages.

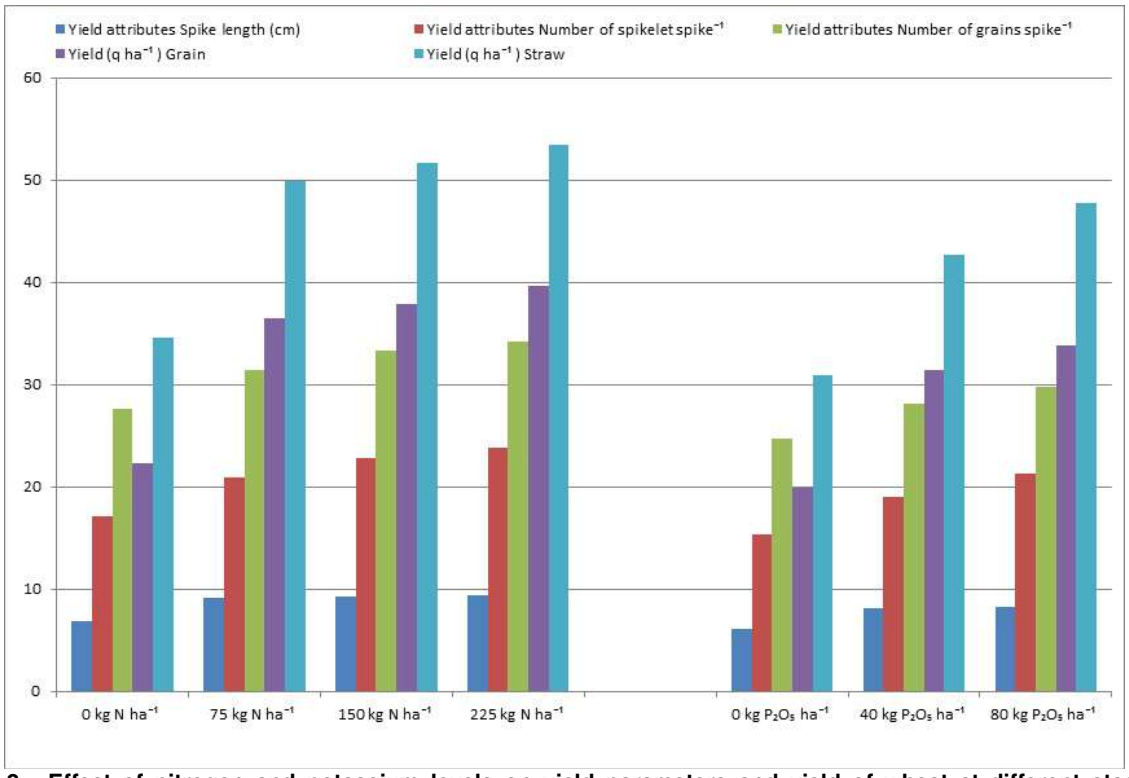

Fig.-2 : Effect of nitrogen and potassium levels on yield parameters and yield of wheat at different stages.

Yield : Significantly higher yield (grain and straw) of wheat (Table-2) was found with application of 225 kg N ha^{-1} as compared to 0 and 75 kg N ha^{-1}, but remained at par with 150 kg N ha^{-1}. This might be due to application of nitrogen increased all growth and yield attributes, thus ultimately enhanced yield of wheat. Saeed *et al.* (2013), Sharma *et al.* (2015), Jat *et al.* (2017), Kumar *et al.* (2018), Sharma *et al.* (2018) and Singh *et al.* (2019) were also supporting these findings. However, harvest index was unchanged due to application of nitrogen.

Effect of potassium levels

Growth parameters : Data in Table-1 showed that application of 80 kg P_2O_5 ha^{-1} was recorded significantly higher growth parameters *i.e.* plant height, dry matter accumulation and number of tillers at CRI, tillering and at harvest stages as compared to rest of the treatments. Application of potassium regulated the stomata and other many enzymes, thus improve the photosynthesis and synthes higher photosynthates and increased dry matter thus enhanced growth of plant. One of the important macronutrients that plants need for healthy growth and development is potassium. It is crucial for the control of metabolic processes such protein synthesis, photosynthesis and plant water status (Kumar *et al*., 2020). Wheat plants can grow and develop more quickly with enough potassium levels in the soil, which increases yield. Similar findings also reported by Kubar *et al*. (2019) and Al-Taher and Al-Naser (2021).

Yield attributes : Maximum and significantly higher yield attributes *i.e.* spike length, number of spikelet $spike^{-1}$ and number of grains $spike^{-1}$ of wheat found with application of potassium 80 kg P_2O_5 ha^{-1} as compared to application of potassium 0 and 40 kg P_2O_5 ha^{-1} (Table-2). Wheat can consume less water and produce more when the soil has an adequate level of potassium. Additionally, it aids in the synthesis and movement of proteins and carbs, which are crucial for grain and fullness, other yield attributes. Similar findings also reported by Kubar *et al*. (2019) and Al-Taher and Al-Naser (2021).

Yield : Data in Table-2 revealed that application of potassium 80 kg P_2O_5 ha^{-1} was significantly increased grain and straw yield of wheat over application of potassium 0 and 40 kg P_2O_5 ha^{-1} (Table-2). Application of potassium significantly increased the growth as well as yield parameters thus ultimately increased the grain and straw yield of wheat. Kubar *et al*. (2019) and Al-Taher and Al-Naser (2021) reported findings that were consistent.

Conclusions

Given the results of our research, it can be concluded that, in terms of growth and productivity, applying 225 kg N ha^{-1} to wheat is the most effective strategy. The application of 80 kg P_2O_5 ha^{-1} resulted in the highest and noticeably higher growth and yield of wheat among the potassium levels.

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Biochemical Changes in Groundunt Genotypes against Tikka and Rust Disease of Groundnut (*Arachis hypogaea* L.)

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Abstract

An experiment was conducted at Agricultural College, Bapatla. Preliminary screening of 42 genotypes for early, late leaf spot and rust, eight groundnut genotypes, two each from resistant, moderately resistant, moderately susceptible, and susceptible were selected to further explore the biochemical mechanisms involved in resistance. Sowing was done during *kharif* (July 2018). Each genotype was sown five rows of 5 m length with a spacing of 45 X 15 cm in RBD with three replications. Biochemical constituents of phenol, Ortho-dihydroxy phenols, total sugar and reducing sugar at 60 DAS (flowering stage) were estimated from leaves of healthy and diseased samples. The biochemical changes (total phenol, Ortho-dihydroxy phenols, total sugar and reducing sugars) in tikka and rust disease were studied in resistant and susceptible genotypes. There was a significant difference in total phenol, Ortho-dihydroxy phenols, total sugar and reducing sugar contents between the healthy and diseased leaves of resistant and susceptible genotypes. The biochemical constituents found more in resistant genotypes and considered as parameter for disease resistance.

Key words : *Total phenol, ortho-dihydroxy phenols, total sugar, reducing sugar, early leaf spot, late leaf spot, rust, groundnut genotypes.*

Introduction

Groundunt, (*Arachis hypogaea* L.) the king of oilseed crops, is believed to be a native of Brazil (South America). It is a unique crop, combining the attributes of both oilseed and legume in the farming system of Indian agriculture. It is the World's fourth most important source of edible oil after soybean, rapeseed and cotton seed and third most important source of vegetable protein. It is a primary source of edible oil (44-50%), protein content (25%) and is also a valuable source of vitamin B, E and K. Groundnut crop often suffers from many fungal, bacterial, viral, phytoplasma, nematode diseases and pests. The major biotic factors affecting groundnut yield and quality in India are foliar fungal diseases, stem rot, collar rot, root rot, rust and seedling rots etc. Of the foliar fungal diseases, the major ones are rust and the two leafspots i.e. late leafspot and early leaf spot together popular as "*Tikka*" in India. Both early and late leafspot (LLS) are in common occurrence wherever groundnut is grown. However, the incidence and severity of diseases vary between localities and seasons (Mc Donald *et al.,* 1985). The main cause for yield loss is the co-occurrence of rust and LLS that can go up to 70% in India when fungicides are not applied (Subrahmanyam *et al*., 1984; Subrahmanyam *et al*., 1985). Use of disease resistant cultivators is one of the best means of reducing crop losses from leaf spot and rust disease. Considering the importance of disease, this study was undertaken with the objectives to screen the groundnut germplasm against tikka and rust disease and to study biochemical reaction against tikka and rust disease.

Materials and Methods

Based on the preliminary screening of 42 genotypes for early, late leaf spot and rust, eight groundnut genotypes, two each from resistant, moderately resistant, moderately susceptible, and susceptible were selected to further explore the biochemical mechanisms involved in resistance. Sowing was done during *kharif* (July 2018). Each genotype was sown five rows of 5 m length with a spacing of 45 X 15 cm in RBD with three replications.

The leaf samples from fully opened fresh young leaves (third from apical node) and old leaves (fifth from the lower most node) were collected from five plants at random at 60 days after sowing from the three middle row plants. Among resistant germplasm accessions identified

during preliminary screening, the total and Ortho-dihydroxy phenols were estimated by adopting the methods of Maliek and singh (1980); Michael *et al.* (1978) and Millar (1972), respectively. Total sugars and reducing sugars were also estimated (Hegde and Hofreiter, 1962).

Results and Discussion

The groundnut genotypes which have exhibited a diseases score of 1 to 3 on a 1-9 scale against three foliar fungal diseases during the preliminary screening undertaken during *Kharif* 2017, *rabi* 2018 and *summer* 2019 were selected for studying the changes associated with resistance and susceptibility. The biochemical components studied includes estimation of total phenols, ortho-dihydroxy phenols, total sugars and reducing sugars which were reported to be associated with disease resistance in different crops in general and groundnut in particular. Eight groundnut genotypes viz., K 1811 and JCG-88-2 (resistant); Girnar 2 and K 1735 (moderately resistant); K 1847 and Girnar 3 (susceptible) and Kadiri 6 and TAG 24 (Highly susceptible) were selected to study the biochemical mechanisms of resistance in groundnut against both leaf spots (early, late) and rust diseases. There was a significant difference between the healthy and diseased leaves of resistant and susceptible genotypes for all the biochemical parameters. The results on the biochemical changes associated with these diseases studied are presented in Table 1 to 4 and detailed below.

Total phenols : There was a significant difference in total phenol contents between the healthy and diseased leaves of resistant and susceptible genotypes (Table-1). The resistant genotypes K 1811 and JCG-88-2 recorded highest phenol content of 11.37 and 9.15 mg/fresh weight, respectively in healthy leaves while corresponding diseased leaves of same genotypes contained more phenol content (14.40 and 14.20 mg/fresh weight) the moderately resistant genotypes Girnar 2 and K 1735 registered phenol content of 6.13 and 6.39 mg/fresh weight in healthy leaves and corresponding diseased leaves of the same genotypes recorded phenol content (12.98 and 12.74 mg/fresh weight). The two susceptible genotypes K 1847 and Girnar 3 had phenol content 5.72 and 5.83 mg/fresh weight in healthy leaves, while diseased leaves of same genotypes recorded more phenol content of 11.59 and 10.03 mg/fresh weight, respectively. The highly susceptible genotypes Kadiri 6 and TAG 24 recorded phenol content of 4.06 and 5.29 mg/fresh weight in healthy leaves, while corresponding diseased leaves of same genotypes contained more phenol content (8.53 and 9.59 mg/fresh weight). Leaf spot and rust infections enhanced the accumulations of total phenol in the leaf tissues.

Table-1 : Effect of early and late leaf spots and rust on total phenol content in groundnut.

Genotypes	Reaction	Total phenol (mg/g fresh weight)	
		Healthy	Diseased
K1811	R	11.37*	14.40*
JCG-88-2	R	9.15*	14.20*
Girnar-2	MR	6.13*	12.98*
K1735	MR	6.39*	12.74*
K1847	S	5.72*	11.59*
Girnar-3	S	5.83*	10.03*
Kadiri 6	HS	4.06	8.53*
TAG 24(C)	HS	5.29	9.59*
CD at 5%		0.05	
CV%		0.23	

Table-2 : Effect of early and late leaf spots and rust on OD-phenol content in groundnut.

Genotypes	Reaction	OD-phenol (mg/g fresh weight)	
		Healthy	Diseased
K1811	R	0.51*	0.67*
JCG-88-2	R	0.58*	0.63*
Girnar-2	MR	0.47*	0.52*
K1735	MR	0.41*	0.51*
K1847	S	0.28*	0.45*
Girnar-3	S	0.34*	0.42*
Kadiri 6	HS	0.26	0.34*
TAG 24 (C)	HS	0.27	0.37*
CD at 5%		0.02	
CV%		2.45	

However, the phenol accumulation was more than 100 per cent in susceptible genotypes, after the symptoms were fully expressed. The level of total phenols increased after leafspots and rust inoculation in both the resistant and susceptible genotypes. The increase in the phenol content with the increase in disease severity may be due to the translocation of phenols to the site of infection and hydrolysis of phenolic glycosides by fungal glycosidase to yield free phenols. Harde *et al.* (2019) reported that total phenol content of resistant genotypes was significantly higher (50 per cent) than the susceptible genotypes at all the stages of observations. Jasani *et al.* (2018), Shinde *et al.* (2016) reported that resistance cultivars of groundnut had higher phenol contents. Contrasting reports by Rojasara *et al.* (2016) phenols indicated that were higher in susceptible entries than resistant entries.

Ortho-dihydroxy phenols (OD-phenol) : The resistant genotypes K 1811 and JCG-88-2 recorded highest OD-phenol content of 0.51 and 0.58 mg/fresh wt respectively in healthy leaves, while corresponding diseased leaves of same genotypes contained more OD-

Table-3 : Effect of early and late leaf spots and rust on total Sugar content in groundnut.

Genotypes	Reaction	Total Sugars (mg/g fresh weight)	
		Healthy	Diseased
K1811	R	1.40*	1.72*
JCG-88-2	R	1.53*	1.70*
Girnar-2	MR	1.06*	1.30*
K1735	MR	1.30*	1.65*
K1847	S	0.74*	1.00*
Girnar-3	S	0.69*	0.96*
Kadiri 6	HS	0.53*	0.84*
TAG 24 (C)	HS	0.51	0.87*
CD at 5%		0.03	
CV%		1.31	

Table-4 : Effect of early and late leaf spots and rust on reducing sugar content in groundnut.

Genotypes	Reaction	Reducing sugar (mg/g fresh weight)	
		Healthy	Diseased
K1811	R	1.20*	1.42*
JCG-88-2	R	1.13*	1.28*
Girnar-2	MR	0.97*	1.08*
K1735	MR	1.00*	1.16*
K1847	S	0.61*	0.98*
Girnar-3	S	0.58*	0.89*
Kadiri 6	HS	0.39*	0.75*
TAG 24 (C)	HS	0.36	0.77*
CD at 5%		0.01	
CV %		0.76	

phenol content (0.67 and 0.63 mg/fresh wt.). The moderately resistant genotypes, Girnar 2 and K 1735 registered OD-phenol content of 0.47 and 0.41 mg/fresh wt in healthy leaves and corresponding diseased leaves of the same genotypes recorded more OD-phenol content (0.52 and 0.51 mg/fresh wt.). The two susceptible genotypes K 1847 and Girnar 3 had OD -phenol content 0.28 and 0.34 mg/fresh wt in healthy leaves while, the diseased leaves of same genotypes recorded more OD - phenol content of 0.45 and 0.42 mg/fresh wt., respectively. The highly susceptible genotypes Kadiri 6 and TAG 24 recorded OD - phenol content of 0.28 and 0.27 mg/fresh wt in healthy leaves, while corresponding diseased leaves of same genotypes contained more OD- phenol content (0.34 and 0.37 mg/fresh wt.). Results are in accordance with the earlier reporters by Sunkad and Kulkarni (2006) reported that resistant and moderately resistant genotypes recorded more sugars, phenols, ortho-dihydroxy phenol and protein contents than susceptible ones. Reddy and Shireesha (2013) reported that increase in phenol, ortho- dihydroxy phenols in groundnut plants infected with *Sclerotium rolfsii* at different stages of disease development after ten days of infection.

Total sugars : The resistant genotypes viz., K 1811 and JCG-88-2 recorded highest sugars of 1.40 and 1.53 mg/fresh wt respectively in healthy leaves, while corresponding diseased leaves of same genotypes contained more sugars (1.72 and 1.70 mg/fresh wt.). The moderately resistant genotypes Girnar 2 and K 1735 registered sugars content of 1.06 and 1.30 mg/fresh wt in healthy leaves and corresponding diseased leaves of the same genotypes recorded more sugars content (1.30 and 1.65 mg/fresh wt.). The two susceptible genotypes K 1847 and Girnar 3 recorded sugars content 0.74 and 0.69 mg/fresh wt in healthy leaves, while the diseased leaves of same genotypes recorded more sugars content of 1.00 and 0.96 mg/fresh wt., respectively. The highly susceptible genotypes Kadiri 6 and TAG 24 recorded lesser sugars content of 0.53 and 0.51 mg/fresh wt, while corresponding diseased leaves of same genotypes contained more sugars content (0.84 and 0.87 mg/fresh wt.). Total sugar content was increased in the resistant as well as susceptible genotypes after leaf spots and rust infection. Results are in accordance with the earlier reporters Mushrif *et al*. (2017), Bhaskar and Parakhia (2010).

Reducing sugars : The resistant genotypes viz., K 1811 and JCG-88-2 recorded highest reducing sugar of 1.20 and 1.13 mg/fresh wt in healthy leaves respectively, while corresponding diseased leaves of same genotypes contained more reducing sugar (1.42 and 1.28 mg/fresh wt.). The moderately resistant genotypes Girnar 2 and K 1735 registered reducing sugar of 0.97 and 1.00 mg/fresh wt in healthy leaves and corresponding diseased leaves of the same genotypes recorded more reducing sugar (1.08 and 1.16 mg/fresh wt.). The two susceptible genotypes K 1847 and Girnar 3 observed phenol content 0.61 and 0.58 mg/fresh wt in healthy leaves, while the diseased leaves of same genotypes recorded 0.98 and 0.89 mg/fresh wt., respectively. The highly susceptible genotypes Kadiri 6 and TAG 24 recorded reducing sugars of 0.39 and 0.36 mg/fresh wt. in healthy leaves, while corresponding diseased leaves of same genotypes contained more reducing sugar content (0.75 and 0.77 mg/fresh wt.).The reducing sugar contents increased with the progress of infection in resistant and susceptible. Harde *et al.* (2019) reported that the reducing sugar content of the susceptible genotypes was higher than the resistant genotypes at 0 stages but subsequently it was found to significantly lower than the resistant genotypes. Similar results were also reported by Parbat *et al.*(2018 b). Contrasting reports by Rojasara *et al.* (2016).

Total phenol, OD Phenol, total sugars and reducing sugars were the biochemical constituents found more in resistant genotypes and considered as parameter for

disease resistance. Resistance supported good growth of plant which ultimately reflects in contributing yields. This knowledge will help to develop cultivars with better resistance to these above diseases even when the environment favors rapid disease increase. Introduction of resistance in the genotypes through breeding programme can be a tool for management of the disease.

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Morphological Characterization among Qualitative Traits in Groundnut (*Arachis hypogaea* L.)

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Abstract

The present study consisting of 42 genotypes were evaluated at Agricultural College Farm, Bapatla, Guntur (Dt.), Andhra Pradesh, located at an altitude of 5.4 m above MSL, 15^{0}54' N latitude and 80^{0}90' E longitude. The experimental field was a traditional coastal sandy loam soil with p^H 7, assured with an irrigation source around the year. The study was conducted in three consecutive seasons *viz., Kharif* (June 2017), *Rabi* (October 2018), *summer* (Feb 2018). The genotypes were evaluated for 16 morphological traits with the objective of assessing the morphological diversity, to know the importance of these traits as a descriptors. Among the 16 qualitative traits studied, growth habit, stem pigmentation, pod beak, pod constriction, pod reticulation, pod size, kernel size and testa colour have exhibited higher levels of variability.

Key words : *Groundnut, descriptors, characterization, PPVFR.*

Introduction

Groundnut is one of the important *kharif* oilseed crops in India, contributing about 27% of the total area and 33% of the total production of the oilseed crops. It is a rich source of edible oil, high quality protein, fat, carbohydrates and good source of all type of vitamin B except vitamin B12.The genus *Arachis* exhibits a considerable amount of morphological diversity consisting of 30 to 50 species (Gregory *et al.,* 1973). These species differ regard various morphological descriptors like plant habit, stem, leaf, root, fruit and seed characteristics. A sound knowledge of various morphological traits in the breeding material helps classification, identification, naming and documentation of the entries in a crop. This hastens the process of utilization of genetic material in the crop improvement programmes. Wider variation is a prerequisite for the success of any crop improvement programme.

Morphological markers have been used to identify varietal genotype and genetic purity based on the assessment of phenotype characteristics. They have played important role in crop improvement since the beginning of modern breeding programme. Prior to the development of molecular markers, genetic characterization was mainly carried out using morphological characters. This work was therefore undertaken to assess morphological variation in groundnut genotypes collected from various locations.

Materials and Methods

The 42 groundnut genotypes acquired from different places of India were evaluated and characterized for 16 qualitative characters using Standard Descriptors for Groundnut (PPVFR authority). As mandated for groundnut crop all the 42 genotypes were evaluated in three consecutive seasons and the results pooled over three seasons for qualitative and quantitative characters are described here under in detail. The qualitative traits included both binary (present or absent), ordinal (absent, slight, moderate, prominent) parameters. Leaf characters were recorded from third fully opened leaf of main stem to get full expression of the character. Observations were recorded on five random plants selected and tagged in each treatment and replication.

Results and Discussion

The 16 qualitative traits were evaluated using the standard descriptors list prepared by PPVFR authority. The habit group-wise descriptor state of the qualitative traits is presented in Table-1.

Growth habit : The growth habit was spreading, semi-spreading and erect in 4, 30 and 8 genotypes,

Table-1 : Characterization of 42 genotypes of groundnut for 16 Qualitative traits in groundnut pooled over three environments.

S. No.	Characteristics	States	Note	No of genotypes
1.	Plant: Growth habit	Erect	1	8
		Semi-spreading	2	30
		Spreading	3	4
2.	Leaflet Colour	Light green	1	-
		Green	2	4
		Dark green	3	38
3.	Flower : Presence on main axis	Absent	1	18
		Present	9	24
4.	Flower : Arrangement on side branches	Sequential	1	18
		Alternate	2	18
		Irregular	3	6
5.	Stem pigmentation scored at pod filling stage	Absent	0	31
		Present	+	11
6.	Stem: Pubescence as Observed on main stem	Absent	1	-
		Sparse	3	14
		Medium	5	28
7.	Type of Inflorescence	Simple	1	-
		Compound	2	42
8.	Peg pigmentation	Absent	0	-
		Present	+	42
9.	Pod: Presence of Beak	Absent	1	19
		Present	9	23
10.	Pod: Constriction	Absent	1	9
		Shallow	3	13
		Medium	5	17
		Deep	7	3
11.	Pod: Reticulation	Absent	1	-
		Medium	3	23
		Prominent	5	19
12.	Kernel: Colour of testa	White	1	-
		Off white	2	10
		Tan	3	2
		Rose	4	-
		Purple	5	-
		Dark purple	6	-
		Salmon	7	11
		Salmon with white flecks	8	18
		Dark red	9	1
13.	Pod size	Small	1	6
		Medium	2	19
		Large	3	17
14.	Kernel : Shape	Round	1	17
		Fusiform	2	25
15.	Shell thickness	Thin	1	12
		Medium	2	13
		Thick	3	17
16.	Seed size	Small	1	1
		Medium	2	22
		Large	3	19

respectively. Similar studies were done by Rajgopal *et al*. (2004).

Leaflet colour : The leaflet colour ranged from green to dark green. The numbers of accessions with dark green leaflet were 38 while green were 4. Most of the genotypes from Kadiri recorded dark green colour, whereas material from Tirupati showed green colour leaflet. Similar findings were obtained by Mallikarjunaswamy *et al*. (2006) and Gill and Joshi (1980).

Presence of flower on main axis : Main stem does not have reproductive axes and alternate pairs of vegetative and reproductive axes are borne on cotyledonary lateral and other n+1 branch in case of Virginia group. In the Spanish-Valencia group reproductive branches are borne

Plate-1 : Pod beak in Dharani (present) K 2077 (absent)

Plate-2 : Pod constriction in 1813 (deep) and K 2077 (Absent)

Plate-3 : Pod reticulation medium (TAG 24) (Kadiri 9)

Plate-4 : Variation in kernel shape i.e. round prominent (Kadiri 8 bold) and fusiform (K 1813)

Plate-5 : Variability in kernel colour.

Plate-6 : Variation in pod size.

in a continuous series on successive nodes of the cotyledonary and other lateral branches on which the first branch is always reproductive.

Among the 42 genotypes studied, 24 showed presence of flower on the main axis indicating that they are either Spanish bunch or Valencia bunch types and remaining 18 genotypes showed absence of flower on the main axis indicating that they are Virginia types. Similar results were observed by Rajagopal *et al.* (2004), Rajgopal *et al*. (1997) and Bhagat *et al*. (1984).

Flower: arrangement on side branches (Branching pattern) : Branching pattern was defined on the sequence of vegetative and reproductive nodes. Among the genotypes studied, number of genotypes with alternate branching pattern were 18 indicating that they belongs to Virginia group; sequential were 18, irregular were six indicating that the they belong to Valencia and Spanish bunch types. In Valencia group n+1 axes are mostly reproductive and n+2 axes are all or nearly are all reproductive branches, whereas Spanish cultivars produces n+1 and n+2 of both vegetative and reproductive branches. Similar reports were observed by Rajagopal *et al.* (2004), Rajgopal *et al*. (1997) and Bhagat *et al*. (1984).

Stem pigmentation : The pigmentation on the main stem was recorded at pod filling stage as presence or absence of anthocyanin pigment. Number of accessions with pigmentation were 11 and those without pigmentation on main stem were 31. Similar findings were observed by Rajagopal *et al.* (2004), Rajgopal *et al*. (1997) and Bhagat *et al*. (1984).

Stem pubescence : Pubescence observed on main stem ranged from absent to medium among the genotypes studied. Number of genotypes with medium pubescence on stem were 28, while 14 were with sparse pubescence on the main stem. Similar results were observed by Rajagopal *et al.* (2004), Rajgopal *et al*. (1997) and Bhagat *et al*. (1984).

Type of inflorescence : Type of inflorescence was characterized as simple and compound. None of accessions were with simple inflorescence and all the 42 had compound inflorescence.

Peg pigmentation : The peg pigmentation was recorded as present or absence of pigmentation on peg. All the 42 genotypes had presence of peg pigmentation.

Pod beak : The pod beak was recorded as absent or present. Number of accessions without pod beak were 19, while remaining 23 genotypes had presence of beak on the pod (Plate-1).

Pod constriction : Pod constriction was characterized as no constriction to deep constriction. Number of accessions with no constriction were 9; shallow constriction were 13; medium constriction were 17 and three genotypes with deep constriction (Plate No:2). Similar reports were observed by Rajagopal *et al.* (2004), Rajgopal *et al*. (1997) and Bhagat *et al*. (1984).

Pod reticulation : Reticulation on the pod was characterized as none to prominent type. Number of accessions with medium reticulation were 23 and prominent reticulation was recorded in 19 genotypes and not even a single genotype showed absence of reticulation on the pods (Plate No: 3). Similar results were observed by Rajgopal *et al*. (1997) and Bhagat *et al*. (1984).

Kernel colour/Testa colour : Testa colour was characterized one month after the harvest. It ranged from white to dark red in colour. The number of accessions with off white were 10; tan 2; salmon 11; salmon with white flecks 18 and one genotype with dark red colour (Plate-5).

Color of the seed coat or testa is also an important market trait whose intensity may vary depending on maturity, environment, genotype or the interaction between genotype and environment (Rao and Murty 1994). The groundnut collection offered a wide diversity of seed coat colors with desirable agronomic traits for commercial usage and breeding studies. Pink, red, tan and shades of these colors are generally selected for snack food and confectionary industries and many high yield genotypes had these seed coat colors in the collection. Transferring seed coat color by hybridization is possible in groundnut (Branch 2011) and therefore, the genotypes with desirable seed coat color but higher yield should be used as parent in breeding studies. Similar reports by Bhagat and Lalwani (1981).

Pod size : Pod size was characterized as small, medium and large. The number of accessions having the small size pods were 6, medium size 19 and large size 17 (Plate-6).

Seed/kernel shape : The seed shape was characterized as round and fusiform. The number of accessions with round shape were 17 and fusiform shape 25 (Plate-4).

Shell thickness : The thickness of shell was characterized as thin, medium and thick. The number of genotypes with thin, moderate and thick shells were 12, 13 and 17, respectively.

Seed size : The seed size was characterized as small, medium and large based on 100 kernel weight. The number of accessions with small seed size was 1(100 kernel weight <36g), medium seed size were 22 (36-50g) and large seed size were 19 (>51g).

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Study on Inheritance Pattern of Plant Growth Habit, Flower Type and Flower Colour in F_1 Hybrids of China Aster (*Callistephus chinensis* (L.) Nees)

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Abstract

The inheritance pattern of plant growth habit, flower type and flower colour in F_1 hybrids of China aster was estimated from twenty seven F_1 hybrids, which were developed by involving nine lines and three testers in line × tester mating design during the year 2021-23 at Floriculture unit, Department of Horticulture, University of Agricultural Sciences, GKVK, Bengaluru. The twenty seven F_1 hybrids along with parents and standard check (Arka Kamini) were evaluated in RCBD design with two replications for inheritance of plant growth habit, flower type and flower colour. The results revealed that Powder puff flower type was dominant over semi-double type. For plant habit types, spreading type found dominant over semi-erect and erect types. Erect type was recessive among all the plant habit types studied. Inheritance of flower colour leads to a conclusion that; purple colour was dominant over all the other flower colours.

Key words : *inheritance, dominant, china aster, powder puff.*

Introduction

Flowers are associated with our civilization since time immemorial. Floriculture is one of the most promising components of the horticulture industry, being important from aesthetic, social and economic points of view. It has potential for generating employment opportunities around the year and earning foreign exchange. Due to undeviating upsurgement for the demand of flowers leads to floriculture has become one of the key commercial trades of horticulture. Modifying lifestyle, corporate culture and urbanization have preceded to advancement in the floriculture industry. Among the traditional flower crops grown for loose and cut flowers, china aster is currently popular among the small and marginal farmers of India because of it's ease in cultivation (Singh, 2006).

China aster (*Callistephus chinensis* Nees.), is an important commercial flower crop of family Asteraceae. It is diploid with chromosome number 2n=18 and is originated in China. The genus *Callistephus* is derived from two Greek words *Kalistos* and *Stephus* referes to 'most beautiful' and 'a crown' (flower head) respectively. It was first named by Linnaeus as *Aster chinensis* and later Nees changed this name to *Callistephus chinensis* (Janakiram, 2006). During 18th century, it was introduced to Europe and other tropical countries (Bailey, 1963).

The ornamental plant market is highly dynamic and always demands constant novelties. The existing commercial cultivars in India have semi-double flowers with prominent disks and short flower stalks with less vase life. Hence, development of china aster for both cut and loose flowers needs improvement in growth, yield and quality attributes such as plant height, number of branches, flower yield, flower color, flower stalk length, shape, flower size and increased vase life. The crosses need to be compared with a commercial check cultivar rather than merely comparing with their mid or better parent. Understanding the transfer of traits will help in the development of F_1 hybrids with different colours such as white, pink, violet, red, scarlet, *etc*. and different forms like single, semi-double, pompon, powder puff *etc*. Moreover, F_1 hybrids can be developed for cut flower production with long and sturdy stalk with contrasting bigger size flower heads, extended blooming period, higher vase life and high flower yield.

A study on Mendelian genetics in flower colour has been studied by Wit (1937), Beale (1941) and Forkmann (1977). Flower colour in China aster is determined by accumulation of chalcones (yellow), flavones and flavonols (cream) and anthocyanins (red to blue). Enzymatic studies revealed that genes Ch, F, R and M control the activities of the enzymes chalcone isomerase (CHI), dihydroflavonol 4-reductase (DFR), flavonoid 3',5'-hydroxylase (F3'5'H) and anthocyanin 5-glucosyltransferase (A5GT), respectively. Flower doubleness (DD) was observed to be monogenically dominant over singleness (dd).

Materials and Methods

The present experiment, Study on inheritance pattern of plant growth habit, flower type and flower colour in F_1 hybrids of China aster (*Callistephus chinensis* (L.) Nees)"

Table-1 : Plant growth habit, flower colour and flower form in parents of china aster.

Parents	Plant growth habit	Flower colour	Flower form
AAC-1	Spreading	Vivid purplish pink-B 66	Semi-double
Arka Kamini	Erect	Strong purplish red-A 67	Semi-double
Arka Poornima	Erect	White-C 155	Powder puff
Arka Archana	Semi-erect	White-D155	Semi-double
Phule Ganesh White	Semi-erect	White-C 155	Semi-double
Phule Ganesh Pink	Spreading	Red-Purple group N74B	Semi-double
Phule Ganesh Purple	Spreading	Dark purple-A 79	Semi-double
Miraj Local	Erect	Vivid purplish red-A 67	Semi-double
Local Pink	Semi-erect	Red-Purple group 63 A	Semi-double
Local White	Semi-erect	White-D155	Semi-double
Namdhari Pink	Semi-erect	Vivid purplish pink-C 66	Semi-double
Namdhari White	Semi-erect	white-D 155	Semi-double

Table-2 : Plant growth habit, flower colour and flower form in F_1 hybrids of china aster.

Parents	Plant growth habit	Flower colour	Flower form
Arka Poornima × AAC-1	Spreading	Moderate purplish pink group-A65	Powder puff
Arka Poornima × Arka Kamini	Semi-erect	Vivid purplish red group-B 67	Partial Powder puff
Arka Poornima × Phule Ganesh Purple	Erect	Dark purple group-A 79	Partial Powder puff
Arka Archana × AAC-1	Spreading	Phlox pink group-625/2	Semi-double
Arka Archana × Arka Kamini	Semi-erect	Fuchsine pink group-627/1	Semi-double
Arka Archana × Phule Ganesh Purple	Spreading	Dark purple group - A 79	Semi-double
Phule Ganesh White × AAC-1	Spreading	Magenta group 27/3	Semi-double
Phule Ganesh White × Arka Kamini	Semi-erect	Vivid purplish red group-B 67	Semi-double
Phule Ganesh White × Phule Ganesh Purple	Spreading	Dark purple group-A 79	Semi-double
Phule Ganesh Pink × AAC-1	Spreading	Vivid purplish pink group-B 66	Semi-double
Phule Ganesh Pink × Arka Kamini	Semi-erect	Strong purplish red group-A 67	Semi-double
Phule Ganesh Pink × Phule Ganesh Purple	Spreading	Violet blue group-42	Semi-double
Miraj Local × AAC-1	Spreading	Vivid purplish pink group-A 66	Semi-double
Miraj Local × Arka Kamini	Erect	Crimson group-824/3	Semi-double
Miraj Local × Phule Ganesh Purple	Spreading	Violet blue group-42/1	Semi-double
Local Pink × AAC-1	Spreading	Vivid purplish pink group-B 66	Semi-double
Local Pink × Arka Kamini	Semi-erect	Strong purplish red group-A 67	Semi-double
Local Pink × Phule Ganesh Purple	Spreading	Spectrum violet group-38	Semi-double
Local White × AAC-1	Spreading	Roseline purple group-629/3	Semi-double
Local White × Arka Kamini	Semi-erect	Strong purplish red group-A 67	Semi-double
Local White × Phule Ganesh Purple	Semi-erect	Dark purple group-A 79	Semi-double
Namdhari Pink × AAC-1	Spreading	Vivid purplish pink group-B 66	Semi-double
Namdhari Pink × Arka Kamini	Semi-erect	Deep purplish pink group-D 66	Semi-double
Namdhari Pink × Phule Ganesh Purple	Spreading	Mauve group-B 65	Semi-double
Namdhari White × AAC-1	Spreading	Roseline purple group 629/2	Semi-double
Namdhari White × Arka Kamini	Semi-erect	Strong purplish red group - A 67	Semi-double
Namdhari White × Phule Ganesh Purple	Spreading	Dark purple group - A 79	Semi-double

was carried out in Floriculture unit, Department of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra, Bengaluru, during 2021-23. Twenty seven F1 hybrids were developed by using nine lines (Arka Poornima, Arka Archana, Phule Ganesh White, Phule Ganesh Pink, Miraj Local, Local Pink, Local White, Namdhari Pink and Namdhari White) and three testers (AAC-1, Arka Kamini and Phule Ganesh Purple) by adopting the line x tester mating design. Arka Kamini was used as standard check. The parents, F_1 hybrids and standard check were planted in randomized complete block design (RCBD) with two replications at a spacing of

30 cm × 30 cm. Uniform cultural practices were followed for proper growth and development and five plants were tagged to record the observations on inheritance of flower colur, flower type and plant growth habit.

Results and Discussion

Plant growth habit, flower colour and flower form in parents and F_1 hybrids was presented in the table-1 and 2.

Plant growth habit : Parents selected for the experiment had all three types of plant growth habits namely, erect, semi-erect and spreading types. AAC-1, Phule Ganesh Pink and Phule Ganesh Purple had spreading type of growth habit. Arka Kamini, Arka Poornima and Miraj Local had erect type of growth habit. Arka Archana, Phule Ganesh White, Local Pink, Local White, Namdhari Pink and Namdhari White had semi erect type of growth habit.

Crosses with AAC-1 and Phule Ganesh Purple as tester had recorded spreading type of plant growth habit. The crosses Arka Poornima **×** Arka Kamini, Phule Ganesh White **×** Arka Kamini, Phule Ganesh Pink **×** Arka Kamini, Local Pink **×** Arka Kamini, Local White **×** Phule Ganesh Purple, Namdhari Pink **×** Arka Kamini and Namdhari White **×** Arka Kamini recorded semi- erect type of plant growth habit. Whereas, Arka Archana **×** Arka Kamini, Miraj Local **×** Arka Kamini and Local White **×** Arka Kamini erect type of plant growth habit. Hence, spreading type was dominant over both semi-erect and erect types. Erect type found recessive among all the plant habit types studied. Similar results were recorded by Pratiksha (2018) in china aster.

Flower colour : Royal Horticulture Society color chart was used to identify the flower color. All the parents which had AAC-1 as tester developed pink shade coloured flowers, Arka Kamini as tester developed dark pink shade coloured flowers and Phule Ganesh Purple as tester developed dark purple shade coloured flowers. Purple color was dominant over all the other flower colours. Purple color was dominant followed by pink and white. White color was recessive to all the other flower colours studied. Similar results were recorded by Pratiksha (2018) in china aster and Shwetha *et al.* (2022) in chrysanthemum.

Flower form : Powder puff type was dominant over semi-double type. The F_1 flowers of Arka Poornima × AAC-1 were of powder puff types and Arka Poornima × Arka Kamini and Arka Poornima × Phule Ganesh Purple were of partial powder puff types and rest of the crosses had semi-double type flowers. Similar results were recorded by Anjali *et al.* (2015) and Nataraj (2020) in china aster.

Conclusions

All the crosses had semi-double type flowers except Arka Poornima x AAC-1 (Partial powder puff type), Arka Poornima x Arka Kamini (Partial powder puff type) and Arka Poornima x Phule Ganesh Purple (Partial powder puff type). Powder puff flower type was dominant over semi-double type. For plant habit types, spreading type found dominant over semi-erect and erect types. Erect type was recessive among all the plant habit types studied. Inheritance of flower colour leads to a conclusion that; purple colour was dominant over all the other flower colours. Purple colour was dominant followed by pink and white. White colour was recessive to all the other flower colours studied under this aspect.

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Effect of Biotic Factors on Population of Mustard Aphid *Lipaphis erysimi* Kalt

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Abstract

Rapeseed (*Brassica compestris)* and Mustard (*Brassica juncea*) is the most important rabi oilseed crops in india. Mustard aphid is the major insect–pest of rapeseed mustard. It causes 66% to 99% loss in *B. compestris* L. and 27-28% in *B. juncea* L. with losses in oil content of 15%. In mustard the incidence and spread of aphid is largely influenced by weather condition such as temperature, humidity, rainfall, sunshine etc. similarly other severe pest such as mustard sawfly and beetle also attack the rapeseed mustard crops at the seeding stage in severe losses to the germinating crops.

Key Words *: B. juncea, B. compestris, temperature, humidity, rainfall, germinating.*

Introduction

These crops are grown under a wide range of agro-climatic conditions. Indian mustard is the most important member of the group, accounting for more than 70% of the area under rapeseed-mustard, followed by toria, yellow sarson and brown sarson. Taramira is raised on very poor sandy soils with low rainfall. Mustard and sarson group of plants, however, are grown both on sandy and heavy soils under irrigated as well as rainfed conditions. These crops are commonly cultivated in areas of marginal and submarginal productivity, either mixed or intercropped with wheat, barley, gram, pea, sugarcane, lentil etc. In areas of advanced agronomy they are chiefly grown as pure crop. The oil content varies from 37 to 49%. The seed and oil are used as condiment in the preparation of pickles and for flavouring curries and vegetables. The oil is utilized for human consumption throughout the northern India, in cooking and frying purposes. It is also used in the preparation of hair oils and medicines. It is used in the manufacture of greases. The oil cake is used as feed and manure. Green stem and leaves are a good source of green fodder for cattle. The oil cakes contain 'sinirgin', that causes palatability problem due to its bitter taste, and glucosinolate that limits use of oil cake as protein supplement. The leaves of young plants are used as green vegetables as they supply sulphur and minerals in the diet. In the tanning industry, mustard oils used for softening leather. It is an herbaceous annual plant. The plant is shorter in height (45-150 cm) than mustard (rai). The roots are more or less confined to surface layers with an extensive lateral spread. The stem is usually covered with a waxy deposit. In rape, leaves are borne sessile and are glabrous and hairy. Fruits are thicker than those of mustard (rai) and are laterally compressed, with a beak one-third to half their length. Seeds are either yellow or brown with a smooth seed coat. Rape is self-pollinated, but cross pollination also takes place to some extent. It is known as rai, raya or laha. The plants are tall (90-200 cm), erect and more branched. The plant bears normally long and tapering roots. The leaves are not dilated at the base and clasping as in the case of rape, but are stalked, broad and pinnatified. The fruits (pods) are selender and only 2.0-6.5 cm long strongly ascending or erect with short and stout beaks. The colour of seed is brown or dark brown. Seed coat is rough. Mustard is self-pollinated, but cross-pollination also takes place to some extent. Flowers of both the species have 4 sepals and 4 petals of deep yellow to pale yellow colour. Each flower has 6 stamens; 4 with long and 2 with short filaments. The pistil is compound, which is separated by a false septum, thus providing 2 chambers.

Rapeseed and mustard seed is a rich source of oil and protein which is 46% to 48% and 43.6% respectively in whole seeds meal (Frank, 1990) and their green leaves both are used for human food and animal fodder (Huxley and Levy, 1992). The leaves of young mustard plants are used as green vegetables as they contain suphur and minerals in the diet. The biocontrol agents like Coccinellids and other have been reported to be effective for controlling the aphids, *L. erysimi* (Singh *et al.,* 2009).

Materials and Methods

The experiments were conducted to study the Influence of a biotic factor on aphid population under mustard ecosystem. The varuna variety was selected for present study. It is high yielding and moderately susceptible to mustard aphids. It matures in 120-125 days. It is bold seeded fertilizer responsive variety. Plants are tall and semi spreading type. Seeds are bold brownish – black

with an average oil content of 42.0 per cent. The plant is moderately branched with good number of pods and petiolated smooth leaves. The yield under ideal condition is 15-20 q/ha. It is widely grown in U.P, Gujarat, Bihar and W.B.

Among the various insect-pest associated with mustard crop mustard aphid is the most important insect pest. The insect possesses serious threat to successful cultivation of this very important oil seed crop. Its infestation on the physiological maturity of the crop. Both nymph and adults suck the sap from leaves, flower, pods and tender shoots. It is mostly confined to the apical parts of the plants. This insect also has parthenogenesis mode of reproduction. So it attains very high population in very short period under favorable weather condition. Severely infested plants either dry or unprotected crop fail to produce any seed under severe infestation condition.

Bioagents including syrphid flies *S. confrater*, *S. balteatus* and *L. scutellaris*, lady bird beetle, *C. septempunctata*, *C. transversalis* and *daeretiella rapae* are the important entomophagous predators and parasitoid, respectively upon many species of aphids and observed as an efficient and mightiest predator of *L. erysimi* in field condition. The bio- control agents like coccinellids and other have been reported to be effective for controlling the aphids, *L. erysimi* singh *et.al.,* 2009. This beetle occupies quite a remarkable place among the naturally occurring biocontrol agents of mustard aphid mathur, 1983. Both adult and larvae are known primarily as predators of aphids, but they also prey upon many other pests such as soft scale, mealy bug, spider mites and eggs of the calorado potato beetle as well as European corn borer, while a few feeds on plant and pollen mildews. These predatory beetles can be used in biological control of insects pest. For most agricultural system, the augmentative releases and conservation techniques for lady bird beetles are greatly emphasized to maximize their uses in biological control.

To record the aphid population, 5 plants were randomly selected and tagged in each plot. The aphid population was recorded at 3 days intervals starting with their first appearance till harvesting of the crop. The aphid population was recorded from top 10 cm. of terminal shoot. thus the data obtained on average number of aphid per plant have been subjected to log transformation, log (x+1) singh and rai (1994) for the sake of statistical analysis and correlated to study the combined influenced of various weather parameters on aphid population recorded on that particular day of observation.

Results and Discussion

Bioagent populations were observed to be active in mustard ecosystem in this region. The occurrence of bioagent population was observed during third week of January when the mean aphid population was varying between 8.47 to 16.70 aphid / 10 cm terminal shoot. During 3rd week of January the mean of bioagent population was observed to be 0.02 per plant. The maximum and minimum temperatures on this day of observation were 23.61^{0}c and 8.05^{0}c and the maximum and minimum relative humidity were 94 per cent and 78 per cent respectively. On successive days of observation at an interval of 7 days the bioagent population gradually increased till 7th week reaching to a peak of mean population of 1.72 per plant.

It was derived significant that increase in temperature and decrease in relative humidity have no impact of bioagent population, but have great influence on aphid population. It appears that bioagent population is mainly host dependent and with the increased at host population, the bioagent population also increased initially, but the increased bioagent population predated up on the host population causing reduction in host aphid population. This reduction in aphid population besides increase in bioagent population was also coupled with unfavorable a biotic factors like increased in temperature, decrease in relative humidity, rainfall etc.

The presence of bioagent population on aphid showed a negative correlation but again the values were observed to be statistically non- significant. However, the influence of abiotic factors on bioagent population when considered, a significant negative correlation was observed with relative humidity. Although temperature showed a positive correlation with bioagent population but values were statistically non- significant.

A survey was conducted to observe the incidence and abundance of bioagent of *L. erysimi* in mustard niche. The various bioagent associated with the insect pest, the coccinellids, syrphid fly, Diaeretiella rapae were the only bioagent population recorded to be predating on L. erysimi during the period of observation. On the basis of survey conducted, were observed found tobe very active in mustard ecosystem in this region and the initial population of bioagent was observed during last week of January when the mean aphid population was varying between 16.70 and 22.00 aphid/10 cm terminal shoot. During the period when the aphid population reached its peak recording 42.42 aphid/10 cm terminal shoot, the bioagent population was recorded to be 1.72/ plant. Thereafter, with the decrease in bioagent population reaching to a maximum of 1.25/plant during third week of February, the aphid population gradually decreased reaching to as low as 9.71 aphid/10 cm terminal shoot. However, the impact on decrease of aphid population

Table-1 : Average of Aphid population Bioagent population and different abiotic factors during experimental period (January-March 2018) under mustard ecosystem.

Standard Week	Aphid pop. Per 10 cm terminal shoot	Bioagent population per plant	Temperature (°C)			Humidity (°C)			Rainfall (mm)
			Max.	Min.	Range	Max.	Min.	Range	
1st	0.00	0.00	16.41	8.15	8.26	94.33	73.21	21.12	0
2nd	3.25	0.00	20.45	7.42	13.03	98.00	81.01	16.99	0
3rd	8.47	0.02	23.61	8.05	15.56	94.00	78.00	16.00	0
4th	16.70	0.14	24.64	9.18	15.46	93.85	62.25	31.60	0
5th	22.00	0.50	25.82	10.38	15.44	83.71	50.15	33.56	0
6th	27.53	1.12	26.57	12.00	14.57	72.85	43.00	29.85	0
7th	42.42	1.72	25.98	13.35	12.63	80.71	51.00	29.71	0
8th	9.71	1.25	30.32	14.05	16.27	84.14	44.22	39.92	0
9th	4.20	0.98	32.01	17.44	14.57	73.71	41.26	32.45	0
10th	4.09	0.22	32.75	16.14	16.61	61.57	38.00	23.57	0
11th	0.14	0.08	35.12	17.98	17.14	57.28	36.00	21.28	0
12th	0.00	0.02	35.71	17.42	18.29	51.71	36.25	15.46	0
13th	0.00	0.00	37.77	18.57	19.20	47.14	33.70	13.44	0

Average of 5 plants and three replication in both the cases i.e aphid and Bioagents.

could be due to both abiotic as well as biotic factor. The existing abiotic factors also had a considerable impact on bioagent population. The correlation anylysis revealed that temperature had a positive correlation with bioagent populations, whereas a significant negative correlation was observed with relative humidity. It is thus indicated that bioagent population was appeared with advent of aphid appearance and abundance, making it host density dependent and also with the three major abiotic factors. Kulkarni, A.V. patel, I.S. (2001). Conducted a field survey on the seasonal incidence of the mustard aphid, *L. erysimi*, and its associated biological control agentaphid parasitoidin Indian mustard crops were conducted in Gujarat. Ghosh and chaudhari (2015) reported that the present study was undertaken to find out the suitable variety against insect pests attack as well as incidence of natural enemies and their effect on yield on three group of brassica varieties in tarai agro-ecological condition of west Bengal, among the different insects the important ones were aphid, fleabeetle, diamond back moth and saw fly. Natural enemies include ladybird beetle, syrphid fly and spider.

Discussion on the experimental finding finally revealed that temperature and relative humidity play the significant role in growth and development of aphid population as well as predatory coccinellid population. The correlation of temperature and relative humidity with occurrence and abundance of aphid population was negative and positive, respectively and interestingly the correlation was just opposite with occurrence and abundance of bioagent population. However the abundance of bioagent population was reflected mostly due to abundance of its host population i. e., in the mustard aphid the recession of mustard aphid after last week of February could be due to increasing temperature increase in bioagent population as well as maturity of the crop advancing nearer to harvest. A combined effect of all these factors also could not be avoided in understanding the seasonal incidence and abundance of aphid in mustard ecosystem.

Conclusions

Rapeseed and mustard is most important rabi oilseed crop in india. Mustard aphid is the major insect pest of rapeseed mustard. It causes 66% to 99% loss in *B. campestris* L. and 27- 28% in *B. juncea* L. with losses in oil content of 15%. In mustard the incidence and spread of aphid is largely influenced by weather condition such as temperature, humidity, rainfall, sunshine etc. similarly other severe pest such as mustard sawfly and beetle also attack the rapeseed mustard crop at the seedling stage resulting in severe losses to the germinating crops. The bioagent population leads in decline of aphid population. In such condition growth and multiplication of bioagent normally experienced during the third and fourth week of February in this region. After third week of February temperature was raised regularly and relative humidity was further decrease. The aphid population was also decreased due to the bioagent population. Therefore, from the finding of present experiments it could be concluded that aphid population on mustard is greatly influenced by both abiotic and biotic factors. Further it is also very clear that no application of insecticides is necessary after second week of February as biotic do not favour the growth and multiplication of the aphids on mustard.

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Sustainable Production Interventions in Maize under Changing Climate

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Abstract

Major maize area falls under kharif season and crop may frequently expose to moisture stress which is increasing in intensity and frequency under changing climate specially during rainy season affecting maize production especially in the sub tropical climatic conditions. Therefore, a study was carried out to derive possible production interventions for sustainable maize production under changing climate particularly moisture stress by maintaining water stress condition through withholding of irrigation between 20-40, 40-60, 60-80 and 80-100 DAS. And suitability of staggered sowing at monthly interval (viz., June, July and August) and heat tolerant genotypes (viz., RCRMH 2, RCRMH 3 and RCRMH 4) were examined under moisture stress in Tunga Bhadra Project irrigation command. Results revealed that among sowing dates July sown crop performed better with significantly higher yield (5610 kg ha^{-1}) as it was free from moisture stress because of intermittent rains, whereas June sown crop though experienced stress between 40-60 DAS on par with July, but August sown crop during 80-100DAS shown significantly lesser grain yield. Among genotypes superior performance of RCRMH 3 (5511 kg ha^{-1}) was noticed over RCRMH-4, and found on par with RCRMH 2 (5300 kg ha^{-1}). All the moisture stress treatments were found on par with each other with the use of heat tolerant genotypes indicating their ability to sustain the moisture stress.

Key Words : *Staggered sowing, heat tolerant genotypes, moisture stress, maize grain yield.*

Introduction

Maize is the leading crop worldwide and is pivotal to current as well as future global food security (1) and more so in most of the developing countries including India. Its importance lies in the fact that it is used for human food and animal feed besides its use as a basic raw material as an ingredient to thousands of industrial products that include starch, glucose, oil, protein, alcoholic beverages, food sweeteners etc. in food, pharmaceutical, cosmetic, textile, gum, package and paper industries. The crop is cultivated widely throughout the world and has the highest production among all the cereals. It is being considered as one of the fastest growing cash crops in the world and has become the largest component of global coarse-grain trade. Maize is a preferred staple food for over 900 million poor, 120-140 million poor farm families and about one-third of all malnourished children globally. The changing global food demands and consumer preferences have made maize to become a wonder crop for many countries especially developing countries like India.

In India, maize is the third most important food crop after rice and wheat. Among the maize growing countries, India ranks 4th in area and 7th in production, representing around 4% of world maize area and 2% of total production. In 2018-19, the country's maize area reached to 9.2 million ha (2). Fifteen million farmers in India are engaged in maize cultivation (3).

The global demand for maize is estimated to increase with most of the increased demand coming from developing countries. By 2050, the demand for maize in developing world will be double. But, only 15% of cultivated area of maize is under irrigation and water shortage has been a challenge for sustainability in production. Therefore, there is dire need for increased efforts for maize production in the prevailing changing climatic conditions (particularly relating to water stress, salinity and extreme temperature) as Global food production is facing serious challenges from changing climate (4) through increasing temperatures, changing precipitation patterns and greater frequency of some extreme events.

Under these conditions of climate change to ensure adequate future supply we must, therefore, adopt techniques, or accordingly develop suitable production practices to overcome the adverse effect of elevated climatic conditions and improve the productivity. Adaptation to climate change may involve the use of crop varieties that are endowed with tolerance to higher temperatures and drought, and resistance to emerging

pests and diseases, and adjusting the date of sowing to cope with changing climate.

Hence, keeping these points in view, to derive some of the possible interventions for sustainable maize production under changing climate specially to moisture stress/drought, the present study was under taken including three staggered sowing of maize to expose the crop to natural stress which may encounter during kharif season of the region, and under which three heat tolerant genotypes were used to know their ability to withstand drought occurring in the season.

Materials and Methods

A field experiment was conducted during *kharif 20*19 at Agricultural Research Station, Dhadesugur, University of Agricultural Sciences, Raichur, Karnataka, India, situated between 15° 46' N latitude and 76° 45' E longitude with an altitude of 358 meters above the mean sea level. Initial soil sample was taken and analyzed for physico-chemical properties and the soil of the experimental site was clay soil with near neutral reaction pH (7.53), normal in soluble salts (EC 0.86), low organic carbon (0.47 % OC), medium available nitrogen (282 kg ha^{-1} of) and medium phosphorus (47 kg ha^{-1}) and high potassium (356 kg ha^{-1}). The experiment was laid out in split split plot design with three replications, in which main plots with three dates of sowing at monthly interval viz.,D_1- June, D_2-July and D_3-August, sub plots with four moisture stress treatments at twenty days interval from 20 DAS to 100 DAS viz., S_1-with holding of irrigation at 20-40 DAS, S_2-with holding of irrigation at 40-60 DAS, S_3-with holding of irrigation at 60-80 DAS and S_4-with holding of irrigation at 80-100 DAS). Though the four moisture stress treatments were planned, only S_2 of June month and S_1 of August month were successful because of intermittent rainfall occurred as the experimentation was planned during *kharif* season. To avoid effect of horizontal water movement two meters buffer zone was maintained between main plots and between replication. Whereas, sub sub plot treatments comprised of three stress tolerant genotypes viz., RCRMH 2, RCRMH 3 and RCRMH 4. These genotypes were heat stress tolerant single cross maize hybrids developed and recommended for zone-2 of Karnataka state by University of Agricultural Sciences, Raichur, Karnataka in collaboration with CIMMYT-Asia, Hyderabad under 'Heat Stress Tolerant Maize for South Asia through public private partnership' (HTMA) project funded by USAID.

The crop was sown on 18thJune, 20th July, and 16th August of 2019 respectively, and all the recommended package of practices for the maize production to the region was followed. Moisture stress was imposed by withholding irrigation as per the sub plot treatments. Data were subjected to statistical analysis as described by Gomez and Gomez (1984). Means were compared using Duncan's Multiple Range Test.

Results and Discussion

Production interventions in maize in the form of sowing time, exposure to moisture stress and genotypes and their interactions revealed varied grain yield (kg ha^{-1}). Main effects due to time of sowing and genotypes were significant while those due to stage of stress of 20 days were not significant, and the factor combinations revealed significant variations. Among the different dates of sowing, significantly higher kernel yield occurred with early (D_1 -June) to mid (D_2 - July) season sowing, both were on par and better harvest of the two was observed with the latter (5610 kg ha^{-1}), while end (August) season sowing (D_3) recorded lower kernel yield (4768 kg ha^{-1}). Among the genotypes, cv. RCRMH 3 (G_2) recorded significantly higher kernel yield (5511 kg ha^{-1}) and was comparable to RCRMH 2 (G_2- 5300 kg ha^{-1}) and was significantly superior to RCRMH 4 (G_3 - 5119 kg ha^{-1}) which produced almost 400 kg lesser yield. The impact of stress (S_1 to S_4) imposed at different growth stages did not reveal significant variations, though the trend revealed lesser effect of stress in the early stages particularly at knee height stages with relatively greater reductions with stress during reproductive and ripening stages and more so with the latter. This trend is on the expected line as heat tolerant cultivars used which probably fared better under stress though temperatures were generally inhibitive to growth and development of maize. Kernel yield due to different treatment (three factor) combinations revealed significant differences and in that cv. RCRMH 3 sown during July with stress during vegetative stage ($D_2G_2S_2$) recorded the highest kernel yield (5770 kg ha^{-1}) closely followed by same cultivar sown early in the season again with stress during vegetative stage ($D_1G_2S_2$ - 5754 kg ha^{-1} on pooled basis), both treatments were on par and were significantly superior to the low yielding treatment combination involving cv. RCRMH 4 sown late during August (end part of rainy season) experiencing stress during ripening stage ($D_3G_3S_4$ – 4613 kg ha^{-1}) with 20.05% lesser yield than the former combination, while other combinations fell in between and were on par. Muneeb *et al.* also observed differential performance of stress tolerant cultivars.

The present study revealed significant interaction of cultivars and dates of planting. Though, in general the yield decreased with delay in sowing cv. RCRMH 3 performed better with regard to growth during early (June) and mid (July) sowings followed by RCRMH 2. In Nepal, observed better performance of cultivars with earlier sowing due to higher kernel row^{-1}, kernel rows ear^{-1} and 1000-kernel weight was recorded (7) as observed in the

Table-1 : Grain yield (kg ha^{-1}) of maize as influenced by response of maize genotypes to sowing time and stages of stress during rainy season.

D x S x G		Grain yield (Kg ha^{-1})			
		D_1	D_2	D_3	S x G
S_1	G_1	5451^{ab}	5607^{ab}	4963^{ab}	5340^{a}
	G_2	5558^{ab}	5754^{a}	5359^{ab}	5557^{a}
	G_3	5315^{ab}	5390^{ab}	4780^{ab}	5161^{a}
S_2	G_1	5027^{ab}	5678^{a}	5013^{ab}	5240^{a}
	G_2	5321^{ab}	5770^{a}	5264^{ab}	5452^{a}
	G_3	4826^{ab}	5523^{ab}	4880^{ab}	5076^{a}
S_3	G_1	5559^{ab}	5723^{a}	4869^{ab}	5384^{a}
	G_2	5707^{a}	5751^{a}	5326^{ab}	5594^{a}
	G_3	5220^{ab}	5404^{ab}	4786^{ab}	5137^{a}
S_4	G_1	5399^{ab}	5579^{ab}	4736^{ab}	5238^{a}
	G_2	5670^{a}	5626^{ab}	5026^{ab}	5440^{a}
	G_3	5172^{ab}	5516^{ab}	4613^{b}	5100^{a}
DoS		5352^{a}	5610^{a}	4968^{b}	
			D X S		S
S	S_1	5441 ^{ac}	5584^{ab}	5034 ^{b}	5353 ^{a}
	S_2	5058^{bd}	5657^{a}	5053^{bd}	5256 ^{a}
	S_3	5495^{ac}	5626^{a}	4993^{cd}	5372 ^{a}
	S_4	5414^{ac}	5574^{ab}	4791^{d}	5260 ^{a}
			D X G		G
G	G_1	5359^{ac}	5647^{ab}	4895de	5300^{ab}
	G_2	5564^{ac}	5725^{a}	5244^{bd}	5511^{a}
	G_3	5133^{ce}	5458^{ac}	4765^{e}	5119^{b}
Check Outside (No stress)		5450	5680	4970	

Comparison	**S.Em±**
DoS (D)	87
Stress (S)	100
Genotype G	86
D x S	173
D x G	149
S x G	172
D x S x G	298

Check Outside (No stress)	S.Em±	C.D. (p=0.05)
	165.8	467.0

D_1 : June	S_1 : Water stress at 20-40DAS	G_1 : RCRMH 2
D_2 : July	S_2 : Water stress at 40-60DAS	G_2 : RCRMH 3
D_3 : Aug	S_3 : Water stress at 60-80DAS	G_3 : RCRMH 4
	S_4 : Water stress at 80-100DAS	Check : RCRMH 2

Note : The values between the same set of classes for each treatment followed by the same letter are not significantly different.

present study. At Dharwad in 2018, higher kernel yield with sowing during II FN of June (among I & II of June and I FN of July) was recorded(8) , while in the present study sowing from June middle (D_1) to July middle (D_2) yielded higher and comparable kernel yields, latter being superior. Probably, this betterment with advancement in sowing could be ascribed to changing climate. Under future climate change scenarios later planting dates produced higher yields (9) . In Northeast China reported that the optimum sowing date was comprehensively determined by comparing the rainfed yield simulated by using the CERES-Maize model with different sowing dates. The optimal sowing dates for spring maize were 30 days later than normal sowing dates during the 2030s, 2050s, and 2070s (10).

Conclusions

Heat tolerant genotypes bred for relatively higher temperature situations were also found suitable under changing climate for cultivation during rainy season in the north eastern dry zone of the state receiving irrigation from TBP and UKP irrigation commands. Cultivars RCRMH 3 and RCRMH 2 fared better during rainy season over RCRMH 4, and hence can be recommended to farmers in the north eastern dry zone. Stress during rainy season though common and frequent, the present investigation found no significant influence of stage of stress on heat tolerant maize cultivars (cvs. RCRMH 2, RCRMH 3 and RCRMH 4), and hence under such a situation use of stress tolerant genotypes is useful.

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Finger Millet Processing, Value Addition and Health Benefits : A Review

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Abstract

Finger millet (*Eleusine coracana*) is one of the important small millets with high nutraceutical value in the world.It has excellent nutritional value as it contains 6% to 8% protein, 1% to 1.7% fat, 65% to 75% starch, 2% to 2.25% minerals and 18% to 20% dietary fiber and it provides highest level of 344 mg/100mg of calcium and 0.3 to 3% of phenolic compounds. Among small millet's, finger millet occupies the largest areas under cultivation. Compare to cereals such as barley, rye and oats, finger millet is a unique due to higher nutritional contents. It is a rich source of calcium among all cereals and millets. A multitude of small farmers grow finger millet with limited water resources and in many countries this crop is often referred to as "poor people's crop". Finger millet is not only used for human consumption, but it is also used as feed for cattle and birds. Processing technologies of finger millet grains such as milling, roasting, popping and malting gives different types of food preparations to make the final food product more attractive in appearance, taste, flavor and overall acceptability. This review gives the nutritional and health benefits of finger millet and its utilization in value added food products. Finger millet is used in the preparation of different foods both in natural and malted forms, like porridge, puddings, pancakes, biscuits, roti, bread, noodles, and other snacks. Besides this, it is also used as a nourishing food for infants when malted and is regarded as wholesome food for diabetic patients.

Introduction

Millets are minor cereals of the grass family (Poaceae) which is alternative food source of increasing world population. There are some challenges faced by human being and also animals as water scarcity, rising food prices and other socio-economic impacts. Thus, millet is called as a poorest people food in arid and sub-arid regions (Saleh *et al.,* 2013). They are small seeded, annual cereal grasses, many of which are adapted to tropical and arid climates.

Processing of Finger Millet : Similar to other cereal grains finger millet is also required to undergo certain basic steps of primary processing operations, such as cleaning, grading and separation where in removal of unwanted materials like, stones, soil particles, stalks, chaffs, grains of other crops etc. These operations are also importantfor adding value to the produce from the point of view of getting better returns from their sale.

Milling : Generally, finger millet is pulverized to flour for preparation of food products. First, it is cleaned to remove foreign materials such as stones, chaffs, stalks, etc., then passed through abrasive or friction mills to separate out glumes (non-edible cellulosic tissue), and then pulverized. Normally, it is pulverized in stone mill or iron disk or emery-coated disk mills. Sometimes, pearling or decortications is used to dehusk the finger millet grain; it results in pulverization of both the seed coat and endosperm. Hence, finger millet is invariably pulverized along with the seed to prepare whole meal. Centrifugal sheller can also be used to dehull/decorticate the small millets (Gull *et al.*, 2015).

Roasting : Traditional roasting of grains is used primarily to enhance flavor, but other benefits include reduction of anti nutritional factors (D'Appolonia,1978; Khan *et al.*,1988; Gahlawat and Sehgal,1992) and extension of storage life (Huffman and Martin,1994). Roasting and grinding processes render the grain digestible, without the loss of nutritious components. The puffing and roasting are almost similar processes, but the volume expansion in puffing is higher (Srivastava *et al*, 1994). Finger millet subjected to roasting at different temperatures for a different time was milled into flour and porridge was prepared. It was found that porridge viscosity decreased with increasing roasting time and temperature. Viscosity decreased by 50–60% in roasted finger millet; however, roasting did not affect the proximate composition (Auko, 2009).

Popping : Puffing or popping of cereals is an old traditional practice of cooking grains to be used as snack or breakfast cereal either plain or with some spices/salt/sweeteners. (Wadikar *et al.,*2007) prepared puffed grains of different varieties of finger millet by conditioning grains for 2 hours with 20% moisture content and puffed the grains using hot sand at a temperature of 220– 230 °C and observed that the changes in fatty acid composition were non-significant. However, in puffing neutral lipids decreased by 9.3% with an increase in glycolipids of 21.92% and phospholipids 33.3%. The varietal effect of finger millet on puffing quality shown that

brown seeded varieties are more suitable for puffing whereas white seeded varieties yielded organoleptically superior quality puff (Shukla *et al.,*1986).

Malting : Malting of finger millet is commonly practiced or specialty foods. During this process bioavailability of proteins, carbohydrates and minerals are enhanced. Some B-group vitamins are synthesized and concentration of anti-nutritional factors is also reduced. Malting involves soaking of viable seeds in water to hydrate and to facilitate sprouting. These sprouts are then kiln dried. Finally, the rootlets are separated from the grain manually by rubbing with hand. All these operations influence the quality of malt. Seed germination is most important step because during this process the hydrolytic enzymes are developed these cause endosperm modification and increases nutritional properties. Malting of finger millet has been successfully utilized for developing various health foods such as infant food, weaning food, milk-based beverages and confectionary products (Malleshi, 2007)

Value added food products using finger millet : Finger millet can be used in a variety of ways and is a great substitute for other grains such as rice and other starchy grains. Some of the examples of value-added products and possibilities of utilizing this minor millet as one of the basic ingredients are discussed.

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Value added food products using finger millet : Finger millet can be used in a variety of ways and is a great substitute for other grains such as rice and other starchy grains. Some of the examples of value-added products and possibilities of utilizing this minor millet as one of the basic ingredients are discussed Finger millet can be used in a variety of ways and is a great substitute for other grains such as rice and other starchy grains. Some of the examples of value-added products and possibilities of utilizing this minor millet as one of the basic ingredients are discussed below. These products are either in practice or have been demonstrated for enhancing consumption of this particular millet.

Bakery Products : Incorporation of finger millet flour in the preparation of bakery products like biscuit, nankhatai, muffins and bread has been attempted and efforts are being made to standardize the recipe and product quality. The use of millets in bakery products will not only superior in terms of fiber content, micronutrients but also create a good potential for millets to enter in the bakery world for series of value-added products. In a recent study, attempts have been made to improve the nutritional quality of cakes with respect to the minerals and fiber content by supplementing with malted finger millet flour (Desai *et al.*,2010). In recent years, finger millet has received attention and efforts are under way to provide it to the consumers inconvenient forms (Singh *et al.*, 2012).

Chapatti (Roti) : Wheat and finger millet in the ratio of 7:3 (wheat: finger millet) is suitable for making chapatti (roti). In this proposed blend, though the gluten content is reduced the making of flattering chapatti is not affected. Moreover, the color of the chapatti turns to slightly dark.Fortification of finger millet in chapattis not only improves the taste but also controls glucose levels in diabetic patients very efficiently. Slower digestion rate and bulkiness of the fibres makes us feel fuller on, fewer calories and therefore may help to prevent from eating excess calories. In addition, Finger millet fiber content is helpful to the individuals having the problem of constipation (Gull *et al.*, 2014).

Malting and Weaning Foods : Traditionally, the millet malt is utilized for infant feeding purpose. Finger millet possesses good malting characteristics and its malting is popular in Karnataka and part of Tamil Nadu. Malting helps to increase significantly the nutrient composition,

fiber, crude fat, vitamins B, C and their availability, minerals (Sangita and Srivastav, 2000), improve the bioavailability of nutrients, sensory attributes of the grains. Millet malt is used as a cereal base for low dietary bulk and calorie dense weaning foods, supplementary foods, health foods and also amylase rich foods. Malting reduces paste viscosity of flour than many other heat treatments (Malleshi and Desikachar, 1981).

Papad : Papad is a traditional product in south India. Finger millet flour (15-20%) added in other essential ingredients such as black gram, rice and spices. (Begum, 2007) ,reported that addition of finger millet flour (upto 60%) is possible and practiced in Karnataka. During papad preparation finger millet flour is first cooked in water up to gelatinized. A thin sheet is prepared by rolling and cutting the dough into desired shapes and sizes followed by drying of these papad pieces to desired moisture content of 7. Since the pericarp of finger millet grain is not separated out from the starch so that it gives a little dark colour to the papad. The dark colour of papad turns to lighter after frying (Verma and Patel, 2012).

Noodles : The changing food habits of children and teen aged groups have created a good market of noodles in India and abroad. The demand for millet noodles particularly the noodles made out of finger millet is growing due to awareness of its nutritional properties. Noodles are the pasta products also known as convenience foods prepared through cold extrusion system which become hard and brittle after drying. The cooking of these noodles is very convenient and requires few minutes. Noodles of different combinations are prepared such as noodles exclusively made of finger millet, finger millet and wheat in the ratio of 1:1 and finger millet blended with wheat and soy flour in the ratio of 5:4:1. In case of exclusive millet-based noodles, pre treatment to the millet flour is given to facilitate extrusion and smooth texture which should retain while drying and cooking. Generally, in the preparation of noodles, wheat flour is invariably used as an important member of blend because the presence of wheat gluten has an added advantage which not only helps in easy extrusion but also gives a smooth and fissure free texture to the noodles. Several other combinations of blends can be explored in the preparation of noodles keeping food values of ingredients and their availability in mind (Thapliyal and Singh, 2015)

Fermented foods : (Varma and Patel, 2013) stated fermented foods like Idli and Dosa are well-liked foods in several parts of India as breakfast and even as evening meals in southern parts. Ragi is broadly utilized as one of the core ingredient sin many of fermented food products which not only improves the taste but also enriches the food with fiber, calcium and protein content due to the reduction in anti nutrients content. Fermented foods are also prepared using malted or sprouted finger millet grains depending on the taste and choice. (Mugocha *et al.,* 2000) optimize the bacterial cultures formulation to produce the composite finger millet and skimmed milk based powder gruel.

Health benefits of Finger millet : The interest in finger millet due to its health benefits namely, hypoglycemic characteristics (Lakshmi and Sumathi, 2002) and also antimicrobial and antioxidant activities of its polyphenols have been growing (Chetan and malleshi,2007). (Chandrasekara and Shahidi, 2010) reported in their studies on free-radical quenching activity of finger millet (Eleusinecoracana), that non-processed brown finger millet had the highestradical quenching Activity than the processed one and postulated that tannins and phytic acid werereponsible for the activity (Devi *et al.*,2014; Quesada *et* Several studies are available on the antioxidant Properties (Chandrasekara and Shahidi, 2011; Hegde and Chandra, 2005; Sripriya *et al.*,1996; Subba Rao and Muralikrishna, 2002; Varsha *et al.*,2009; Veenashri and Muralikrishna, 2011) and antimicrobial properties of finger millet (Antony *et al.,*1998; Chethan and Malleshi, 2007; Varsha *et al.,*2009). Production of statins (antihypocholestrolemic metabolites) from finger millet was attempted by (Venkateswaran and Vijayalakshmi, 2010). The other healtbeneficial aspects of finger millet feeding, namely, the glucose lowering, cholesterol lowering, nephro protective properties, antioxidant properties, wound healing properties, and anti cataractogenesis properties of finger millet were reported by several authors (Hegde *et al.*,2005; Hegde, Rajasekaran *et al.*,2005; Rajasekaran *et al.*,2004; Shobana *et al.*, 2010). Improvement on the status of hemoglobin in children on feeding finger millet-based food was reported by (Tatala *et al.*,2007).

Conclusions

Health benefits and nutritive value of millet grains were found comparable to major cereals. Several processing technologies were found to improve nutritional characteristics of millets. Utilization of millet grains as food is still limited to populations in rural areas. This is due to the lack of innovative millet processing technologies. Finger millet is an important staple food in parts of eastern and central Africa and India. Its nutritional and functional properties have been reviewed and found best among all cereal grains. Vitamins, minerals, fatty acids and antioxidant properties of this make its strong contribution to human nutrition. Processing and value addition technologies have made it possible to process and prepare value added products acceptable to both rural

and urban consumers. This review provides a scientific rationale use of finger millet as a health-promoting food.

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Fermentation : A Nutritional Additives Process in Food Products

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Abstract

Fermentations are induced by the action of micro-organisms or enzymes in food products converting carbohydrates into alcohol, carbon dioxide and organic acids. It also reduces non-digestible poly- and oligosaccharides. And also their side effects such as abdominal distention and flatulence. Fermented foods are appreciated now days for their specific pleasant flavour, aroma, texture and also better digestibility. Micro-organisms such as homo- and hetero fermentative lactic acid bacteria; moulds such as Mucor, Rhizopus, Trichoderma, Aspergillus and Penicillium; and yeasts are used for the fermentation purposes. Globally cereals are favourable food crops and also fermentation substrates.

Key words : *cereal products, fermentation, starch, nutritional additives etc.*

(1) Fermentation and Fermented Foods

(A) Introduction : Fermentation is the slow decomposition process of organic substances induced by micro-organisms, or by complex nitrogenous substances (enzymes) of plant or animal origin" (Walker 1988). It is a biochemical change, brought by the anaerobic or partially anaerobic oxidation of carbohydrates by either microorganisms or enzymes. Microbiologists describe "fermentation" as form of energy-yielding microbial metabolism in which an organic substrate usually a carbohydrate is incompletely oxidised, and an organic carbohydrate acts as the electron acceptor (Adams, 1990). Food products owe their production and characteristics to the fermentative activities of micro-organisms in order to bring a desirable change. Various raw materials have been subjected to the action of micro-organisms or enzymes in food fermentation, thereby converting carbohydrates into alcohol, carbon dioxide and organic acids (William and Dennis 2011). This definition clearly states that the processes involving ethanol production by yeasts or organic acids by lactic acid bacteria are considered as fermentations. Finally it may be stated that foods submitted to the influence of lactic acid producing microorganisms is considered a fermented food. In general Fermented foods can be described as palatable and wholesome foods prepared from raw or heated raw materials and are highly appreciated for attributes such as pleasant flavour, aroma, texture and improved cooking and processing properties. (Holzapfel, 2002).

(B) Nutritional additives : Fermentation can have multiple effects on the nutritional value of food. Microbial fermentation leads to a decrease in the level of carbohydrates as well as some non-digestible poly- and oligosaccharides. The latter reduces side effects such as abdominal distention and flatulence. Certain amino acids may be synthesised and the availability of B group vitamins may be improved [Nout, *etal*, 1997]. Fermentation has been shown to improve the nutritional value of grains such as wheat and rice, basically by increasing the content of the essential amino acids lysine, methionine and tryptophan (Adams, 1990).

Fermentation of rice by lactic acid bacteria enhances the flavour, nutritive value and available lysine content (Lee, 1999). Fermentation of cereals especially by lactic acid bacteria has been reported to increase free amino acids and their derivatives by proteolysis and/or by metabolic synthesis. The microbial mass can also supply low molecular mass nitrogenous metabolites by cellularlysis (Mugula,2003). Lactic acid bacteria and yeasts were observed in higher numbers and increased with progression of fermentation. Coliforms disappearance corresponded to increase in acidity (drop in pH) during fermentation. Acid production results in souring which imparts a characteristic sour taste. The acid produced also lowers pH which slows down the rate of microbial spoilage and inhibits the growth of pathogenic organisms like coliforms (Steinkraus, 1996). The lactic acid in the sourdough has an effect of softening the endosperm protein, which tightly encloses the starch granules (O'Rourke T 2000). Softening the protein allows more rapid up take of water by the starch granules and thus speed up gelatinisation during roasting. The purpose of souring was to shortens the fermentation process and avoids undesirable growth of yeasts and minimizes the loss of fermentable substrate. Yeasts lead to high carbon dioxide production and other volatile compounds that

result in loss of dry matter. Roasting not only imparts a desirable flavour and colour but also to some extent gelatinises the starch in the dough rendering it readily available for gelatinisation by malt diastatic enzymes during mashing step. The method of cooling dough, after roasting, may contribute to the microbial population participating in the fermentation.

Spontaneous lactic acid fermentation also enhances taste and flavour, modify texture and improve the microbial safety of foods. When applied to nixtamalized corn mixed with traditional steeped corn it is expected to further improve the functionality, improve nutritional quality and provide an alternative corn-based ingredient. The food sample derived from 100% steeped corn, showed increases in water absorption capacity, texture and cooked paste viscosity with increasing fermentation time. Nixtamalized corn can be subjected to spontaneous fermentation to produce thin, energy dense gruels of acceptable qualities. It solves the low energy density problem of weaning foods i.e. practices of malnutrition, one of the problems facing in many developing countries easily from fermented corn.It can be clearly stated that malnutrition is partly due to non-availability of food, it is also due to low energy and nutrient density and low bioavailability of nutrients in the available foods (Ljungqvist *et al.,* 1981). The presence of some anti-nutritional factors such as phytic acid, tannins and polyphenols in some cereals used as weaning foods is known to be responsible for the low availability of proteins (Maclean et *al.,* 1980) and iron (Gilooly *et al.,* 1984).

Household lactic acid fermentation of cereals has been found effectively to reduce the amount of phytic acid, polyphenols and tannins and improved protein availability in sorghum (Chavan *et al.,* 1988) and millet (Khetarpaul and Chauhan, 1990). It has also led to improved iron (Svanberg and Sandberg, 1988), minerals (Khetarpaul and Chauhan, 1990) and sugar (Khetarpaul and Chauhan, 1990) availability. Lactic acid production of cereal-based weaning foods in Africa has been found to improve the nutri tional quality of these products by either decreasing the number of inhibitors or releasing the nutrients for absorption (Svanberg and Lorri, 1991).

Fermentation is an important process which significantly lowers the content of anti-nutrients (phytates, tanins, polyphenol) of cereal grains (Sindhu,2001). Fermentation also provides optimum pH conditions for enzymatic degradation of phytate (present in cereals in the form of complexes with polyvalent cations such as iron, zinc, calcium, magnesium and proteins) due to phytase activity, resulting into increasing the amount of soluble iron, zinc, calcium several folds (Blandino, 2003, Nout,1997). Optimal temperature for phytase activity has been known to range between 35 °C and 45 °C (Sindhu, 2001). Tanin levels may be reduced as a result of lactic acid fermentation, leading to increased absorption of iron, except in some high tanin cereals, where little or no improvement in iron availability has been observed (Nout, 1997).

(2) Fermented food

Fermented foods originated many thousands of years ago when micro-organisms contaminated local foods. In present scenario these foods comprise about one-third of the worldwide consumption of food and 20–40 % (by weight) of individual diets. Globally, cereals tops in ranking as food crops as well as fermentation substrates. Traditional fermented foods prepared from rice, wheat, maize, millet and sorghum which are very common cereals. Fermented cereal based foods produced in Africa (Hansen, 2002), Although differences exist between regions, the preparation procedure could be generalised. Some are utilised as colourants, spices, beverages and breakfasts or light meal foods, while a few of them are used as main foods in the diet. The traditional foods made from cereal grains usually lack flavour and aroma (Charalampopoulos, 2002). During cereal fermentations several volatile compounds are formed, which contribute to a complex blend of flavours in products. The presence of aromas represented by diacetyl, acetic acid and butyric acid makes fermented cereal-based products more appetizing (Blandino ,2003). The proteolytic activity of fer-mentation microorganisms often in combination with malt enzymes may produce precursors of flavour compounds, such as amino acids, which may be deaminated or decarboxylated to aldehydes and these may be oxidized to acids or reduced to alcohols (Mugula,2003). Knowledge of biochemical pathways leading to flavour production can help in making the right choice of starter culture. However, the end product distribution of lactic acid fermentations depends also on the chemical composition of the substrate (carbohydrate content, presence of electron acceptors, nitrogen availability) and the environmental conditions (pH, temperature, aerobiosis/ anaerobiosis), controlling of which would allow specific fermentations to be channelled towards a more desirable product (Charalampopoulos, 2002).

(A) Microbiology of Fermented Foods : Traditionally, the fermenting organisms came from the natural micro flora or a portion of the previous fermentation and it is termed as starter culture. In many cases, the natural micro flora is inefficient, uncontrollable and unpredictable or is destroyed during pre-processing stages. It is always beneficial to use previously characterised, well-identified starter culture as it can provide particular characteristics to

the food in a more controlled and predictable manner. The most important fungi involved in industrial fermentation are from two of the main classification groups: the *aseptate zygomycota*, which includes *Mucor* and *Rhizopus* and the *septate deuteromycotina (fungi imperfecti),* which includes the genera *Trichoderma, Aspergillus Penicillium, Aureobasidium and Fusarium*. Yeasts are unicellular fungi that generally reproduce by budding; however, some exceptional species reproduce by binary fission such as Schizosac-charomyces pombe. *Saccharomyces* is the most widely used yeast in industrial fermentations and has applications in alcohol production and baking. All the strains ferment glucose and many ferment other plant associated carbohydrates such as sucrose, maltose and raffinose but none can ferment lactose. *Kluyveromyces lactis*, which contains the necessary lactose-transporting and degrading enzymes, is particularly useful in production of alcohol and biomass from whey. *Zygosaccharomyces rouxii* is specially associated with fermentation of plant products at high salt concentration and low water activity. Lactic starters constitute the major group of fermentative organisms that includes bacteria having ability to convert sugars to lactic acid, for example, *Lactococcus lactis.* This group comprises 11 genera of gram-positive bacteria, that is, Carnobacterium, Oenococcus, Enterococcus, Pediococcus, Lactococcus, Streptococcus, Lactobacillus, Vagococcus, Lactosphaera, Weissells and Leuconostoc. The lactic acid bacteria are largely mesophilic and generally grow over a temperature range of about 10–40°C, having temperature optima between 25°C and 35°C. Alternatively, Lactobacillus delbrueckii subspecies bulgaricus is thermoduric and can grow above 40°C. Similarly, the optimum pH range varies from 4 to 8, though, some can grow at a pH as low as 3.2 and as high as 9.6. Heterofermentative organisms like Leuconostoc citrovorum and Leuconostoc dextranicum are particularly desirable for development of flavour and aroma compounds such as acetyl aldehyde and diacetyl. A good starter culture will convert most of the sugars to lactic acid, increase the lactic acid concentration to 0.8–1.2 % (titratable acidity) and drop the pH to 4.3–4.5.

(B) Biochemistry of Fermented Foods : Structurally, maize consists of an embryo (germ) and an endosperm enclosed by an epidermis and a seed coat (husk). While the germ is basically a package of nutrients such as amino acids, sugars, lipids, minerals, vitamins and enzymes, the husk is comprised mainly of cellulose, pentosans, pectins and minerals. Depending on the variety, maize may contain a number of important B vitamins, folic acid, vitamin C and precursor to vitamin A. Maize is also rich in phosphorus, magnesium, manganese, zinc, copper, iron and selenium and has small amounts of potassium and calcium. Maize is a good source of dietary fibre and protein, while being very low in fat and sodium. However, maize is naturally deficient in lysine and tryptophan, which are two of the eight amino acids regarded as essential for humans, but Quality Protein Maize (QPM) has been bred to be high in lysine and tryptophan. Maize lacks the protein gluten of wheat and, therefore, makes baked goods with poor rising capability. The endosperm consists of starch granules of different sizes embedded in a protein matrix, which makes the maize an excellent substrate for fermentation. Starch constitutes, approximately, 72–73% of the kernel weight, whereas other carbohydrates are simple sugars that present as glucose, sucrose and fructose in amounts that vary from 1% to 3% only. Chemically, this starch is a complex heterogeneous biopolymer composed of amylose and amylopectin, two high molecular weight components that may be present in different ratios. The former is a linear polymer containing 70–2,100 glucose units linked via -1,4 glucosidic linkages, whereas the latter is a branched polymer with 4–6% -1,6 glucosidic linkages at branched points; the average length of branch chain is 20–25 glucose units (Stewart and Russell 1987). Commonly used starter cultures of yeast and lactic acid bacteria lack the ability to transform this substrate to simple sugars. Clearly, it would require a hydrolysis to glucose by amylases, prior to fermentation. Western techniques use endogenous starch degrading enzymes produced in the grains through the process of malting.

In malting, the grain is moistened by steeping in water and is allowed to germinate. During germination, hydrolytic enzymes present in the aleurone layer surrounding the grain endosperm attack the endosperm, mobilising the nutrients and energy reserve, starch. Some native cultures in South America use salivary amylase for starch hydrolysis by simply chewing the substrate, while some others utilise enzymes produced by cocultured, resident, or externally added moulds.

These techniques, however, are not amenable at large-scale industrial production. Therefore, amylolytic enzymes, a group of starch-splitting enzymes, are of considerable importance to fermentation of grains like maize at industrial level. Starch cannot be converted to sugars easily, as it requires prior gelatinisation by heat treatment, liquefaction by -amylase and saccharification by amyloglucosidase. The enzyme-mediated hydrolysis of starch is a rapid process with little contamination by reversion products and formation of fewer by-products. In addition, it is more specific and higher yields of sugars as well as alcohol and lactic acid are obtained.

Carbon, nitrogen and other nutrients from surroundings of micro-organisms enter the cell and

transform into either new cell material or the product, through a process called metabolism. These transformations require energy, and since most of the micro-organisms involved in industrial fermentations are heterotrophs, therefore, this energy is obtained from breakdown of organic compounds. While in aerobic or respiratory processes, organisms are able to completely oxidise substrate into CO2 + H2O, resulting in maximum energy production, in anaerobic or fermentative metabolism, cells are less efficient in conversion of organic substrate into cellular material and usually excrete partially degraded intermediates, yielding lesser energy. Inside the cell, the sugars are broken down by one of the three pathways: the Embden Meyerhof Parnas (EMP) pathway, hexose monophosphate (HMP) pathway and Entner Doudoroff (ED) pathway. The EMP pathway most widely occurs in animals, plants and fungal, yeast and bacterial cells for glucose utilisation. A few bacteria including pseudomonas species, which do not metabolise glucose via EMP pathway, utilise ED pathway. HMP pathway is especially useful in generating precursors of aromatic amino acids and vitamins and the supply of NADPH and H+ needed for many biosynthetic pathways. A significant product for all the three pathways mentioned earlier is pyruvic acid, which is channelled into tricarboxylic acid (TCA) cycle in aerobic metabolism and in the precursor for various acids, alcohols and other end products in anaerobic metabolism.

Lactic acid bacteria are gram-positive, nonspore-forming rods or cocci, mostly aero-tolerant anaerobes that lack cytochromes and porphyrins and are, therefore, catalase- and oxidase-negative. Some do take oxygen through the mediation of flavoprotein oxidase, which is used to produce hydrogen peroxide and/or to reoxidise NADH produced during dehydrogenation of sugars. Cellular energy is derived from fermentation of carbohydrates to produce peripherally lactic acid using two different pathways: homofermentative and heterofermentative. Homofermentative lactic acid bacteria contain aldolase, a key enzyme of glycolysis, and produce virtually a single product, that is, two molecules of lactate per glucose molecules. They follow the Embden Mayerhoffs Parnas (EMP) pathway where the six-carbon molecule glucose is phosphorylated and isomerised before cleavage by enzyme aldolase into glyceraldehyde-3-phosphate and dihydroxyacetone phosphate. These intermediates can be further converted into two pyruvate and finally two lactate molecules, generating 2 ATP by substratelevel phosphorylation. NADH produced during the oxidation of glyceraldehyde-3-phosphate to 1,3-bisphosphoglycerate is reoxidized to NAD+ in the formation of lactate from pyruvate by the action of lactate dehydrogenases (LDHs). Hetero fermentative LAB lacks aldolase and thus cannot break down fructose bisphosphate to triose phosphate. Instead, they oxidise glucose-6- phosphate to 6-phosphogluconate and then decarboxylate this to pentose phosphate, which is then converted into triose phosphate and acetyl phosphate by key enzyme phosphoketolase. In heterofermentative LAB, triose phosphate is converted ultimately to lactic acid with the production of one ATP molecule, whereas, to achieve redox balance, acetyl phosphate is reduced by NADH to ethanol, without the generation of any ATP. These heterofermentative bacteria can receive additional ATP molecules through conversion of acetyl phosphate to acetate.

Conclusions

Fermented foods were discovered before mankind had any knowledge of micro-organisms, but these were simple observations that certain way of storing food effected desirable changes in its characteristics such as shelf life. These characteristics, in the industrial world, became less important with the advent of alternative preservation methods such as canning, chilling and freezing. Modern technology, however, in no way has diminished the sensory appeal, contributed by peculiar flavour and aroma, of fermented products. Fermented foods are considered beneficial over non-fermented products as microbial action not only improves shelf life by producing acids, alcohols and bacteriocins but also provides better digestibility, nutritional supplementation, retention of micro- and macronutrients, improved aroma and flavour characteristics to foods.

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Studies on Relationship between the Abundance of Redgram Pod Insects and Weather Factors with Special Reference to the Management of Spotted Pod Borer, *Maruca vitrata* Geyer with Newer Insecticides

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Abstract

Seasonal incidence of redgram pod borers was studied in Madurai district. At early flowering stage, number of *Maruca* webs was 43/25 rachis (I week of Jan, 2020) and it's peak (65/25 rachis) was observed in full flowering stage (III week of Jan, 2020). Gram pod borer population was noticed from early pod development stage (1/25 rachis) in IV week of Jan, 2020 and in pod development stage, their population ranged from 2.0 to 3.0/25 rachis in I fortnight of Feb, 2020. Plume moth population was observed at pod maturity stage (4.0 to 6.0/25 rachis) in II fortnight of Feb, 2020. Pod bug population ranged from 2.0 to 8.0/25 rachis. Maximum pod fly seed damage was at maturity (12%) (IV week of February, 2020). Incidence of *M.vitrata* showed significantly negative & positive correlations with max. and min. temperatures respectively. *H.armigera* population showed significantly positive & negative correlations with max. temperature and min. RH respectively. Plume moth population and pod fly incidence showed significantly positive & negative correlation with max. temperature & max. RH respectively. Plume moth & pod bug population and pod fly incidence showed significantly negative correlation with min. RH. Novaluron 10 EC (2 ml/lt) was effective in reducing the pod borer population and their incidence and comparatively more yield was recorded in this treatment. Flubendiamide 480 SC (2 ml/lt) and indoxacarb 15.8 EC (0.7 ml/lt) were the next best treatments. Novaluron recorded high BC ratio of 1: 1.4. Indoxacarb recorded high BC ratio than the flubendiamide (1:1.29) due to it's low cost.

Key words : *Redgram , pod borers , seasonal incidence , weather factors , new insecticides.*

Introduction

In India, pulses are the major sources of proteins and other vitamins & minerals complimenting cereal proteins for vegetarian people. They provide high quality protein and are considered as "rich man's vegetable" and "poor man's meat". Pulses are a low fat source of protein, with a high fibre content and low glycemic index. In India, pulses are cultivated under diversified agro ecological conditions like kharif, rabi & summer seasons., mixed or mono cropping situations., rainfed or irrigated conditions, under traditional or progressive farming practices etc. These varied cultivable conditions resulted in numerable pest problems in pulse ecosystem. Among the pulses, redgram is an important one which is prone to attack of a complex of pod borers when compared to the rest of the pulses. *Maruca vitrata* Geyer (Lepidoptera; Pyralidae) is commonly called as spotted pod borer or legume pod borer and is a major pod damaging insect in redgram in both tropical and subtropical conditions.

Host range of spotted pod borer is very wide and is capable of surviving on alternate host plants like wild legume plants and on weeds during the off season. At flowering and pod formation stages, spotted pod borer larvae web the flower buds, flowers and pods and feeds by remaining inside. Third instar larvae prefer to feed on the pods than the flowers and leaves. However, first instar larvae prefer flowers over pods and leaves (Sharma, 1998). Egg laying by female moths was observed throughout the crop period, but damage occurs mainly during flowering and podding stages in beans (Rekha and Mallapur, 2007).

Flower damage ranging from 9.40 to 12.70 per cent was reported by Ganapathy (1996) in different pigeon pea cultivars in Tamil Nadu, India. Giraddi *et al.,* 2000 stated that late sowing of redgram and dry spell during crop period resulted in an outbreak of spotted pod borer which in-turn caused complete loss of yield in Karnataka. In this background, studies were undertaken on the seasonal incidence of various pod damaging insects of redgram in relation to various weather parameters and on the management of spotted pod borer, *M.vitrata,* with new insecticide molecules.

Materials and Methods

Field trials on seasonal incidence and management of pod borers were conducted in the farmer's field at T.Kunnathur village of T.Kallupatti block, Madurai district with the redgram variety, VBN 3. In the seasonal incidence trial, regular observations were recorded on the incidence of various pod borers, pod bugs and pod fly at weekly intervals starting from flowering to harvest. During flowering stage, total number of flower webs webbed by *Maruca* was counted randomly from 25 rachis (redgram inflorescence of 30 cm length). During this period, inflorescence were also observed for the presence of

other pod borers i.e., gram pod borer, plume moth larvae and pod bugs. During pod formation and pod maturity stages, total number of *Maruca webs,* gram pod borer larvae, plume moth larvae and pod bugs were counted from 25 randomly selected redgram rachis. During pod maturity stage, per cent pod fly infestation was calculated by observing 100 randomly collected redgram pods. During the observation period, weather parameters were recorded and correlated with the pod borer population and incidence.

In the spotted pod borer management trial, the following treatments were evaluated in a randomized block design with four treatments and five replications.

S. No.	Treatment	Particulars
1.	T_1	Novaluron 10 EC - 2 ml/lt.
2.	T_2	Flubendiamide 480 SC - 2 ml/lt.
3.	T_3	Indoxacarb 15.8 EC - 0.7 ml/lt.
4.	T_4	Untreated control

First spray with the respective insecticides was done at flowering stage after observing the *Maruca* webs. Second spray was done after 15 days of the first spray. Before the first spray, pretreatment count was taken on number of webs/25 rachis. After 7 and 14 days of first and second sprays, post treatment observations were recorded. At harvest, per cent pod damage and yield (kg/ha) were recorded in all the treatments. BC ratio was calculated for each treatment separately.

Results and Discussion

Seasonal incidence of redgram pod borers : At early flowering stage, number of *Maruca* webs started from 43.0/25 rachis in January I week, 2020 (Table 1). Peak number of webs observed during the crop period was 65.0/25 rachis during full flowering stage rachis in January III week of 2020. At pod development stage, 16.0 to 39.0 webs/25 rachis were recorded. At pod maturity, very less number of webs (5.0 to 8.0 webs/25 rachis) were noted in the second fortnight of February, 2020. At ICRISAT, Hyderabad light trap catches of spotted pod borer moths revealed two peaks *i.e.,* first September and second in early November to mid December (Srivastava *et al.,* 1992). In Karnataka, Thejaswi *et al.,* 2008 reported the incidence of *Maruca* from second fortnight of September to first fortnight of February and it was peak from second fortnight of November to December first fortnight in field bean.

Gram pod borer, *Helicoverpa armigera* population was noticed from early pod development stage (1.0/25 rachis) in fourth week of January, 2020. During pod development stage, 2.0 to 3.0 *H.armigera* larvae were noted per 25 rachis in first fortnight of February, 2020. Plume moth population was observed during the pod maturity stage (4.0 to 6.0/25 rachis) in second fortnight of February, 2020. Pod bugs were observed from full flowering stage itself (III week of January, 2020) and occurred up to the maturity stage (II fortnight of February, 2020). During the crop period, their population ranged from 2.0 to 8.0/25 rachis. At pod development stage, pod fly seed damage started with 2.0% (II week of February, 2020) and at maturity 12 per cent seed damage was observed (IV week of February, 2020).

Incidence of *M.vitrata* showed significantly negative correlation with maximum temperature and significantly positive correlation with minimum temperature. The present finding is in agreement with the findings of Sharma, 1998 who has reported that high humidity and low temperatures during the months of November and December are highly favorable for the pest build up. *H.armigera* population showed significantly positive correlation with maximum temperature and significantly negative correlation with minimum relative humidity (Table 2). Plume moth population and pod fly incidences showed significantly positive correlation with maximum temperature and significantly negative correlation with maximum relative humidity. Plume moth & pod bug population and pod fly incidence showed significantly negative correlation with minimum relative humidity.

Management of spotted pod borer, *M. vitrata* : Before spraying, number of *Maruca* webs per 25 rachis ranged from 45.0 to 47.0. At seven days after first spray, novaluron 10 EC (2 ml/lt) and flubendiamide 480 SC (0.2 ml/lt) were found to be on par in effectiveness in reducing the *Maruca* webs by recording 26.0 to27.0 webs/25 rachis while in untreated control, it was 47.0. MahaLakshmi *et al.* (2012) reported the efficacy of flubendiamide @ 0.2 ml/lt against spotted pod borer in blackgram.

After 14 days of first spraying, novaluron 10 EC (2 ml/lt) was found to be the first best treatment in reducing the number of live webs of this borer under field conditions. This treatment recorded 18.0 webs/25 rachis (Table-3) as against 43.0 in untreated control. Next to this, flubendiamide 480 SC (0.2 ml/lt) (20.0/25 rachis) and indoxacarb 15.8 EC (0.7 ml/lt) (21.0/25 rachis) were found to be equally effective. The effectiveness of flubendiamide 480 SC @ 48g a.i/ha followed by Indoxacarb 14.5 SC @ 75g a.i/ha in controlling the pod borers in blackgram was also reported by Ashok Kumar and Shivaraju (2009).

At 14 days after second spraying, number of *Maruca* webs per 25 rachis was less (6.0/25 rachis) in the treatment, novaluron 10 EC (2 ml/lt). Flubendiamide 480 SC (2 ml/lt) and indoxacarb 15.8 EC (0.7 ml/lt) were the next best treatments with 10.0 and 11.0 webs per 25 rachis respectively and both were on par with each other. In untreated control, 34.0 webs per 25 rachis were

Table-1 : Incidence levels of redgram pod borers and details of weather parameters.

Date	Std. Week	No./25 rachis				Pod fly (%)	Max. Temp.	Min. Temp.	Max. RH	Min. RH	Rainfall
		Maruca webs	*Helico-verpa* larvae	Plume moth larvae	Pod bugs						
07.01.20	1	43.0	0.0	0.0	0.0	0.0	31.67	14.08	89.67	61.17	0.00
14.01.20	2	52.0	0.0	0.0	0.0	0.0	30.86	12.29	84.43	54.43	0.00
21.01.20	3	65.0	0.0	0.0	2.0	0.0	30.29	12.50	87.14	55.71	0.00
28.01.20	4	48.0	1.0	0.0	8.0	0.0	31.27	11.93	88.71	52.00	0.00
04.02.20	5	39.0	0.0	0.0	5.0	0.0	32.63	12.24	88.43	43.86	0.00
11.02.20	6	16.0	3.0	0.0	7.0	2.0	32.69	13.09	89.71	45.43	0.00
18.02.20	7	8.0	2.0	6.0	6.0	8.0	33.63	13.04	83.86	41.43	0.00
25.02.20	8	5.0	3.0	4.0	3.0	12.0	33.69	13.37	78.86	39.71	0.00

Table-2 : Relationship of incidence of pod damaging insects of redgram with weather parameters.

Particulars	Correlation coefficient values				
	Max. Temp. (°C)	Min. Temp. (°C)	Max. RH (%)	Min. RH (%)	Rain fall (mm)
Maruca vitrata	-0.9591*	-0.4551	0.4893	0.8071*	-0.9591*
Helicoverpa armigera	0.7374*	-0.4551	-0.4211	-0.7215*	0.7374*
Plume moth	0.7435*	0.3005	-0.7189*	-0.6628*	0.7435*
Pod bugs	0.3927	-0.3728	0.2083	-0.5607*	0.3927
Pod fly	0.7942*	0.3876	-0.8427*	-0.7346*	0.7942*

* Significant

Table-3 : Evaluation of newer insecticides for the management of *M.vitrata* in redgram.

S. No.	Treatment	PTC	Mean no. of *Maruca* webs /25 rachis			Mean no. of *Maruca* webs /25 rachis		
			I spraying			II spraying		
			7 DAS	14 DAS	Mean	7 DAS	14 DAS	Mean
1.	Novaluron 10 EC (2 ml/lt)	47.0	26.00 (5.10)[a]	18.00 (4.24)[a]	22.0	10.0 (3.16)[a]	6.0 (2.45)[a]	8.0
2.	Flubendiamide 480 SC (0.2 ml/lt)	45.0	27.00 (5.20)[a]	20.00 (4.47)[b]	23.5	14.0 (3.74)[b]	10.0 (3.16)[b]	12.0
3.	Indoxacarb 15.8 EC (0.7 ml/lt)	46.0	32.00 (5.66)[b]	21.00 (4.58)[b]	26.5	18.0 (4.24)[c]	11.0 (3.32)[b]	14.5
4.	Untreated control	45.0	47.00 (6.86)[c]	43.00 (6.56)[c]	45.0	37.0 (6.08)[d]	34.0 (5.83)[c]	35.5
	CD (0.05)		0.1640	0.2139		0.2747	0.2557	
	SEd		0.0753	0.0982		0.1261	0.1174	

Table-4 : Efficacy of newer insecticides against *M. vitrata* at harvest and cost economics.

S. No.	Treatment	% pod damage at harvest	Yield (kg/ha)	B : C ratio
1.	Novaluron 10 EC (2 ml/lt)	4.0 (11.54)[a]	780[a]	1 : 1.40
2.	Flubendiamide 480 SC (0.2 ml/lt)	8.0 (16.43)[b]	720[b]	1 : 1.29
3.	Indoxacarb 15.8 EC (0.7 ml/lt)	9.0 (17.46)[b]	710[b]	1 : 1.32
4.	Untreated control	18.0 (25.10)[c]	525[c]	1 : 1.01
	CD (0.05)	2.0404	16.1953	
	SED	0.9365	7.4330	

observed. Highest reduction in larval population of pod borers was recorded with flubendiamide 480SC and indoxacarb 14.5SC in dolichos bean (Mallikarjuna *et al.*, 2009).

Observations on *Maruca* pod damage in harvested pods revealed that, in novaluron 10 EC (2 ml/lt), comparatively less pod damage i.e., 6.0 per cent was recorded. Next to this, flubendiamide 480 SC (2 ml/lt) and indoxacarb 15.8 EC (0.7 ml/lt) treatments recorded less pod damage of 8.0 and 9.0 per cent respectively. In plots in which no chemical was sprayed, 18.0 per cent pods were damaged by borers. Among the treatments, from

novaluron 10 EC (2 ml/lt) sprayed plots, comparatively more yield (780 kg/ha) was obtained (Table 4), while in untreated control it was 525 kg/ha. Flubendiamide 480 SC (2 ml/lt) and indoxacarb 15.8 EC (0.7 ml/lt) treatments were on par with 720 and 710 kg/ha. However, indoxacarb 15.8 EC (0.7 ml/lt) recorded high BC ratio than the flubendiamide 480 SC (2 ml/lt) (1:1.29) due to it's low cost. Novaluron 10 EC (2 ml/lt) recorded high BC ratio of 1: 1.4 (Table 4) and in untreated control it was 1:1.01.

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Freeze-dried Probiotics for Improved Shelf Life and Scalability in the Food Industry

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Abstract

Probiotics, known for their health-promoting properties, have gained widespread popularity in the food industry. However, challenges persist in preserving their viability and enhancing scalability for mass production. The applications of freeze-drying as a promising technique to address these challenges are vast. Freeze-drying, or lyophilization, is renowned for its ability to extend the shelf life of probiotics by minimizing moisture content and preventing degradation. The review delves into the various factors influencing the freeze-drying process, including formulation considerations, cryoprotectants, and optimization strategies. Furthermore, the potential advantages of freeze-drying in terms of enhanced probiotic survivability during storage and distribution are discussed. Scalability is a crucial aspect for the incorporation of probiotics into a broad spectrum of food products. The paper elucidates the scalability challenges associated with traditional methods and explores how freeze-drying presents a viable solution for large-scale production. The economic considerations, energy efficiency, and environmental impact of freeze-drying in the context of probiotics are also discussed. By addressing issues related to shelf life and scalability, freeze-drying emerges as a pivotal technology for the integration of probiotics into diverse food applications, contributing to the realization of healthier and more accessible food products.

Keywords : Freeze-drying, Cryoprotectants, Probiotics, Scalability and Viability.

Introduction

The increasing global demand for functional probiotic foods can be attributed to consumers' growing understanding of the health benefits of probiotics and their well-being. As a result, food producers are now placing more of an emphasis on creating probiotic and functional meals. Probiotics are "live microorganisms which when administered in adequate amounts confer a health benefit on the host," according to FAO/WHO (2001). To attain the desired health advantages, the Food Safety Standards Authority of India (FSSAI) states that the product's live probiotic bacteria concentration should be greater than 10^8 CFU/100 g at the time of intake. Prebiotics, on the other hand, are food ingredients that stimulate intestinal bacterial growth and are beneficial to harmful bacteria. In food, the FSSAI has approved 16 substances as prebiotics and about 30 live microorganisms as probiotics.

Health benefit of Probiotic Culture

The term "microbiota" refers to the 10-100 trillion microorganisms primarily residing in the human gastrointestinal tract. Probiotics play a vital role in maintaining the balance of intestinal health, positively influencing the host's gut microbial equilibrium for overall health benefits. Examples of probiotic species include Lactobacillus, Streptococcus, Enterococcus, Bifidobacterium, and Saccharomyces. These probiotic strains have demonstrated enhancements in human digestive health, protection of the gastrointestinal (GI) tract and epithelial cells, reduction of gut inflammation, regulation of antibodies, improvement of lactose intolerance, prevention of colorectal cancer, and inhibition of harmful bacteria like Helicobacter pylori.

Research reports by Szajewska et al. (2014), Tan-Lim and Esteban-Ipac (2018), Roobab et al. (2020), and Sharif et al. (2020) suggest that probiotics can aid in treating food allergies and preventing acute diarrhea by maintaining the microbial balance in the gut. Probiotic bacteria safeguard this balance, enhancing the body's defense against infections, protecting lipids and proteins from oxidative damage, and boosting immunity. L. rhamnosus GG, a well-studied probiotic strain, has demonstrated positive effects on health. It can be incorporated into various foods such as curd, cheese, and fermented milk products or taken as a dietary supplement. Its health benefits have earned it a 5-star rating on www.probiotics.org. L. rhamnosus offers advantages like preventing diarrhea, reducing blood cholesterol,

enhancing immunity, inhibiting harmful bacterial growth, and eliminating antibiotic-resistant bacteria.

However, the effectiveness of probiotics is hindered by challenges such as poor viability and growth-suppressive properties. Factors like pH, sugar content, salt concentration, and microenvironment in food negatively impact probiotic viability. To fully realize the potential health benefits, it is crucial to address the decline in viability during food storage and gastrointestinal transit. Encapsulation, a widely used method, protects probiotics in the food matrix by isolating them from external influences, thereby extending their viability and shelf life. Various encapsulation techniques can also enhance probiotic vitality during storage.

Microencapsulation Techniques Used for Encapsulation of Probiotic Culture : Probiotics become more resistant to adverse environments through the process of microencapsulation. Encapsulation is the process of enclosing microbial cells in a membrane to decrease damage to the cells, shield them from environmental challenges, and prolong their vitality. Electrospinning, spray drying, freeze drying, extrusion, emulsification, fluidized bed drying, and other techniques can be employed to achieve it. By utilizing an appropriate encapsulating technique to convert probiotics from an aqueous solution to a dry form, the long-term stability of the microorganisms can be attained, particularly at room temperature. Reduced water content is necessary to maintain probiotics in dry form and improve their long-term stability, according to Vesterlund *et al*. (2012).

Probiotic cultures can be freeze-dried to achieve greater storage stability and a high degree of cell viability. Freeze drying has drawbacks, such as low temperature and damage to microorganisms from the cold, but these are overcome by the benefits of the cryoprotectants used in the process. Thus, probiotics are frequently encapsulated using freeze drying. On the other hand, spray drying offers the advantage of quickly and continuously encapsulating probiotics, even though its high drying temperature results in relatively low survival.

1. “It is an effective method that generates a substantial quantity of products. In their 2016 study, Broeckx and colleagues investigated processing conditions and various factors influencing the choice of a suitable drying method for probiotic strains, as outlined in Table 1. Freeze drying and spray drying are two commonly employed techniques to preserve probiotics. Typically, proteins (whether milk-based or non-milk-based) and carbohydrates (comprising hydrocolloids, polysaccharides, reducing sugars, and sugar alcohols) or a combination thereof are chosen as wall components in these methods.

2. Freeze drying : According to Jennings and Duan (1995), freeze drying is the process of freezing feed or product to an extremely low temperature and then drying it under vacuum. Sublimation is the underlying principle of freeze drying (Shukla *et al*., 2011). The solid state of water instantly transforms into the gaseous state. Heat and air pressure are the two variables that influence a substance’s phase transition from solid to gas. Usually, liquid nitrogen is used to freeze the product that needs to be dried. The feed solution’s water crystallizes below the eutectic point.

During the first drying stage, vacuum is used to regulate pressure. The cool condenser plates that make up the main drying chamber give the water vapor a surface to re-solidify on. This condenser does not keep the material frozen; instead, it keeps water vapor from getting to the vacuum pump and keeps the pump from performing worse. During primary drying, the frozen water is eliminated through sublimation, while during secondary drying, the unfrozen water molecules are eliminated through desorption. The objective of this phase is to destroy any physico-chemical interactions that formed between the water molecules and frozen substance by raising the temperature above that of the primary drying phase, maybe even exceeding 0°C. Following the freeze-drying process, the material is typically sealed when the vacuum is broken using an inert gas like nitrogen. When the product is fully dried, it will have a very low and safe final residual water content of 1 to 4 %. Heat-sensitive materials are typically dried using this method; encapsulation is more practical and straightforward. The final product is dry, doesn’t need to be refrigerated, and may be delivered similarly to products that are produced traditionally. However, compared to other encapsulation procedures, this process is more time-consuming and costly.

3. Cryoprotectants used for the Encapsulation of Probiotics by Freeze Drying : Furthermore, freeze drying can have detrimental effects on biological systems, particularly impacting the structure of delicate proteins and the physical state of membrane lipids, potentially reducing the viability of probiotics during extended storage periods. Hence, when employing freeze drying, the inclusion of suitable cryoprotectants becomes imperative. Zayed *et al*. (2004) observed an 83-85% survival rate for *L. salivarius subsp. salivarius* when sucrose, trehalose, and skim milk were used as wall materials during freeze drying. Similarly, Savedboworn *et al*. (2017) reported survival rates of 98.13% and 97.58% for *L. plantarum* TISTR 2075 after freeze drying with protein/trehalose and protein/maltodextrin as wall materials, respectively. Encapsulated cells with a population exceeding 109

Table-1 : Techniques and their features for drying of probiotics.

Parameter	Freeze drying	Spray drying	Vacuum drying	Fluidized bed drying
Control of particle properties	No	Yes	No	Yes
Types of process	Batch	Continuous	Batch	Batch/Continuous
Processing Parameters				
(a) Time	Hours/Days	Seconds/minutes	Hours/days	Hours
(b) Temperature	About 0°C	Up to 200°C	Mild	Mild
(c) Pressure	< 10 mbar	Limited	>10 mbar	Limited

CFU/g displayed increased resistance to simulated gastric (pH 1.2) and bile salt (1% w/v) conditions. B. bifidum microencapsulated with alginate and gelatin demonstrated superior efficacy after three months of storage at 37°C and 60-65% relative humidity.

Sun *et al*. (2021) explored the survival of *L. plantarum* in wall materials like trehalose hydrogel, pullulan, and WPC, achieving a survival rate of approximately 94.36±1.06% for the freeze-dried culture. Rajam *et al*. (2012) encapsulated *L. rhamnosus* using denatured WPI and SA wall materials, resulting in freeze-dried probiotics with a cell viability of 92-96%. The combination of WPI and SA wall materials not only provided better protection *for L. rhamnosus* but also ensured its prolonged and controlled release in bile and acidic environments.

Reddy *et al*. (2009) investigated the impact of various cryoprotectants, including lactose, skim milk, and maltodextrin, on the characteristics of freeze-dried cultures of *P. acidilactici, L. plantarum,* and *L. salivarius.* Maltodextrin proved most effective, exhibiting the highest viability (83%) for L. plantarum after 60 days of storage at 4°C, compared to lactose and skim milk.

Jalali *et al.* (2012) developed probiotic capsules combining *L. paracasei subsp. tolerance* and *L. delbrueckii subsp. bulgaricus*, employing cryoprotectants such as sodium ascorbate, trehalose, and skim milk during freeze drying. The maximum survival rate of 72-76% was achieved with freeze-dried cultures containing 6% skim milk, 8% trehalose, and 4% sodium ascorbate as cryoprotectant. Jofré *et al*. (2014) explored the protective effects of glucose, lactose, trehalose, and skim milk on the survival rate of Lactobacillus strains after freeze drying, revealing an initial survival percentage of approximately 94%, which decreased over a 39-week storage period at 4°C and 22°C. Gwak *et al*. (2015) reported potent protective effects of 10% w/w soy powder as a cryoprotectant on freeze-dried Lactobacillus brevis WK12 and *Lactobacillus lactis* WK11, resulting in high viability (1.85×1011 CFU/g and 1.89×1011 CFU/g, respectively).

In optimizing the concentrations of encapsulating components like FOS and SA for freeze-drying *L. rhamnosus*, Azam *et al.* (2020) assessed various formulations. The use of 50%SA+50%FOS and 25%SA+75%FOS as encapsulating materials yielded the highest encapsulation efficiency of 91±15% and viability of 8.9±0.1 log CFU/g for freeze-*dried L. rhamnosus*, showcasing improved stability and encapsulation effectiveness in gastrointestinal conditions for these formulations compared to pure FOS.

Conclusions

In recent years, encapsulation techniques used to enhance the shelf life of the dairy product and improve their functional properties. Encapsulated probiotic cultures are used for fermented dairy products such as cheese, curd and yogurt etc. Encapsulated dried powder prolongs the quality and nutritive value of fermented foods. Majorly probiotic cultures enhance the flavour, texture and aroma of milk-based products. However, encapsulated dried probiotic culture has a longer shelf life and storage for a longer time. Cryoprotectants are used during freeze-drying techniques to prolong the freeze-dried probiotic culture. Probiotic culture is beneficial for health and improves the gastrointestinal tract. Freeze-dried probiotic culture are used to boost the immune system and enhance the epithelial cells. Protective agents improve the survival rate and viability of freeze-dried probiotic culture.

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Ovicidal Effect of Bio Products on *Galleria mellonella* in *Apis melifera* Colony at Beekeepers' Apiary, Morena

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Abstract

A field experiment was carried out to evaluate the effect of bio products on the hatching percentage of greater waxmoth (G*alleria mellonella* L.). Data revealed during observation period egg hatching per cent was completely abstained due to treatment Bt, Biobit @ 9 gm concentration. Overall minimum hatching percentage of greater waxmoths' eggs was recorded in treatment Pongamia oil @ 0.5% concentration (0.06%) followed by, Citronella oil @ 0.5% concentration (3.88%), Garlic clove extract @ 5% concentration (7.89%), Tobacco leaf extract @ 5% concentration (10.02%) and Bt, Biobit @ 7 gm concentration (10.10%) whereas, maximum hatching per cent was recorded on treatment NSKE @ 3% concentration (45.12%) followed by Tobacco leaf extract @ 3% concentration (44.71%), Bt, Biolep @ 5 gm concentration (44.01%) and Garlic clove extract @ 3% concentration (32.73%) as compare to other treatments. No effect on egg hatching was found in Untreated check (98.58%). All the treatment was showed significant effect at mean per cent egg hatching. Unlike other invertebrates, adult female of *G. mellonella* can be incubated preferably at 30-35^{o}C temperature as well as 50-60% RH, whereas the environmental condition on Chambal region is extremely warm in summer and also unfavorable in winter. Biotic factors are also one of the major challenges for beekeepers.

Key words : *Apiary, Apis mellifera, bio products, eggs, Galleria mellonella, hatching percentage.*

Introduction

Beekeeping is important practice for securing food, poverty reduction, health, environmental protection and plant pollination. These practices are challenged by various biotic and abiotic factors in recent years. These factors influence honey bees and their important products either in combination or alone (Kapil and Sihag, 1983). The environmental factors like extreme temperature, relative humidity, lack of water, deforestation, human factors like poor apicultural practices, use of synthetic pesticides, diseases, and insect pests led to the decline of honeybee colonies and their products (Swamy, 2003). However, the world market demand for honey and other bee products has increased enormously in recent decades since it's important for a wide variety of uses and applications (Mulatu and Gebissa, 2021).

Greater waxmoth are most effectively managed through the maintenance of proper sanitation. This includes keeping up the colony healthy and covering cracks and crevices with proper sources of food. Beekeepers need to have a suitable storage space for hive materials that are vulnerable to pest attacks and to protect colonies from diseases and pests (Omkar, 2017). Physical method techniques are advantageous since the growth and development of GWM are dependent on environmental factors such as temperature (Brar *et al*., 1996).

Neem, Pongamia, Tulasi, *Eucalyptus*, Annona, Clerodendron plant extracts works effectively to control of waxmoth larvae (Surendra *et al*., 2010). *Azadirachtin* disrupted the moulting process in larva and pupa and also induced mortality (Malczeuska *et al*., 1988). The oil of *Origanum majorana* was highly lethal to *G. mellonella*. Neem oil, cedar oil, clove oil, peppermint oil, Karang oil, and neem seed kernel extract highly effects mortality greater waxmoth (*G. mellonella*) in controlled conditions (Kalpana *et al*., 2017).. Tobacco leaf extract, neem oil, castor oil, and groundnut oil were moderately effective in checking egg hatching by *G. mellonella* in live colonies. On feeding the *G. mellonella* larvae in artificial diets contains 0.5, 1, 2, and 4% Neemazal -T/S caused 100% mortality (Lalita *et al*., 2018). With the improvement of new techniques in the field of biotechnology, there was the capability of making a breakthrough using *Bacillus thuringiensis* (Ritter *et al*., 2006).

Materials and Methods

Field studies on the evaluation of bio products were carried out during 2020-21 and 2021-22, at beekeepers' apiary, Morena district under KVK-RVSKVV Gwalior, (M.P.). The effect of different bio products on egg hatching

of greater waxmoth were subjected to different concentrations of bio products such as Pongamia oil, Citronella oil, Neem seed kernal extract, Garlic clove extract, Tobacco leaf extract and commercial formulations of *B. thuringiensis* Var. *kurstaki* such as Biobit (32,000 IU mg^{-1}) and Biolep (16,000 IU mg^{-1}). The details of the field experiments conducted were as mention bellow (Table-1).

The two different oils were mixed with water separately to obtain a concentration of 0.3, 0.4 and 0.5 per cent. For making the plant extract of three different extracts, first crushed and powdered the material and then soaked in water for 24 hours. After 24 hours the liquid was strained through a fine muslin cloth and the additional quantity of water was added to make-up the volume for required concentrations of three, four and five per cent. The commercial formulations of Bt, Biobit (32,000 IU mg^{-1}) and Biolep (16,000 IU mg^{-1}) were mixed with water to obtain an emulsion of different dosages (5, 7 and 9 grams). Observations were made once in 24 hours, to record the eggs hatching of greater waxmoth. Number of eggs hatched was expressed as percentages. These values were transformed by using Arc Sin values and analysed statistically by analysis of variance using RBD (Randomized Block Design; Sundararaj *et al.,* 1972).

All the hives were cleaned thoroughly before application and once in a week after application of the bio products. The eggs, larvae and debris, if any present on the bottom board were cleaned thoroughly using a hive tool. The bio products were smeared on the spaces and grooves present between the bottom board and brood chamber, brood chamber and super chamber, super chamber and roof which are vulnerable for egg laying by waxmoths. A control was maintained without treating any of the products and also without cleaning.

Results and Discussion

The data recorded on effect of different concentration of bio products on the hatching percentage of greater waxmoth eggs at one, two, three and four week after treatment (WAT) (Table-2).

At one week after treatment no egg hatching was observed in treatment *Bt*, Biobit @ 9 gm concentration. Minimum hatching percentage was found in treatment Pongamia oil @ 0.5% concentration (0.22%) whereas, maximum hatching percentage was found in Tobacco leaf extract @ 3% concentration (84.48%) followed by NSKE @ 3% concentration (71.90%) as compare to untreated control (99.78%). Result showed the highest ovicidal effect of greater waxmoth at higher concentrations of bio products and lowest effect at lower concentrations of bio products. The present finding supports the findings of Viraktamath *et al.* (2005), and Gowda and Roopa (2001) who reported lowest hatching percentage of greater waxmoth eggs using plant origin insecticides.

At two weeks after treatment data showed significant effect on hatching percentage of greater waxmoths' eggs, and no egg hatching was found in treatment Pongamia oil @ 0.5% concentration and *Bt*, Biobit @ 9 gm concentration. Minimum hatching percentage was recorded in Citronella oil @ 0.5% concentration (3.24%) followed by Garlic clove extract @ 5% concentration (7.46%) whereas, maximum hatching percentage was recorded in Tobacco leaf extract @ 3% concentration (57.03%) followed by NSKE @ 3% concentration (55.55%) and *Bt*, Biolep @ 5 gm concentration (53.49%) as compare to untreated control (99.55%).

Similarly at three weeks after treatment data showed significant effect on hatching percentage of greater waxmoths' eggs, and no egg hatching was found in treatment *Bt*, Biobit @ 9 gm concentration and Pongamia oil @ 0.5% concentration even in Citronella oil @ 0.5% concentration. Minimum hatching percentage was recorded in *Bt*, Biobit @ 7 gm concentration (0.22%) followed by Tobacco leaf extract @ 5% concentration and Garlic clove extract @ 5% concentration (both 0.33%) whereas, maximum hatching percentage was recorded in NSKE @ 3% concentration (38.89%) followed by *Bt*, Biolep @ 5 gm concentration (30.63%) as compare to untreated control (96.22%). Verma (1995) also witnessed a similar efficacy of Dipel on eggs of *G. mellonella* in *A. cerana* colonies.

At four weeks after treatment result showed significant effect on hatching percentage of greater waxmoths' eggs and minimum hatching per cent was recorded in Pongamia oil @ 0.4% concentration and NSKE @ 4% concentration (both 0.11%) followed by Citronella oil @ 0.4% concentration and Tobacco leaf extract @ 4% concentration (both 0.22%) whereas, maximum hatching per cent was recorded in *Bt*, Biolep @ 5 gm concentration (21.11%) followed by Garlic clove extract @ 3% concentration (15.46%) and Tobacco leaf extract @ 3% concentration (14.81%) as compare to untreated control (98.78%). No hatching was observed in other treatments. Goodwin (1985) also found adequate control of egg hatching by using B 401 (a formulation of *Bt* spores and crystals) and other plant products for a longer period of time.

Data revealed during observation period egg hatching was completely abstained due to treatment *Bt*, Biobit @ 9 gm concentration. Overall minimum hatching percentage of greater waxmoths' eggs was recorded in treatment Pongamia oil @ 0.5% concentration (0.06%) followed by, Citronella oil @ 0.5% concentration (3.88%), Garlic clove extract @ 5% concentration (7.89%),

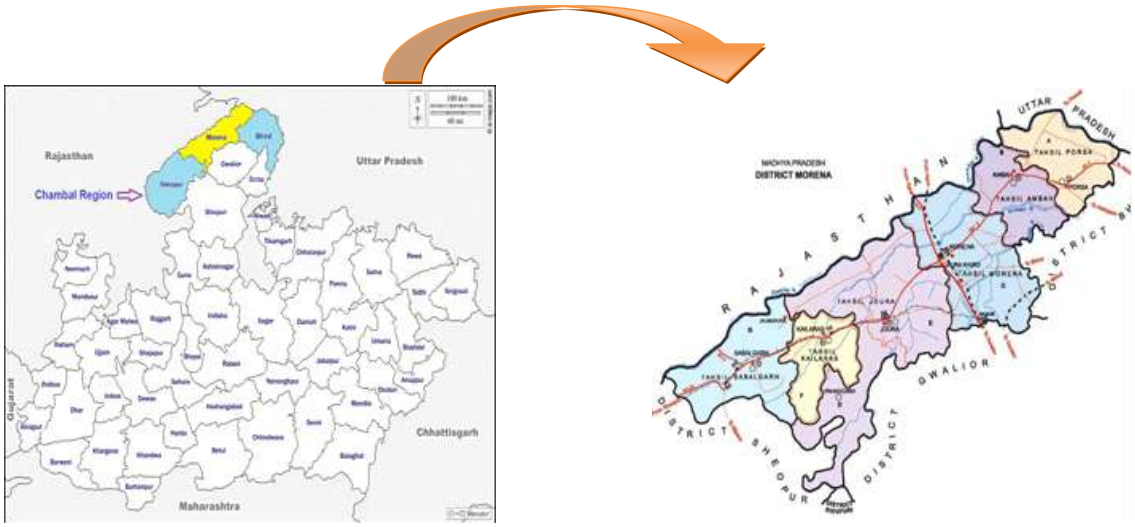

Fig.-1 : Location map of study area.

Treatments details :

Number of treatments : 22
Number of Replication : 3
Design : RBD (Randomized Block Design)

Table-1 : Treatments details

Treatment code	Treatment name	Per cent concentration	Treatment code	Treatment Name	Per cent concentration
T1	Pongamia oil	0.3	T12	GCE	5
T2		0.4	T13	Tobacco leaf extract	3
T3		0.5	T14		4
T4	Citronella oil	0.3	T15		5
T5		0.4	T16	*Bt.* Biobit (32,000 IU mg^{-1})	5
T6		0.5	T17		7
T7	NSKE	3	T18		9
T8		4	T19	*Bt.* Biolep (16,000 IU mg^{-1})	5
T9		5	T20		7
T10	Garlic clove extract	3	T21		9
T11		4	T22	Untreated control	

(NSKE-Neem seed karnal extract, GCE-Garlic Clove Extract, Bt.-*Bacillus thuringiensis* Var. *Kurstaki*)

Tobacco leaf extract @ 5% concentration (10.02%) and Bt, Biobit @ 7 gm concentration (10.10%) whereas, maximum hatching per cent was recorded on treatment NSKE @ 3% concentration (45.12%) followed by Tobacco leaf extract @ 3% concentration (44.71%), Bt, Biolep @ 5gm concentration (44.01%) and Garlic clove extract @ 3% concentration (32.73%) as compare to other treatments. No effect on egg hatching was found in Untreated check (98.58%). All the treatment was showed statistically significant effect in mean per cent egg hatching. MC Killup and Brown (1991), Izhar-ul-Haq *et al.* (2008), Swamy *et al.* (2003), and Kapil and Sihag (1983) also studied the effect of Bt as a biocontrol agent against eggs of *G. mellonella* and found effective to controlling *G. mellonella* without any adverse effect on the honeybees.

Conclusions

From the entire experimental investigation, it can be concluded that different concentrations of bio products influenced the growth and development of eggs of *G. mellonella* adult female. Efficacy of bio products was recorded maximum in application of higher concentration on apiary and also hatching per cent of eggs of greater waxmoth was shorter. Maximum reduction on egg hatching was recorded in Bt, Biobit (32,000 IU mg^{-1}) @ 9 gm concentration followed by Pongamia oil @ 0.5%

Table-2 : Effect of bio products on eggs of *G. mellonella* in different time period.

Treatment	Bio-products	1 WAT	2 WAT	3 WAT	4 WAT	Mean
T1	Pongamia oil @ 0.3% concentration	45.13 (42.18)	35.36 (36.49)	21.68 (27.73)	11.81 (20.03)	28.50 (31.61)
T2	Pongamia oil @ 0.4% concentration	14.22 (22.12)	14.73 (22.55)	13.11 (21.19)	00.11 (01.10)	10.54 (16.74)
T3	Pongamia oil @ 0.5% concentration	00.22 (01.55)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.06 (00.39)
T4	Citronella oil @ 0.3% concentration	46.78 (43.14)	36.19 (36.96)	28.79 (32.37)	11.57 (19.70)	30.83 (33.04)
T5	Citronella oil @ 0.4% concentration	16.00 (23.54)	15.46 (23.13)	08.71 (16.31)	00.22 (01.55)	11.42 (14.50)
T6	Citronella oil @ 0.5% concentration	12.29 (20.47)	03.24 (05.27)	00.00 (00.00)	00.00 (00.00)	03.88 (06.44)
T7	NSKE @ 3% concentration	71.90 (58.09)	55.55 (48.20)	38.89 (38.54)	14.14 (21.74)	45.12 (41.64)
T8	NSKE @ 4% concentration	43.47 (41.24)	26.00 (23.79)	21.68 (27.73)	00.11 (01.10)	22.82 (23.47)
T9	NSKE @ 5% concentration	36.19 (36.96)	26.00 (30.64)	14.81 (19.99)	00.00 (00.00)	19.25 (21.90)
T10	Garlic clove extract @ 3% concentration	56.51 (48.74)	32.96 (35.01)	26.00 (23.79)	15.46 (23.13)	32.73 (32.67)
T11	Garlic clove extract @ 4% concentration	39.39 (38.86)	25.54 (22.83)	17.39 (24.60)	08.71 (16.31)	22.76 (25.65)
T12	Garlic clove extract @ 5% concentration	23.78 (29.12)	07.46 (11.31)	00.33 (02.65)	00.00 (00.00)	07.89 (10.77)
T13	Tobacco leaf extract @ 3% concentration	84.48 (66.91)	57.03 (49.05)	22.51 (28.30)	14.81 (19.99)	44.71 (41.06)
T14	Tobacco leaf extract @ 4% concentration	55.55 (48.20)	43.33 (41.16)	21.11 (27.33)	00.22 (01.55)	30.05 (29.56)
T15	Tobacco leaf extract @ 5% concentration	26.64 (31.04)	13.11 (21.19)	00.33 (02.65)	00.00 (00.00)	10.02 (13.72)
T16	Bt, Biobit (32,000 IU mg^{-1}) @ 5 gm concentration	45.38 (42.33)	34.24 (35.8)	25.49 (22.91)	08.71 (16.31)	28.46 (29.34)
T17	Bt, Biobit (32,000 IU mg^{-1}) @ 7 gm concentration	29.33 (32.77)	16.12 (23.66)	00.22 (01.55)	00.00 (00.00)	10.10 (16.13)
T18	Bt, Biobit (32,000 IU mg^{-1}) @ 9 gm concentration	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)	00.00 (00.00)
T19	Bt, Biolep (16,000 IU mg^{-1}) @ 5 gm concentration	70.79 (57.32)	53.49 (46.99)	30.63 (33.58)	21.11 (27.33)	44.01 (41.31)
T20	Bt, Biolep (16,000 IU mg^{-1}) @ 7 gm concentration	34.16 (35.76)	32.47 (34.70)	28.56 (32.30)	14.44 (22.30)	27.41 (31.27)
T21	Bt, Biolep (16,000 IU mg^{-1}) @ 9 gm concentration	28.56 (32.30)	14.36 (20.08)	07.99 (16.40)	01.40 (05.55)	13.08 (18.58)
T22	Untreated control	99.78 (88.44)	99.55 (86.87)	96.22 (80.73)	98.78 (85.73)	98.58 (85.44)
	Mean	40.03 (38.23)	29.19 (29.80)	19.29 (21.85)	10.07 (12.88)	24.65 (25.69)
	Sem	1.22	1.49	2.15	1.60	1.20
	CD (5%)	3.59	4.25	6.15	4.57	3.44

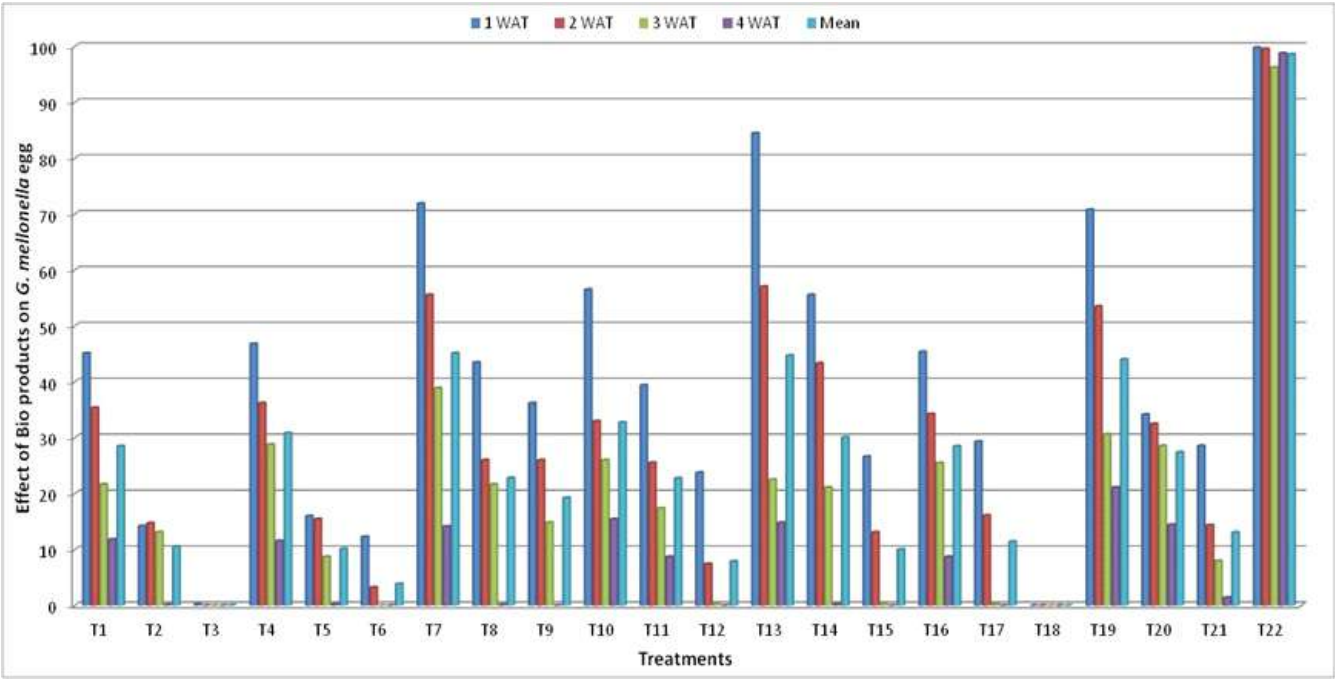

Fig.-2 : Effect of bio products on the greater waxmoth eggs at 1, 2, 3 and 4 week after treatment in Apiary.

concentration, minimum reduction on egg hatching was recorded in Tobacco leaf extract @ 3% concentration and NSKE @ 3% concentration.

Future scope

For the management of grater waxmoth infestation, the higher concentration of bio products and plant originated (natural occurring) ecofriendly biopesticides (*viz*., pongamia oil and citronella oil more than 6 per cent concentration, eucalyptus oil, peppermint oil, onion extract and malagueta pepper extract) should be used for further experimental findings. The observation may vary depends on different biotic and abiotic factors, but it is similar to the natural condition, so further work is suggested on different natural diet sources for the biological study of greater wax moth.

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Effect of Different Types of Fruit Bagging on Quality of Harvested Guava Fruits (*Psidium guajava* L.) cv. Lalit

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Abstract

An investigation on improvement of quality of guava cv. Lalit fruits through bagging was carried out at Department of horticulture, Suresh Gyan Vihar University India during November 2022-feb 2023. The area of experiment was dry and comes under subtropical, with hot summers and cool winters of Rajasthan. Various different bags colours i.e. Butter paper, Brown paper, White paper and News paper, Yellow polyethylene, Blue polyethylene, Red polyethylene, White polyethylene and Trans-parent polyethylene were included for the study and uncovered fruits were kept for the control. The results revealed that fruit bagging in general, improved the growth and quality development of guava fruits as compared to un-bagging control. It was also observed that fruit size, weight and pulp content increased due to fruit covering. Fruit was found maximum in size under brown paper bag followed by white paper bag and yellow polyethylene bag. Fruit bagging also improved the fruit quality in terms of TSS, total sugars and TSS: acid ratio which were found maximum (28.32° Brix, 82.28% and 8.59, respectively) under brown paper bags,and fruit weight and fruit volume was found maximum in under paper bag followed by white paper bags. Among the various fruit covering materials bagging with brown paper bags was found to be the best for overall improvement of physico-chemical quality of winter season guava cv. Lalit subtropical, with hot summers and cool winters.

Key words *: Guava, paper bag ,polyethylene bag, quality, yield.*

Introduction

Guava (*Psidium guajava* L.), often known as “poor man’s apple,” is a Myrtaceae family member. It is a popular fruit crop that is widely grown throughout the world’s tropical and subtropical climates. The fruit originated in tropical America and spread from Mexico to Peru before reaching many nations worldwide. The Guava was domesticated due to its outstanding adaptability to a wide range of climatic conditions, hardiness, and prolific bearing (Mishra *et al.* 2017). Guava, also known as the “apple of India,” is the country’s most common and important fruit, ranking fifth in terms of area and productivity behind mango, citrus, banana, and apple (Sharma *et al.* 2018). Guava has become so popular in India that it looks to be a native fruit. It is grown successfully in UP, MP, Bihar, MH, West Bengal, Orissa, and Tripura in India. Uttar Pradesh is the most important guava-growing state in India, and the Allahabad-Varanasi region is noted for producing the best guavas in the country and around the world. In 2021, India produced 4.58 million tonnes from an area of 3.06 lakh hectares, accounting for 4% of total global production (NHB Database 2021). The major guava producing areas in rajasthan include Sawaimadhopur, tonk accounts for 3.06% of overall production in India.

Guava has become a popular fruit due to its high market consumption, demand, and profit. The fruit is climatic, delicious, and nutrient-dense. The fruit easily fits into the burgeoning functional food category known as “Super-fruits.” The guava fruit provides 14.3 grams of carbs. Protein content is 2.55 grams. Lycopene 5204g, Vitamin-C 228 mg, Calcium 8 mg, Energy 68 kcal, Vitamin-A 624 IU, and 496 mg/100 gram fruit anti-oxidant (Nagaraju and Banik, 2017). Guava fruits are eaten fresh as well as used to make jam, jelly, paste, toffees, and sweets. Traditional medicine uses guava fruits, leaves, and roots to cure dysentery, and other diseases (Patel *et al.* 2015).

In north Indian agro-climate conditions, guava flowers twice a year: once in April-May for the rainy season crop, and once in September-October for the winter season harvest. The rainy season harvest yields more fruit than the winter season crop, but the flavor and quality of the rainy season produce are lower (Maji, 2015).

Fruit covering has been found to be useful for protecting against fly assault and boosting fruit quality among the many ways. According to several workers, pre-harvest bagging boosted fruit growth and development when compared to the open environment

(Patil, 2003; Kawit and Siriwan, 2002). Pre-harvest bagging can also produce a more appealing fruit weight, enhancing growers' export potential and profit (Singh *et al*.2006).Fruit bagging is a phytosanitary method that is commonly employed to increase aesthetic quality by encouraging fruit colour, but it also improves internal fruit quality and minimizes the frequency of insects, pests, and illnesses. Pre-harvest bagging affects fruit size, maturity, peel color, flesh mineral content, and fruit quality, which could be attributable to bag type differences. It helps to reduce or eliminate the usage of insecticides and fungicides (Jia *et al.,* 2005;Lemos and Silva, 2002; Pinheiro, 2006).

This strategy has been used by several countries to combat fruit fly damage. Pre-harvest bagging, on the other hand, has been widely used in a range of fruit crops to boost skin color and minimize splitting, mechanical damage, and sunburn of the skin. Fruit bagging before harvest reduces pesticide residue effects, prevents sunburn, reduces mechanical damage, and controls insect pest damage (Amarante *et al*. 2002). Fruits such as mango, apple, litchi, strawberries, and grapes can benefit from pre-harvest bagging to improve ripening and decrease disease and physical damage (Jia *et al.* 2005).This is a green strategy because there will be no pesticide residue on the fruit or in the environment. Fruit bagging can help lessen the occurrence of mechanical damage, illness, fruit sunburn, and bird damage (Sharma *et al*. 2014).

Polyethylene (in various colors), kraft paper, aluminum foil, and polyester are examples of guava bagging materials. To some extent, most bagging materials can protect humidity and gas exchange. Tissue paper, black polythene, brown paper, newspaper, and white polythene have all been recorded as being used in guava packing by various workers. Though few tests were conducted with the primary goal of examining the effect of fruit bagging on the effects of fruit fly attack and pests/diseases, some results revealed that fruit bagging influenced the growth and development of fruit, maturity as well as quality parameters of guava fruits (Meena *et al*. 2016).

Materials and Methods

The present investigation entitled "Effect of Different Types of Fruit Bagging on Quality of Harvested Guava Fruits (*Psidium guajava* L.) cv. Lalit," was carried out in the Guava fruit orchard Ranoli, Sikar Rajasthan in 2022–2023. This chapter includes a description of the specific experimental tools, processes, and methods used during the experiment The experiment was laid down in Randomized Block Design which consisted 10 treatment combinations viz.

B_0 Control (no Bagging) ,B_1 Bagging with Butter paper bag, B_2 Bagging with Brown paper bag ,B_3 Bagging with White paper bag ,B_4 Bagging with Newspaper bag, B_5 Bagging with Yellow Polyethylene bag, B_6 Bagging with Blue Polyethylene bag ,B_7 Bagging with Red Polyethylene bag ,B_8 Bagging with White Polyethylene bag, B_9 Bagging with Transparent Polyethylene bag and replicated three times. Randomly three fruits were selected from each replication of the treatment for recording the physical and bio-chemical characteristics and organoleptic test.

Results and Discussion

The experimental findings of the investigation entitled "Effect of Different Types of fruit Bagging on Quality of Harvested Guava Fruits (*Psidium guajava* L.) cv. Lalit" are presented in this chapter

Physical parameter : The data present in Table-1 revealed that the physical parameters of fruit are an expression of a plant's vegetative activity, which was also significantly influenced by bagging with different types of paper bags and polyethylene bags. The results showed that maximum fruit length (7.50 cm), width (7.73 cm), fruit weight (175.09 g), volume (171.85 ml), optimum specific gravity (1.02), pulp weight (166.78 g), pulp thickness (2.85 cm), pulp percent (97.58%) and minimum seed weight per fruit (6.24g) with the treatment of B_2 (bagging with brown paper bag) at harvest were significantly superior to B_0 (no bagging). The results indicate that all bagged treatments were superior to un-bagged (control) fruits. This might be due to the micro climate surrounding the fruit being changed favorably by fruit bagging that leads to more fruit length. The a-biotic factors temperature and humidity play a critical role in fruit growth and development. Bagging on fruits alters the micro environment around them (Sharma *et al.,* 2014).

Bio chemical parameter : The data present in Table-2 revealed that the treatments of bagging with paper bags and polyethylene bags not only increase the physical properties of fruits but also improve the fruit quality. Their application alone or in combination influenced significantly the chemical constituents of the fruit, *viz.,* TSS, tiratable acidity content, TSS: acidity ratio, total sugar, reducing sugar, ascorbic acid. The maximum TSS (28.32 ^{0}Brix) were found in B_2 (bagging with brown paper bag), TSS: acidity ratio(82.28) were found in treatment (B5) bagging with a yellow polyethylene bag, titratable acidity in (0.60%) were found in treatment B0 (no bagging), while maximum total sugars (8.59%), the maximum reducing sugar (5.23%) were found in treatment B_2 (bagging with brown paper bag). The maximum ascorbic acid content (195.39mg) was found in treatment B3 (bagging with white paper bag).

	Treatments	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Fruit volume (ml)	Specific gravity	Pulp weight (g)	Pulp thickness (cm)	Pulp (%)	Seed weight per fruit (g)
B_0	Control (no Bagging)	6.01	6.63	140.64	146.40	0.96	137.05	1.30	83.95	7.39
B_1	Bagging with Butter paper bag	6.60	6.75	165.13	154.10	1.07	154.68	1.92	93.89	6.87
B_2	Bagging with Brown paper bag	7.50	7.73	175.09	171.85	1.02	166.78	2.85	97.58	6.24
B_3	Bagging with White paper bag	6.98	7.37	159.33	150.73	1.06	159.94	2.47	94.20	6.28
B_4	Bagging with Newspaper bag	6.93	7.08	157.11	148.14	1.06	153.38	1.86	87.75	6.73
B_5	Bagging with Yellow Polyethylene bag	7.30	7.35	158.20	152.07	1.04	152.60	2.08	94.26	6.60
B_6	Bagging with Blue Polyethylene bag	7.27	7.64	162.88	153.10	1.07	153.57	2.20	96.05	6.44
B_7	Bagging with Red Polyethylene bag	6.73	7.30	162.44	155.05	1.05	151.63	1.91	95.97	6.48
B_8	Bagging with White Polyethylene bag	6.57	6.92	167.70	158.87	1.06	145.68	1.71	88.61	6.95
B_9	Bagging with Transparent Polyethylene bag	6.46	6.90	163.60	153.61	1.07	139.88	1.56	92.05	7.07
	S.Em. ±	0.14	0.14	2.77	2.60	0.03	2.71	0.06	1.55	0.11
	C.D. at 5%	0.42	0.40	8.24	7.72	0.08	8.04	0.18	4.61	0.34

	Treatments	TSS (°Brix)	Titratable acidity %	TSS/Acid ratio	Total sugars (%)	Reducing sugar (%)	Ascorbic acid (mg/100 g)
B_0	Control (no Bagging)	10.26	0.60	17.39	6.18	3.53	167.47
B_1	Bagging with Butter paper bag	13.60	0.54	25.23	6.83	3.97	177.59
B_2	Bagging with Brown paper bag	28.32	0.35	82.28	8.59	5.23	195.39
B_3	Bagging with White paper bag	23.34	0.41	57.55	8.44	4.43	190.49
B_4	Bagging with Newspaper bag	21.84	0.42	52.48	7.52	4.26	185.51
B_5	Bagging with Yellow Polyethylene bag	25.09	0.37	68.46	7.90	4.72	185.07
B_6	Bagging with Blue Polyethylene bag	17.57	0.47	37.67	7.66	4.50	175.40
B_7	Bagging with Red Polyethylene bag	16.55	0.42	39.12	7.42	4.07	180.79
B_8	Bagging with White Polyethylene bag	14.98	0.52	29.02	7.68	4.46	187.79
B_9	Bagging with Transparent Polyethylene bag	12.96	0.53	24.51	7.21	3.42	175.20
	S.Em. ±	0.41	0.01	1.79	0.16	0.09	3.08
	C.D. at 5%	1.22	0.03	5.31	0.46	0.26	9.14
	Cv	6.68	7.62	12.35	6.17	6.14	5.07

	Treatments	Taste	Colour	Aroma
B_0	Control (no Bagging)	6.00	6.00	6.33
B_1	Bagging with Butter paper bag	7.67	6.67	6.33
B_2	Bagging with Brown paper bag	8.33	8.33	8.67
B_3	Bagging with White paper bag	7.67	7.33	7.00
B_4	Bagging with Newspaper bag	7.33	7.33	7.67
B_5	Bagging with Yellow Polyethylene bag	8.00	7.67	7.33
B_6	Bagging with Blue Polyethylene bag	7.67	7.67	8.00
B_7	Bagging with Red Polyethylene bag	7.33	7.33	7.67
B_8	Bagging with White Polyethylene bag	7.67	7.67	7.33
B_9	Bagging with Transparent Polyethylene bag	7.33	7.00	7.00
	S.Em. ±	0.20	0.23	0.23
	C.D. at 5%	0.60	0.69	0.68
	Cv	8.03	9.54	9.43

Organoleptic test : The data present in Table-3 revealed that The organoleptic test was also improved. The fruit was bagged in different bags (paper bags and polyethylene bags). Fruits bagged in brown paper bags were found significantly superior in the organoleptic test with the highest scores in terms of fruit taste, colour and aroma (8.33, 8.63 and 8.67, respectively), rated as like very much to Like extremely, while the control obtained the lowest scores in terms of taste, colour and aroma (4.4, 5.8 and 5.6), respectively. Similarly, earlier workers have also reported that fruit bagging can improve fruit quality mainly by keeping the fruit appearance and preferable uniform coloration of the fruit, as reported in Singh *et al.,* (2017) and Sarker *et al.,* (2009). Rahman *et al.,* (2018)

reported the colour of open fruits was light green and the surface was rough. They were bagged with brown paper and white paper improved the colour of the fruit with a yellowish green color and smooth surface.

Conclusions

The significant findings, as above, from the experiment carried out, bring the conclusion that physical, bio-chemical properties and organoleptic characteristics of guava fruits can be influenced by bagging with different types of paper and polyethylene bags. It is concluded that bagging of guava fruits with brown paper bags may be recommended to enhance the physical characteristics, bio-chemical properties and they also have better organoleptic properties .

B_0Control (no Bagging) B_1 Bagging with Butter paper bag B_2 Bagging with Brown paper bag B_3 Bagging with White paper bag B_4 Bagging with Newspaper bag B_5 Bagging with Yellow Polyethylene bag B_6 Bagging with Blue Polyethylene bag B_7 Bagging with Red Polyethylene bag B_8 Bagging with White Polyethylene bag B9 Bagging with Transparent Polyethylene bag

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Assessment of Seminal Quality Parameters of Magra Ram in Arid Bikaner Region during Breeding Season

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Abstract

The purpose of this study was to assess the essential characteristics of fresh Magra ram semen. A total of eight adult Magra rams weighing 38 ± 5 kg and possessing a strong libido were chosen at random to have their semen quality evaluated. Using the artificial vagina procedure, semen was taken twice a week for three weeks in a row. A total of forty-eight fresh seminal ejaculates were obtained and examined for both functional and physico-morphological characteristics. The following mean values of fresh semen were measured and recorded: 0.87±0.02, 4.36±0.08, 6.76±0.03, 82.77±0.52, 4335.63±63.42, 1.75±0.18, 85.07±0.62 for ejaculated volume, mass motility (0–5), pH, individual sperm motility (%), sperm concentration (millions/ml), sperm abnormality (%) and sperm viability (%), respectively. According to this study, the majority of the seminal characteristics that were assessed for semen quality fell within the range of good quality semen and semen may be preserved for artificial insemination in the field to speed up genetic advancement.

Key words : *Ram, artificial insemination, fresh semen, breeding season.*

Introduction

The Indian agricultural economy relies significantly on the commercially vital livestock species known as sheep (*Ovis aries*), particularly in arid and semi-arid regions and hilly areas. A significant portion of Rajasthan state's landless laborers and tiny, marginal farmers practice sheep farming. In particular, sheep farming gives the rural residents of the less fortunate segments of society a means of subsistence and nutrition. Sheep are raised for their several uses, including meat, wool, milk, manure, and skin, in an arid and extreme region where crop and dairy production is not profitable (Pampori *et al*., 2018). Sheep numbers in India now 74.26 million, up 14.13 percent from the 2012 census. With 7.9 million sheep, Rajasthan has 13.86 percent of India's total population. India is the world's seventh-largest producer of raw wool, accounting for 1.8 percent of global production, with approximately 4.2 percent of the world's sheep population (20th Livestock Census, 2019). In and around the Bikaner, Nagaur and Churu regions of Rajasthan Magra sheep are extensively dispersed. The Magra breed is proud of producing the world-famous carpet wool and is known locally as Bikaneri Chokhla. In addition, it is well-known for its capacity to survive in a severe semi-arid climate and on limited supplies of grain and fodder.

The majority of sheep bred in fields yield little and is non-descript. Controlling reproductive efficiency is essential for maintaining and expanding the pure breed's superior genetics as well as increasing farmers' income. Artificial insemination (AI) is one of the effective tools in reproductive assisted procedures to accelerate genetic progress. It makes it easier for a superior sire to distribute semen to a large number of females, which improves the production of milk, meat, and wool, among other desirable traits (Maxwell and Salamon, 1993). The primary component that has a greater impact on male fertility in sheep is the quality of the semen. Worldwide, sheep are artificially inseminated cervically using fresh ram semen (Evans and Maxwell, 1987). Male fertility is typically assessed using biochemical evaluations in conjunction with physical semen examinations (Hafez, 1987). Physical characteristics of semen, such as volume, color, motility, spermatozoa concentration, percentage of living spermatozoa, morphologically abnormal sperms and acrosomal integrity, are generally investigated to assess the quality and fertility of the semen (Pal, 1957; Kumar,

2014; Allai *et al*., 2018). O'Hara *et al*. (2010) state that artificial insemination (AI) utilizing fresh, liquid-preserved, or frozen-thawed semen boosts the rate of lambing in sheep breeding. According to Anel *et al*. (2005), fresh semen can effectively be utilized in artificial insemination in ewes with a 40–60% conception rate via the cervix. Fresh semen, however, has a short shelf life and a small window for transportation, which limits the dissemination of AI in field conditions (Najafi *et al*., 2014). The assessment of ram's semen is essential in predicting its reproductive success and profitability before AI is applied (Maclaren, 1988). Thus, the current study aimed to analyze Magra Ram's fresh semen properties which can be used for AI or field breeding.

Materials and Methods

Experimental location and management of animals : The current study was conducted in February and March of 2021 at the ICAR-CSWRI, Arid Region Camps, Bikaner, Rajasthan (India). The location of Bikaner is 230 meters above mean sea level, at 73°18'E longitude and 28°1'N latitude. There is 200 to 300 mm of annual rainfall in the area, which is distributed unevenly throughout the year due to its dry climate. The ambient temperature falls between 4ºC and 49ºC on a yearly basis. The vegetation in this area comprises of fodder shrubs and trees (*Prosopsis cineraria, Acacia senegal* and *Azadirachataindica*) and grasses (*Indigoforacardifolia, Zizyphusnummularia* and *Crotolariabruche*). Healthy breeding Magra rams (n = 8), with an average age of 1.5–3 years, body weight 38 ± 5 kg with good libido were used as semen donors using artificial vagina technique. Rams were permitted to graze in free land pasture for at least 7 hrs per day and provided dry roughage and concentrate in pellets form according to the requirement given by Indian Council of Agricultural Research (ICAR, 2013). All the rams were housed under the same managerial conditions.

Chemicals : All the chemicals used in this study were procured from Sigma Aldrich (St. Louis, MO, USA), unless otherwise indicated.

Collection : Semen collections were done twice in a week from all the eight rams for 3 consecutive weeks using an AV made up of hard rubber and measuring 20 cm in length and 4-5 cm in diameter. The AV was filled with hot water at temperature of 42-45ºC and inside pressure was adjusted by filling air intact. The AV was lubricated with liquid paraffin. Parameters like pressure, lubrication and inner temperature of AV were checked just prior to collection. Separate AV was used for each ram. The collections were obtained by exposing the ram to the oestrus ewe as dummy. A total 48 ejaculates (6 ejaculates per ram) were taken from all the experimental rams. Immediately after collection, the semen collected cup was transferred to the laboratory and placed in water bath at 37ºC for further evaluation.

Evaluation of semen quality : Immediately after collection, the fresh semen samples were analyzed for colour, consistency, volume, pH, mass motility, individual sperm motility, sperm concentration, percentage of live spermatozoa and total sperm abnormalities. The colour and consistency of fresh semen was noted directly by visual observation. The characteristics of semen according to variation in colour and consistency were graded as per Youngquist and Threlfall (2007). Mass motility (scale 0-5) was measured in each semen sample. A little drop of fresh semen was placed on a clean, dry, and pre-warmed glass side, and it was inspected under a 10X low power microscope (Dewinter Binocular Microscope, Italy). To assess individual sperm motility a drop of 5 µl freshly collected semen was mixed with 495 µl pre-warmed normal saline. A small drop was taken from the mixture on a pre-warmed glass slide and a cover slip was placed over it. The individual sperm motility was recorded in percentage depending upon progressively motile spermatozoa (0-100) observed at a high magnification (40X) of microscope on controlled warm stage. Neubaur's counting chamber (Haemocytometer) was used to measure the concentration of spermatozoa (millions/ml). 10 µl of fresh semen were diluted using 9990 µl of spermicidal diluting fluid (1:1000), following the procedure outlined by Evan and Maxwell in 1987. The digital multiparameter pH meter HI2020 (Hanna Instruments, Italy) was used to measure the pH of the semen. The eosin–nigrosin staining method (Swanson & Bearden, 1951) was used to assess abnormalities and sperm viability (the percentage of viable sperm). To prepare the slide, a small drop (30 µl) of semen was placed on a grease-free, clean slide, and the same amount of eosin–nigrosin dye was added, thoroughly mixed with a blunt end fine glass rod. After a minute, the mixture was thinly smeared onto a glass slide, allowed to air dry, and 300 spermatozoa were counted at 40X and 100X magnifications, respectively, to determine sperm viability and abnormalities. The appearance of total stain exclusion was used to assess spermatozoa viability, whereas morphological abnormalities in the head, body, or tail were regarded as abnormalities in spermatozoa (Evans and Maxwell, 1987).

Statistical Analysis : The data were analysed statistically by using one-way analysis of variance test (ANOVA) with the help of SPSS version-20 (Snedecor and Cochran, 1994).

Results and Discussion

Results of the present study are depicted in Table. The

Table : Mean values of physical properties of fresh ram semen throughout the period of the study (Mean ± SEM).

Parameter	Mean ± SEM (range)	Parameter	Mean ± SEM (range)
Volume (ml)	0.87±0.02 (0.80±0.07 to 0.92±0.06)	Sperm Concentration (millions/ml)	4335.63±63.42 (3950±117.62 to 4633.34±234.05)
Mass motility (0-5)	4.36±0.08 (4.00±0.22 to 4.5±0.18)	Sperm Viability (%)	85.07±0.62 (83.70±2.08 to 86.42±1.95)
pH	6.76±0.03 (6.65±0.07 to 6.84± 0.07)	Total Sperm Abnormality (%)	1.75±0.18 (1.50±0.62 to 2.00±0.58)
Individual Sperm Motility (%)	82.77±0.52 (81.67±1.63 to 84.34±1.54)		

colour of the Magra ram semen was recorded as creamy or creamy white and the consistency of the Magra ram semen was thick creamy. The mean ejaculate volume of the neat ram semen during the study period was ranged between 0.80±0.07 to 0.92±0.06 ml and overall mean of ejaculate volume recorded as 0.87±0.02 ml with no significant difference among the rams. The mean mass motility score (0-5 scale) for different rams varied between 4.00±0.22 to 4.5±0.18 with the overall mean value noted as 4.36±0.08, without significant difference among the rams. The overall mean pH value of the neat ram semen was recorded as 6.76±0.03 which ranged between 6.65±0.07 to 6.84±0.07. The overall mean pH value differed non-significantly among the rams. The mean individual sperm motility percentage of different rams varied between 81.67±1.63 to 84.34±1.54 with the overall mean value as 82.77±0.52. The mean individual sperm motility didn't differ significantly among the rams. The mean live sperm percentage in the semen of different rams varied between 83.70±2.08 to 86.42±1.95 with the overall mean value of 85.07±0.62, without significant difference among the rams. The overall mean percentage of total sperm abnormalities in the neat semen of Magra rams were recorded as 1.75±0.18 which ranged between 1.50±0.62 to 2.00±0.58 percentage. No significant difference was noted for total sperm abnormality percentage among the rams. The mean sperm concentration of rams was ranged between 3950±117.62 to 4633.34±234.05 millions/ml. The overall mean concentration of sperms was recorded as 4335.63±63.42 millions/ml. The mean sperm concentration didn't differ significantly among the rams.

In the present study, the colour and consistency of Magra ram semen observed was creamy white and thick creamy, respectively. The present observations are also in agreement with the findings of Bharti *et al.* (2009), Toppo (2013), Kurmi (2014), Rajashri (2016), Anil (2017) and Singh (2020) who also found the colour of rams semen to be creamy or creamy white. Anil (2017) and Mahala (2019) also observed thick creamy consistency in Deccani and Magra rams, respectively while creamy consistency was reported to semen of Ille de France and Schwarzkopf breeds by Marian *et al.*(2012) and moderate for Garut ram semen by Nalley and Arifrantini (2013b). The slight variation in colour might be possible due to difference in breed and feeding and season and variation in concentration of spermatozoa. The difference in consistency might also occurred due to sperm concentration, season, breed and testosterone concentration (Youngquist and Therefall, 2007). The mean semen ejaculate volume of Magra ram was ranged between 0.80±0.07 to 0.92±0.06 ml and overall mean of ejaculate volume recorded as 0.87±0.02 ml without significant difference among rams. In previous study similar mean total ejaculate semen volume was reported in Magra rams by Mahala (2019), Kumar (2020) and Singh (2020). Compared to the present study, higher mean semen volume 1.4 ml in Ghezel rams (Pour *et al.,* 2013) and 1.21 ml in Awassi rams (Kayali *et al.,* 2014) have been reported. While lower values of ejaculated semen has been reported by Toppo (2013) and Kurmi (2014) in Chhotanagpuri rams and Rajashri (2016) in Deccani rams that might be due to the season, breed, age of rams, environmental factors (Moghaddam *et al.,* 2012) and methods of semen collection (Carter *et al.,* 1990).

The overall mean pH value of the neat ram semen was recorded as 6.76±0.03 which ranged between 6.65±0.07 to 6.84± 0.07. Non-significant difference was found in seminal pH value of the neat ram semen among the treatment groups and was in consonance with previous observations made by Kumar (2019) and Singh (2020) in Magra rams. Similar findings were observed by Jayaganthan *et al*. (2015) in Muzzafarnagari rams, Asadpour (2012) in crossbred rams (Merino × Moghani) and Moghaddam *et al.* (2012) in crossbred of Ghezel × Baluchi and Arkharmerino × Ghezel.Variation in pH might be due to breed, age, ionic concentration and buffering capacity various components in seminal plasma. The overall mean mass motility score (0-5 scale) of Magra rams was 4.36±0.08 with a range of 4.00±0.22 to 4.5±0.18. The results recorded during the present study was also within normal range and are in consonance with the findings of Bharti *et al.* (2009), Toppo (2013) and Kurmi (2014) in Chhotanagpuri rams. Similar values were also noted by Khalifa (2017) in Barki rams and Kumar

(2020) in Magra rams. In the present study non-significant difference was observed for mass motility among the treatment groups. Lower values of mass motility than the present findings have been reported in different breeds of ram (Pawar, 2003; Kafi *et al*., 2004; Mehta, 2015; Mahala, 2019). The mass motility of sperms in different breeds of rams has been observed by various workers. Mass activity has been observed to vary with breed, biochemical constituents of semen and pre sexual stimulation (Salisbury *et al.,* 1978). Genetic and environmental changes, nutritional status and seasonal change are the other factors that can affect the mass motility (Salrose and Molnar, 1995; Abdel- Rahman *et al.,* 2000; Rege *et al.,* 2000; Gundogan *et al.,* 2004; Colas, 1981; Toe *et al.,* 1994; Ibrahim, 1997). The overall mean value of individual sperm motility percentage was 82.77±0.52 for Magra rams which ranged between 81.67±1.63 to 84.34±1.54.Findings of present study are in agreement with the observations of Kumar (2020) and Singh (2020) in Magra rams. However, higher values of individual sperm motility percentage were observed by Pour *et al.* (2013), Abbass (2015), Hamedani *et al.* (2015) and Al-Anazi *et al.* (2017) in Ghezel ram semen. The lower values for individual sperm motility percentage were observed by Nalley and Arifiantini (2013a) in Garut rams, Bhalothia (2020) and Mahala (2019) in Magra rams.These results signify that there are various factors like breed, method of collection, ram's age at collection, the time interval between collection and number of semen collection per day that affect values of individual sperm motility (Jennings and Mcweeny, 1976).

The overall mean value of live sperm percentage was recorded as 85.07±0.62 for Magra rams which is varied between 83.70±2.08 to 86.42±1.95. The results are in agreement with the findings of Bharti *et al.* (2009), Toppo (2013), Kurmi (2014) in Chottanagpuri rams and finding of present study was in close consonance with previous observations made by Kumar (2020) and Singh (2020) in Magra rams. The present results is higher than observations made by Kumar (2019) and Mahala (2019) in Magra rams and results of this study is lower than observations made by Boediono *et al.* (2004) in Garut rams. The mean values of live sperm percentage for the Magra ram semen didn't differ significantly among the treatment groups. Similar, to studies conducted by Mahala (2019), Kumar (2020) and Singh (2020) in Magra rams. The values of live spermatozoa percentage has been believed to differ as a result of methodological errors, feeding variation, breeds of rams and their adaptability in varying agro-climatic conditions of the places of investigation, season and frequency of semen collection (Pandey *et al.,* 1985). The mean concentration of sperms was ranged between 3950±117.62 to 4633.34±234.05 millions/ml and overall value of mean concentration of sperms was recorded as 4335.63±63.42 millions/ml for Magra rams. The findings of present study is line with the results of Kumar (2010), Toppo (2013) and Kurmi (2014) in Chottanagpuri rams whereas Al-Anazi *et al.* (2017) in Naimi and Najdi rams during spring season. Kumar (2019), Kumar (2020) and Singh (2020) reported moderately lower values of overall mean concentration of sperms in Magra rams. However, much lower values compared to current experiment were also reported by Moghaddam *et al.* (2012) in crossbred rams and Cox *et al.* (2015) in Highlander and Suffolk rams. However, Mahala (2019) observed higher values of mean sperm concentration then present study in Magra rams during non-breeding season. Non-significant difference was found for the values of mean concentrations of sperms among the rams of different treatment groups which are similar to previous study in Magra rams by Kumar (2019), Mahala (2019) and Singh (2020). The variations in sperm concentration could be due to frequency of collection, nutritional status, genetic variations, (Verma *et al*., 1999) climate and breeding season (Gundogan, 2007). The mean percentage of total sperm abnormalities in the neat semen of Magra rams ranged between 1.50±0.62 to 2.00±0.58 with the overall mean value as 1.75±0.18. Values for total sperm abnormality percentage differed non-significantly among the rams. Kumar (2019) and Singh (2020) also reported similar observations in Magra rams. Compared to present study, higher values for total sperm abnormality reported by Bharti (2009), Nalley and Arifiantini (2013b), Mehta (2015), Mahala (2019) and Bhalothia (2020). Difference in breed or variations in methodology, agro-climatic influences and age are some of factors might responsible for the variation in these results (Saxena and Tripathi, 1986).

In brief conclusion the Magra rams' used in the experiment for seminal quality assessment produce good-quality semen that is superior for preservation and can be used for artificial insemination to speed up genetic advancement at the field level, according to the study's findings.

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Cereal Residue Management in the Alluvial Calcareous Soil of the Indo-Gangetic Plains of India

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Abstract

The Indo-Gangetic Plains are facing cereal residue burning due to the unimplementation of cereal residue management extensively. This impacts soil health, air quality, and crop productivity and becomesa sustainable environment at risk. An experimental study was carried out in the alluvial calcareous soil of Pusa, Bihar under cereal residue management of RWCS with organic-N and inorganic-N sources. The study revealed that the incorporation of the N sources under cereal residue management is beneficial over only cereal residue incorporation and control with no incorporation of cereal residue and other nutrient sources. The straw yield of the *rabi*-wheat crop was recorded as significantly highest at T_2 treatment *i.e.,* 4148 kg ha^{-1} which was under 50% cereal residue and 50% RDF at par with T_3 treatment *i.e.*, 3947 kg ha^{-1} under the 50% cereal residue with 50% dhaincha. Similarly, the system productivity of RWCS under cereal residue management was recorded highest by T_2 treatment*i.e.*, 4077 kg ha^{-1}at par with T_3 treatment *i.e.*, 3879 kg ha^{-1}. The soil parameters such as available N, P, and K were also significantly highest under the treatments incorporated with N sources *i.e.*, T_2 and T_3 treatment and T_2 treatment accounted for the significantly highest on the parameters. These results concluded that cereal residue management is beneficial with the incorporation of organic and inorganic N sources. However, long-termobservations under these N sources under cereal residue management are necessary for understanding the soil behaviorsapproaching to sustainable environment.

Key words : *Cereal residue burning, cereal residue management, sustainable environment, alluvial calcareous soil, system productivity.*

Introduction

The Indo-Gangetic Plains (IGPs) of India are facing widespread residue burning. The rice-wheat cropping system (RWCS) is the predominant cropping system in this region and the production ofcereal residues is also surplus. The total cereal residue production accounts for 352 Mt ha^{-1} of which rice contributes 34% and wheat by 22% in the IGPs [1]and shares 62% of the total crop residues being burnt in the country [2]. The reasons behind the cereal residue burning (CRB) are because wide C: N ratio for decomposition, narrow window period after *kharif*-rice and before *rabi*-wheat crops, unfit as feedstock for cattle due to high silica and low protein contents and lack of storage units with the poor farmers. These render the farmers to opt for the cereal residues to be burnt down for sowing the fallow wheat crop in time as a week delay produces low yields. This allows the soil health to be deteriorated and reduces crop productivity. The return of the cereal residues in the soil itselfand facilitated decomposition in a short periodis anapproach to reduce the CRB and enhance soil health for a sustainable environment. However, the soil incorporation of the cereal residues immobilizes the soil available nutrients, especially the soil available nitrogen (N),temporarily for 4 to6 weeks and the standing crop suffers from N-deficiency and affects the crop's growth and development and then low yields [3]. The addition of N-sources as basal doses of 15-20 kg Nha^{-1} along with the cereal residuessupports the standing crop against the N-immobilization [4]. The N-sources may be green manure crops such as dhaincha, sun hemp, cowpea, *Sesbania rostrata,etc*., and inorganic fertilizers such as urea and ammonium and nitrate fertilizers. The application of urea is extensive as compared with the other N-fertilizers in this region.The continuous and imbalanced application of fertilizers degrades the soil health over the years so green manure as an organic N source is preferable for a sustainable environment. Moreover, 45 to 60-day-old green manure crops can supply 100 kg N ha^{-1} so it has the potential to substitute inorganic N fertilizer with a little residual effect for wheat crops [5]. However, the understanding of the soil properties under cereal residue managementalong with green manure and inorganic N-fertilizers is still a lack of knowledge in the alluvial calcareous soil of Bihar of the Indo-Gangetic Plains of India.

Materials and methods

Experimental location : An experiment was conducted in the Soil Science trial site of RPCAU, Pusa for a rice-wheat cropping system (RWCS)during 2021-22. The site was located near the Gandak River (a tributary of the Ganga River) and possessed alluvial calcareous soil with low content of soil organic carbon (SOC), available nitrogen

(N), available phosphorus (P), and moderate content of soil available K. During the experiment, the mean temperature, relative humidity, and rainfall were 27.8^{0}C, 82.6%, and 80.4 mm respectively.

Experimental details : The rice variety, Rajendra Bhagwati, was selected for the *Kharif* season, and the wheat variety, Rajendra Gehu-2 for the *Rabi* season.The 20-25 DAS of rice seedlings were transplanted with a spacing of 20cm×15cmin the main field of 12 m^2 (3m×4m) plot size and the wheat seeds were direct line sown with a spacing of 20 cm between the rows in the same plot. The experiment was practiced withfour treatments under the cereal residue management incorporated with dhaincha (*Sesbania aculeata*)as green manure and urea as an inorganic N source that was replicated thrice *i.e.*, 12 plots. The treatments were "T_1-100% N cereal residue", "T_2-50% N cereal residue + 50% RDF", "T_3- 50% N cereal residue + 50% N dhaincha", "T_4-Control with no cereal residue,RDF, and dhaincha. The cereal residues and dhaincha crop incorporated in the soil based on their total N (%) content and urea fertilizer along with single super phosphate (SSP) and muriate of potash (MOP) were incorporated. The recommended dose of fertilizers in this region was 120:60:40 kg/ha of N: P_2O_5: K_2O.The dhaincha seeds were broadcasted at @45kg ha^{-1} before the *kharif*-rice for 40-45 days. The dhaincha, wheat residue (collected from the previous year of the RWCS),and residue decomposer were soil incorporated and left for 2 to 4 days before the transplanting of the *Kharif rice* and the collected rice residue after harvesting was applied as a mulch for the *Rabi*-wheat crop.The experiment was a complete *in-situ* cereal residue management practice.

Observations to be recorded

Soil properties : Soil samples were collected after the RWCS from a depth of 0-15 cmwhich was collected from five spots in each plot and followed the quaternary method and readied the soil samples after 2mm sieved. The soil properties such as soil pH (1:2.5 suspension), soil electrical conductivity (dS m^{-1}), soil available N (kg ha^{-1}), soil available P_2O_5(kg ha^{-1}), soil available K_2O (kg ha^{-1}), and SOC (%) content were estimated. The soil pH was determined through a soil: water suspension ratio of 1:2.5 [6], soil electrical conductivity (EC) through a conductivity meter [6], soil available-N through alkaline permanganate method [7], soil available-P_2O_5 through Olsen's method [8], soil available-K_2O through neutral ammonium acetate [6], and soil organic carbon (SOC) content through rapid titration method [9].

Yield parameters : The yield parameters such as grain yieldand straw yieldwere recorded in terms ofkilogram per hectare (t/ha)from each of the crops after harvesting.The harvest index (HI %) was also estimated as the economic yield was divided by the biological yield in terms of percentage.

Statistical analysis : The experimental data acquired from Randomized Block Design (RBD) was analyzed in ANOVA for the "F" test and Pearson's coefficient analysis was conducted to find out the correlation among the parameters and Linear Regression Analysis among the correlated parameters.

Results and Discussion

Yield parameters : The impacts on the yield parameters such as grain yield (kg ha^{-1}), straw yield (kg ha^{-1}), harvest index (%), and system productivity (kg ha^{-1}) of rice and wheat crops under the cereal residue management of RWCS are given in Table 1. For the *kharif*-rice crop, the grain yield (GY), straw yield (SY), and harvest index (HI) were statistically non-significant among the treatments as the soil available nutrients especially the nitrogen (N) were immobilized for 4 to 6 weeks[3]. This period was the peak periodfor nutrient absorption for rice tillering and panicle initiation and so negatively impacted the yields of grain and straw of rice crops due to inadequate availability of plant nutrients. For the *rabi*-wheat crop, the grain yield was statistically significant among the treatments and non-statistically different forstraw yield. This result shows that the immobilization of N-nutrient during the *kharif season* was mobilized in the *rabi*-wheat season and available for the wheat grain yield. The incorporation of cereal residue was unable to increase vegetative growth however, it enhanced the yield [10]. The significant highest was observed in the T_1 treatment which was under the application of 50% cereal residue with 50% RDF and was statistically at par with the T_3 treatment under the 50% cereal residue with 50% dhaincha and the significant lowest was recorded by the control T_4 treatment.The system productivity (kg ha^{-1}) under the cereal residue management of RWCS was observed the significantly highest under the T_2 treatment *i.e.*, 4077 kg ha^{-1} (50% cereal residue + 50% RDF) which was statistically at par with T_3 treatment *i.e.*, 3879 kg ha^{-1} (50% cereal residue + 50% dhaincha) and the lowest system productivity was recorded under the control T_4 treatment *i.e.*, 3357 kg ha^{-1}.The above results showed that the impacts on the cereal yield parameters under the application of RDF were statisticallyat par with the application of dhaincha. The incorporation of 40 to 50 days of green manure can supply 80 to 100 kg N ha^{-1} which facilitates to substitutionof the inorganic N fertilizer[11].

Soil parameters : The soil parameters such as bulk density (BD), pH, electrical conductivity (EC), soil organic carbon (SOC) content, available N, available P, and available K were estimated under the cereal residue management of RWCS (Table 2). The soil BD (g cc^{-1}), pH

Table-1 : Effect of organic and inorganic N-sources on the grain and straw yields, harvest index, and system productivity under cereal residue management of RWCS.

Treatments	Kharif-rice crop			Rabi-wheat crop			System Productivity (kg/ha)
	GY (kg/ha)	SY (kg/ha)	HI (%)	GY (kg/ha)	SY (kg/ha)	HI (%)	
T_1	4110	7413	35.5	3558bc	4225	45.7	3497bc
T_2	4613	7907	36.8	4148a	5260	44.3	4077a
T_3	4410	7527	36.9	3947ab	5035	44.0	3879ab
T_4	4000	7367	35.2	3416c	4123	45.4	3357c
SEm ±	288	246	0.93	151	342	1.28	149
CD (5%)	NS	NS	NS	534	NS	NS	524

Table-2 : Effect of organic and inorganic N-sources on soil parameters under cereal residue management of RWCS.

Treatments	BD (g/cc)	pH (1:2.5)	EC (dS m^{-1})	SOC (%)	Avail. N (kg ha^{-1})	Avail. P (kg ha^{-1})	Avail. K (kg ha^{-1})
T_1	1.41	8.26	0.46	0.45b	116abc	14.7c	90.3ab
T_2	1.44	8.25	0.47	0.43bc	126a	18.7a	95.2a
T_3	1.42	8.26	0.46	0.49a	117ab	17.3b	81.4bcd
T_4	1.45	8.32	0.45	0.39d	97.2d	14.1cd	85.1bc
SEm ±	0.02	0.18	0.01	0.01	4.29	0.33	2.65
CD (5%)	NS	NS	NS	0.03	15.1	1.15	9.35

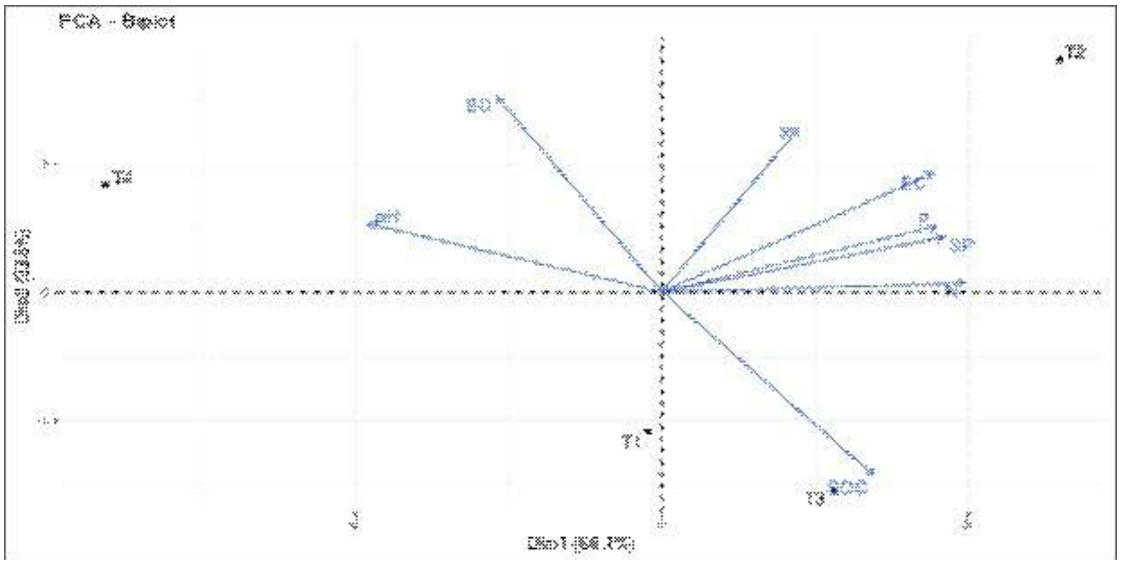

Fig.-1 : PCA-biplot between the soil parameters under cereal residue management of RWCS.

(1:2.5), and EC (dS m^{-1}) were statistically not different among the treatments. However, the SOC (%) content, soil available N (kg ha^{-1}), soil available P (kg ha^{-1}), and soil available K (kg ha^{-1}) were statistically different among the treatments. The SOC (%) content varied statistically from 0.39% to 0.49% and the significant highest was under the T_3 treatment of 50% cereal residue with 50% dhaincha and the lowest was under the control T_4 treatment. Similarly, the soil available N, P, and Kwere in the range from 97.2 kg ha^{-1} to 126 kg ha^{-1}, 14.1kg ha^{-1} to 18.7 kg ha^{-1}, and 81.4 kg ha^{-1} to 95.2 kg ha^{-1}respectively. The significant highest of available N, P, and K was recorded under the T_2 treatment of 50% cereal residue with 50% RDF *i.e.,* 126 kg ha^{-1}which was at par with T_3 treatment, 18.7 kg ha^{-1}, and 98.2 kg ha^{-1}respectively and the lowest was recorded under the control T_4 treatment. This shows that the application of easily available soil nutrient fertilizers provides higher soil available nutrients as compared with the organicforms of nutrient sources. The soil nutrients applied through organic sources have to undergo microbial processes which are dependent on favorable conditions and are time-consuming, however, the nutrients applied through inorganic fertilizers are easily available for the plants to be absorbed [12].

Principal component analysis : Based on the percentage of contribution of variables as scores and

factors loading calculated through Principal Component Analysis (PCA), a PCA-biplot was plotted and presented in Fig.-1. The dim1 and dim2 described 89.7% *i.e.*, 66.1% and 23.6% respectively in the PCA-biplot. The variables such as soil available N, P, and K, soil EC, and SP were positively correlatedwith each other. However, the SOC content was correlated with the above variables and negatively correlated with soil BD and pH. The treatment T_2 under the 50% cereal residue with 50% RDFwas projected with various variables as compared with the other remaining treatments. Moreover, the treatment T_3 incorporated with 50% cereal residue and 50% dhaincha was projected with SOC (%) content. This result was corroborated by a finding that the incorporation of green manure crops such as *Sesbania sp*.along with crop residues improved the soil carbon content [13].

Conclusions

The incorporation of organic or inorganic N sources under the cereal residue management of RWCS in the alluvial calcareous soil of Indo-Gangetic Plainsenhances the availability of primary nutrients such as N, P, and K and so the yield parameters and system productivity. The similar amount content of the soil available N underthe organic and inorganic N sources suggests a scope to substitute the inorganic N source with an organic N source approaching a sustainable environment.Continuous application of organic and inorganic N-sources and examination of the soil behaviors are necessary to understand its long-term effectson a sustainable environment.

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Biogenic Synthesis of Metal-doped Nanoparticles Mediated from Cow Urine

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Abstract

Nanoparticles, characterized by their size of less than 100 nm, exhibit unique properties attributed to factors such as negligible gravitational force, Brownian motion, van der Waals attraction, dangling bonds, higher electrostatic force, and elevated aspect ratio. The synthesis of metallic or non-metallic nanoparticles (NPs) can be achieved through various methods, including physical, chemical, sol-gel, solution combustion, electrochemical, green synthesis, and biogenic synthesis. This study delves into the biogenic synthesis of metal-doped NPs utilizing cow urine as a sustainable and readily available bioresource. This environmentally friendly approach offers a compelling alternative to conventional NP synthesis methods, often plagued by high costs, the use of harsh chemicals, and environmental concerns. The primary emphasis is on introducing metal dopants into the synthesized NPs to customize their properties for specific applications. The process leverages the reducing and capping agents inherently present in cow urine to stabilize and functionalize the metal-doped NPs.

Key words : *Nanoparticles, cow urine, biogenic synthesis, brownian motion and van der waals attraction.*

Introduction

Nanoparticles are those particles having size less than 100 nm without any change in charge and these characteristic properties can be attributed due to negligible gravitational force, Brownian motion, van der Wall's attraction, dangling bonds, higher electrostatic force as well as higher aspect ratio (Venkatesham *et al*., 2015). NPs can be of different types: carbon-based, metal, metal oxide, ceramics, polymeric and semiconductor NPs (Jejurkar *et al*., 2018).

The synthesis of metallic or non-metallic NPs can be done in many ways like physical, chemical, sol-gel, solution combustion, electrochemical, green synthesis, biogenic synthesis methods, etc. (Dabhane *et al*., 2021a). Nature functions as a vast bio-laboratory, including plants, algae, fungus, yeast and other biomolecule-based organisms. These naturally occurring biomolecules have been discovered to play a key role in the production of NPs of all shapes and sizes, paving way for the development of greener, safer and environmentally friendly NP synthesis techniques (Sharma *et al*., 2019). Sarvalkar *et al*. (2021) stated that due to low cost of synthesis, high effectiveness and easy availability of animal extracts as well as products, biosynthesis method had become a major trend in which animal products such as milk, ghee, curd and animal extracts such as dung, urine can be used separately or in combination to synthesis NPs. The synthesis of NPs could be done by either top-down or bottom-up approaches but Rashid *et al*. (2017) demonstrated that the bottom-up approach involved the synthesis of NPs by self-assembly from already miniaturized atomic components. Specifically, this approach involved physical and chemical production and a cheaper approach than the top-down approach.

Randhawa (2010) stated that cow urine constitutes 95% water, 2.5% urea and the rest contains various salts, minerals, hormones and enzymes. Dabhane *et al*. (2021a) concluded that due to the presence of wide range of bio-compounds, cow urine could easily act as a reducing agent that bio-reduces the metal ion to base metal in a very rapid way and also performed the action of stabilizing, chelating and gelling agents. NPs synthesised from cow urine were found in various applications i.e. biological processes and medical applications such as anti-asthma, antioxidant, antibacterial, antifungal, etc. due to properties like enhanced electrical conductivity, photoluminescence, photocatalyst activity and low cytotoxicity.

Nithya (2021) synthesised the cow ark (distilled cow urine) mediated silver (Ag) NPs and from Fourier transform infrared spectroscopy (FTIR) results, it was concluded that the organic compounds present in the cow ark were able to get stabilized, capped and reduced to synthesised Ag NPs. Sarvalkar *et al.* (2021) used cow urine for the synthesis of Ag NPs by defining it as an

Table-1 : Various methods of synthesis and precursors used for the production of nanoparticles using cow urine (Dabhane *et al.*, 2021a).

S. No.	Nanoparticles	Precursor	Method	References
1.	Ag NPs	$AgNO_3$	Biosynthesis	Govarthanan *et al.* (2014)
2.	Ag NPs	$AgNO_3$	Biosynthesis	Prabhu *et al.* (2014)
3.	Aceprophylline	Aceprophylline	Solvent evaporation	Singh *et al.* (2018)
4.	Graphene nanosheets	Graphene oxide	Biosynthesis	Chamoli *et al.* (2016)
5.	Graphene nanosheets	Graphene oxide	Solvothermal	Chamoli *et al.* (2017)
6.	Cellulose NPs	Cellulose	Microemulsion method	Suk *et al.* (2018)
7.	Cu NPs	$CuSO_4$	Biosynthesis	Arumugam *et al.* (2019)
8.	Ag NPs	$AgNO_3$	Hydrothermal	Jain *et al.* (2019)
9.	$CuFe_2O_4$ NPs	$Cu(NO_3)_2.6H_2O$ $Fe(NO_3)_2.9H_2O$	Sol-gel auto combustion	Satheeshkumar *et al.* (2019)
10.	Ag_2O	$AgNO_3$	Combustion	Vinay *et al.* (2019)

environmental as well as an economical friendly approach and it was also claimed that organic transformation reactions were catalysed by these Ag NPs. The poly-dispersed crystalline NPs with face-centered cubic structure were obtained as per X-ray diffractogram (XRD) pattern and the crystallite size was 29.92 nm.

Cow urine mediated biogenic synthesis of metal oxide nanoparticles : Cow urine attracted the interest of various researchers for the synthesis of NPs due to the presence of vast number of biomolecules such as urea, minerals, peptides, vitamins, etc. in significant amount which makes it a potential reducing, capping as well as stabilizing agent. Cow urine mediated cellulose NPs were synthesised using microemulsion method and evaluated for antimicrobial activity against *Aspergillus niger* and *Bacillus subtilis* by Suk *et al.* (2018). Jain *et al.* (2019) hydrothermally synthesised Ag NPs from cow urine and found impressive antibacterial activity against bacterial strain *Pseudomonas sp.* Synthesis of spherical shaped copper iron oxide ($CuFe_2O_4$) NPs was done using sol-gel method in which cow urine was used as chelating agent (Satheeshkumar *et al.*, 2019).

By using combustion method, Vinay *et al.* (2019) successfully synthesised cow urine mediated silver oxide (Ag_2O) NPs after heating at 500°C in which cow urine acted as natural fuel due to the presence of vast biological compounds and studied their antibacterial properties as well as photocatalytic properties. Results confirmed the potent antibacterial activity of Ag_2O NPs against foodborne pathogens and due to their sensitivity to absorb light with a wide bandgap energy, NPs showed good photocatalytic degradation of methylene blue as well.

Prasad *et al.* (2020) observed the antimicrobial, antioxidant and catalytic activity of synthesised palladium (Pd) NPs using cow excreta. Dabhane *et al.* (2021b) synthesised cow urine mediated zinc oxide (ZnO) NPs. The ultraviolet-visible (UV-vis) spectroscopy study revealed the bandgap of ~2.96 eV, whereas the XRD pattern confirmed the wurtzite structure with a particle size of 3.99 nm. Cow urine mediated synthesis of metal and metal oxide NPs are given in Table-1.

Synthesis of material doped nanoparticles : Pure metal oxide NPs cannot fulfil the requirement of desired properties such as very high thermal conductivity, overall heat transfer coefficient and stability at elevated processing temperatures. Pure ZnO NPs showed poor structural and optical features such as oxygen vacancy, point defects, etc. (Ahmad *et al.*, 2012). Wang *et al.* (2009) confirmed that doping of noble metals to ZnO NPs helped to overcome the inferior optical and structural features of pure ZnO NPs.

Therefore, due to the demand for producing new and enhanced particle functionality with altered properties, hybrid nanotechnology received attention (Aguirre *et al.*, 2011), which further enlightened the concept of hybrid NPs and material doped NPs. Amornpitoksuk *et al.* (2012) synthesised Ag-doped ZnO powder in nanocrystalline form using chemical method at 70°C without calcination. The simple sol-gel approach was used by Khan *et al.* (2013) to successfully produce Aluminium-doped ZnO (AZO) NPs. Alkahlout *et al.* (2014) synthesised AZO NPs using hydrothermal treatment processing. The authors used three different precursors namely aluminium nitrate nonahydrate, aluminium isopropoxide and aluminium chloride to prepare stable crystals of AZO.

Dias *et al.* (2019) described two different methods for the preparation of silver-doped ZnO (Ag-doped ZnO) NPs. The binary metal oxide or material doped NPs commonly used was AZO which possess unique properties such as environment friendly, cheaper, stable at higher temperature, mature production process and good optical properties (Kim *et al.*, 2000; Marouf *et al.*,

2017; Drewelow *et al*., 2019). Rameshkumar *et al*. (2020) adopted sol-gel approach to produce AZO NPs. $Zn(CH_3COO)_2.2H_2O$ and $Al(NO_3)_3.9H_2O$ were used as zinc and aluminium precursors, respectively. As a precipitation agent and solvent, NH_3 and de-ionized water were utilised. Ranjithkumar *et al*. (2021b) prepared Ag-doped ZnO NPs by green combustion method using cow urine as natural fuel. Urea present in cow urine acted as chelating and gelling agents and was found to have excellent antimicrobial properties against *B. subtilis* and *E. coli* bacteria.

Conclusions

The synthesis of nanoparticles (NPs) using cow urine as a bioresource has emerged as an eco-friendly and cost-effective method. The various biomolecules present in cow urine, such as urea, minerals, peptides, vitamins, etc., make it an ideal candidate for acting as a reducing, capping, and stabilizing agent in the synthesis process. This natural approach has gained popularity due to its low cost, high effectiveness, and easy availability. The NPs synthesized from cow urine have shown diverse applications, including biological processes and medical applications, owing to their unique properties like enhanced electrical conductivity, photoluminescence, photocatalyst activity, and low cytotoxicity.

Researchers have explored different methods for synthesizing metal and metal oxide NPs using cow urine, such as biosynthesis, sol-gel, microemulsion, and combustion methods.

The effectiveness of cow urine as a bioresource is evident in the successful synthesis of various NPs, including silver (Ag), copper (Cu), copper iron oxide (CuFe2O4), zinc oxide (ZnO), and palladium (Pd) NPs. The synthesised NPs have demonstrated remarkable antimicrobial, antioxidant, and catalytic activities, making them suitable for a wide range of applications.

Furthermore, the incorporation of metal dopants into NPs has been explored to enhance their thermal conductivity, overall heat transfer coefficient, and stability at elevated processing temperatures. This has led to the development of hybrid NPs and material-doped NPs, such as Aluminium-doped ZnO (AZO) and silver-doped ZnO (Ag-doped ZnO). These material-doped NPs exhibit unique properties, including environmental friendliness, cost-effectiveness, stability at higher temperatures, and good optical properties.

In summary, the utilization of cow urine in the synthesis of NPs presents a sustainable and environmentally friendly approach with promising applications in various fields, including medicine and industry. Continued research in this area holds the potential for further innovations and the development of novel nanomaterials with tailored properties for specific applications.

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Bioefficacy of Different Insecticides against Sucking Pests of Okra (*Abelmoschus esculentus* L.)

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Abstract

During the Kharif season 2018-2019 at the Vegetable Research Farm, IAS, BHU, Varanasi, U.P, the research was conducted Different insecticides were checked against sucking pests of okra (aphids, jassid, and whitefly) Overall performance of different insecticide treatments against sucking pests on okra population based on the mean concluded that treatment with Diafenthiuron 50% WP @ 300 g a. i./ha expressed superior control over all sucking pests under experiment after both the sprays. The efficacy of various treatments leading to increase in the yield over control was in order of Diafenthiuron 50% WP (@ 300 g a. i./ha) >Thiamethoxam 25% WG (@ 25 ga.i./ha) >Dinotefuran 20% SG(@ 30 ga.i./ha) >Profenofos 50 % EC (@ 500 ml a.i./ha) >Thiacloprid21.7 % SC(@ 30 ml a.i./ha) >Tobbaco dust powder (@ 5 kga.i./ha) and Azadirachtin 0.03% EC (@ 2.5 lit/ha). Hence, Diafenthiuron 50% WP @ 300 g a. i./ha was observed to be superior to the rest of the treatments in terms of both decline in population and yield effect.

Key words *: Sucking pest (aphid, jessids whitefly),okra, bio-efficacy, insecticides .*

Introduction

India is one of the leading vegetable growing countries in the world. India stands second after China in vegetable production. Vegetables play a significant role in the human diet and provide Minerals, Vitamins, and Carbohydrates which other food compounds are deficient. Uttar Pradesh stands 1st in area and production of vegetables, according to current database. It has an area of 1.47 lakh ha and production of about 28.62 lakh tons for vegetables. The area under okra crop is.51 lakh hectares with the production of 6.21 lakh tons (National Horticulture Mission Database, 2018-19). Among the various types of vegetables, okra (Bhindi) *Abelmoschus esculentus* (L.) (Commonly known as lady's finger) is one of the most choicest vegetable and itis the second largest cultivated vegetable in the world. Okra is grown in approximately all part of the world viz. tropical and subtropical part of the world. In India also, it is grown in all part of the country like Andhra Pradesh, Assam, Bihar, Gujrat, Maharastra, Orissa, Rajasthan, and Uttar Pradesh and West Bengal. Okra alone accounts for 70% of the 30% return earned from exports of vegetables other than onion among cultivated vegetables (Dhankar et al., 2001).Tender pods of okra are used as vegetable in a variety of cooking preparations. The dry roots and stems of okra plant are used for purifying the sugar cane juice when preparing gur (Chauvan, 1972). Mature fruits and stems of okra having crude fiber are used in the paper industry. The greenish yellow edible oil is also extracted from okra seeds. The nutrient quantity of okra seed (*Abelmoschus esculenta* Moench) has been analyzed during studies. Okra seeds contains at least 21 percent protein, 14 percent lipids, and 5 percent ash. Complete removal of seed hulls through grinding and sifting produced a meal with 33 percent protein, 26 percent lipids, and 6 pe recent ash (Savello *et al.,* 1980). The oil has a pleasant test and smell and having the amount of un saturated fatty acids such as oleic acid and linoleic acid. The oil percentage is approximately as high as 40 percent. Okra gives vitamins compound, a calcium compound, potassium compound and other mineral components which are generally lacking in the diet of developing countries like India (IBPGR, 1990).Okra is one of the major economically important vegetable crop which alone has 21 percent of total exchange earnings from export of vegetable crops from India. Insect pests are one of the most significant limitations in okra production Among them, the sucking pest complx composed of aphid (*Aphis gossypii* Gloner), whitefly (*Bemisia tabaci* Genn) and jassid (*Amrasca biguttula biguttula* Ishida)are significant pests and causes a production drop of 17.46 percent in okra (Sarkaret al., 1996). In the initial stage of the crop aphids, leafhopper and whitefly are significant pests that damage the crops, weaken them and decrease

output (Krishnaiah, 1980). The output decline owing to the appearance of leafhopper in okra is 54 to 66 percent (Satpathy *et al.,* 2004). Whitefly is mainly known among the top hundred pests of insects with a pandemic spread and damages many significant crops including vegetable tubers, fiber plants and ornamental. It is also identified as the cause for deadly ' yellow vein mosaic disease 'apart from their immediate harm by sucking crop sap. Management of the pest is very hard due to its fast motion from one crop to another, elevated reproductive capacity and living environment (Fouly *et al.,* 2011). Kulkarni (1924) in Maharashtra reported yellow vein mosaic as a significant disease It had first emerged in 1950 in Maharashtra in epidemic shape (Capoor and Varma, 1950). Subsequently, the disease's epidemic onset was recorded from various okra-growing nations (Tripathi and Joshi, 1967 and Chelliah the disease occurs in endemic and mostly epidemic type in all of India's okra countries, threatening okra production. If crops become infected within 20 days of germination, their development will be slowed few leaves and tiny fruits will be founded and the losses will be very large. Damage magnitude decreases with delay in plant disease is the insect that transmits yellow vein mosaic virus.fly-borne virus species belong to the genus Aphids and jassids is a significant sucking pests of okra. Using piercing and sucking type of mouth parts, both nymphs and adults suck the crop sap. Aphids secrete the honeydew on the leaves, which in turn causes sooty mold fungus development and decreases the younger leaves, the infestation is seen larger than on the older leaves. For some plant viruses, aphids also work as vectors. jassids are significant pests that suck the cell sap of the crop, decrease output. It was disclosed that, failure to control them in the initial phases caused a yield loss of 54.04 percent to the actual yield.(Chaudhary and Dadeech,1989).Number of insecticides assessment for their relative efficacy, specificity, selectivity as well as the value of control operation Current studies have been carried out with the following To study the bio-efficacy of different insecticides.

Materials and Methods

The field experiments were taken out at the Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi to study the" bioefficacy of different insecticides against sucking pests"of okra (*Abelmoschus esculentus* l.)".Varanasi lies between the longitude of 82° 98' 14.2404'' E., Latitude of 25° 19' 18.0624'' Nand at an altitude of 129.93 m. from mean sea level (MSL).

Application of insecticides : With the help of Knapsack sprayer, two foliar sprays of insecticides were given when the insect population reached ETL level. The first application of insecticide was done 35 days after sowing. The untreated control plot were simply sprayed with water. The amount of spray used per hectare was 500 liter. At the start and while changing from one insecticide to another during processing, due care was taken to clean the spray tank with water. During the morning hours, all sprays were performed to prevent drifting from one therapy plot to another owing to strong storms.

Method of recording observations of bio-efficacy of different insecticides against sucking pest of okra : For recording the population of aphids, jessid and whitefly were three leaves**/** plant five plants were randomly selected and tagged in each treatment plot. Three leaves per plant one each from the top, bottom and middle of each plant were tagged and used for counting the pest. The readings were taken one day before each spray and continued till 3,7 and 10 days after spray. The number of surviving individuals were counted post treatment.

Statistical analysis of bio-efficacy of different insecticides : The data obtained from sucking pest of okra before and after each spray was subjected to statically analysis, They were transformed using square root transformation. differences for different treatments were calculated at 5 % level of significance. By calculating CD at a probability level of 5 percent ,the variations between means were confined to further analysis. Data was analyzed by the website ''OPSTAT''.

Yield data : The yield of marketable okra fruits per plot was recorded at every picking. The treatment wise total yield was calculated by summation of the yield obtained per plot in every picking. The total yield obtained in kg (per /plot) was converted in ton (q/ha.). Additional yield of control plot was also calculated.

The percent improvement in yield over controlled plot in different treatments was calculated by using the following formula.

$$\text{Increase in yield (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \quad 100$$

Results and Discussion

Aphids

First insecticidal spray : Three day safter first insecticidal spray on the third day after the first insecticidal spray we took same tagged plants and counted the number of aphids from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (0.867) aphids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha (1.267) aphids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2500 ml a.i./ha(2.933) aphids per 3 leaves/plant

Table-1 : Efficacy of different insecticidal treatment on the population of aphids after 1st and 2nd spray.

Tr. No.	Insecticide	Doses g a.i/ha	Average number of aphids per three leaves per plant									
			First spray					Second spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Overall mean	1 DBS	3 DAS	7 DAS	10 DAS	Over all mean
T_1	Azadirachtin 0.03% EC	2500 ml	5.667 (2.58)	2.933 (1.983)	3.533 (2.129)	4.867 (2.42)	3.777	4.867 (2.422)	2.467 (1.862)	3.133 (2.033)	3.533 (2.129)	3.044
T_2	Thiacloprid 21.7 % SC	30 ml	5.800 (2.601)	1.533 (1.591)	2.467 (1.862)	4.133 (2.266)	2.711	4.133 (2.266)	1.067 (1.437)	1.533 (1.591)	2.933 (1.983)	1.844
T_3	Profenofos 50 % EC	500 ml	5.800 (2.605)	1.600 (1.612)	2.333 (1.826)	3.867 (2.206)	2.600	3.867 (2.206)	1.133 (1.460)	1.600 (1.612)	2.667 (1.915)	1.800
T_4	Diafenthiuron 50% WP	300 gm	5.800 (2.601)	0.867 (1.366)	1.133 (1.460)	2.867 (1.966)	1.622	2.867 (1.966)	0.400 (1.183)	0.600 (1.265)	1.400 (1.548)	0.800
T_5	Thiamethoxam 25% WG	25 gm	6.133 (2.662)	1.467 (1.570)	2.133 (1.770)	3.800 (2.191)	2.466	3.800 (2.191)	0.867 (1.366)	1.133 (1.527)	2.400 (1.844)	1.533
T_6	Dinotefuran 20% SG	30gm	5.867 (2.608)	1.267 (1.505)	2.200 (1.789)	4.000 (2.236)	2.488	4.000 (2.236)	0.867 (1.366)	1.533 (1.59)	2.800 (1.949)	1.733
T_7	Tobbaco dust powder	5kg	5.933 (2.629)	2.467 (1.862)	2.933 (1.982)	4.267 (2.295)	3.222	4.267 (2.295)	1.600 (1.612)	1.867 (1.693)	3.067 (2.016)	2.178
T_8	Untreated control		5.867 (2.610)	7.333 (2.886)	8.133 (3.022)	8.467 (3.077)	7.978	8.467 (3.077)	14.733 (3.967)	13.066 (3.751)	11.533 (3.54)	13.111
	SE(m) ±		(0.138)	(0.077)	(0.023)	(0.018)		(0.018)	(0.019)	(0.025)	(0.018)	
	C.D. at 5%		N/A	(0.025)	(0.690)	(0.056)		(0.056)	(0.059)	(0.075)	(0.055)	

DBS = Day before spray DAS = Days after spray PROC = Percent reduction over control *Mean of three replications

Table-2 : Efficacy of different insecticidal treatment on the population of Jessid after 1st and 2nd spray.

Tr. No.	Insecticide	Doses g a.i/ha	Average number of aphids per three leaves per plant									
			First spray					Second spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Overall mean	1 DBS	3 DAS	7 DAS	10 DAS	Over all mean
T_1	Azadirachtin 0.03% EC	2500 ml	6.067 (2.656)	3.667 (2.160)	4.400 (2.324)	6.200 (2.683)	4.756	6.200 (2.683)	3.733 (2.176)	4.533 (2.352)	6.267 (2.696)	4.844
T_2	Thiacloprid 21.7 % SC	30 ml	6.000 (2.640)	2.467 (1.862)	2.733 (1.932)	4.133 (2.266)	3.111	4.133 (2.266)	1.667 (1.633)	1.867 (1.693)	2.867 (1.966)	2.133
T_3	Profenofos 50 % EC	500 ml	6.267 (2.693)	2.467 (1.807)	2.867 (1.966)	3.200 (2.049)	2.778	3.200 (2.049)	1.267 (1.505)	1.467 (1.57)	1.667 (1.633)	1.467
T_4	Diafenthiuron 50% WP	300 gm	6.267 (2.695)	1.733 (1.653)	2.067 (1.751)	3.133 (2.033)	2.311	3.133 (2.033)	0.867 (1.366)	1.067 (1.437)	1.533 (1.591)	1.156
T_5	Thiamethoxam 25% WG	25 gm	5.667 (2.581)	1.467 (1.570)	2.000 (1.732)	3.467 (2.113)	2.311	3.467 (2.113)	0.933 (1.390)	1.267 (1.505)	1.867 (1.693)	1.356
T_6	Dinotefuran 20% SG	30 gm	5.933 (2.630)	1.867 (1.693)	2.267 (1.807)	3.533 (2.128)	2.556	3.533 (2.128)	1.133 (1.460)	1.333 (1.527)	2.133 (1.770)	1.533
T_7	Tobbaco dust powder	5kg	6.000 (2.646)	3.533 (2.129)	4.133 (2.266)	5.733 (2.595)	4.467	5.733 (2.595)	1.533 (1.591)	3.933 (2.221)	5.467 (2.542)	3.644
T8	Untreated control		6.333 (2.705)	9.800 (3.286)	13.933 (3.864)	12.133 (3.624)	11.955	12.133 (3.077)	9.733 (3.276)	6.333 (2.708)	6.733 (2.781)	7.600
	SE(m) ±		(0.082)	(0.017)	(0.017)	(0.024)		(0.024)	(0.021)	(0.016)	(0.018)	
	C.D. at 5%		N/A	(0.053)	(0.052)	(0.072)		(0.072)	(0.066)	(0.048)	(0.055)	

DBS = Day before spray DAS = Days after spray PROC = Percent reduction over control *Mean of three replications.

followed by control (7.333) aphids from per 3 leaves per plant. (Table-1)

Seven days after first insecticidal spray During the Seven day after the spray of treatment it was observed that the least population of aphids was recorded from the treatment Diafenthiuron 50% WP @ 300 g a.i./ha(1.133) aphids from 3 leaves per plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(2.133) aphids from per 3 leaves/plant. The least control over insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2500 ml a.i./ha(3.533) aphids from per 3 leaves/plant followed by control (8.133) aphids from per 3 leaves per plant. (Table-1).

Table-3 : Efficacy of different insecticidal treatment on the population of whitefly after 1st and 2nd spray.

Tr. No.	Insecticide	Doses g a.i/ha	Average number of aphids per three leaves per plant									
			First spray					Second spray				
			1 DBS	3 DAS	7 DAS	10 DAS	Overall mean	1 DBS	3 DAS	7 DAS	10 DAS	Over all mean
T_1	Azadirachtin 0.03% EC	2500 ml	6.133 (2.667)	3.867 (2.206)	4.800 (2.408)	5.467 (2.543)	4.711	5.467 (2.543)	3.467 (2.113)	4.267 (2.294)	4.733 (2.394)	4.156
T_2	Thiacloprid 21.7 % SC	30 ml	5.933 (2.633)	3.200 (2.049)	3.867 (2.206)	4.867 (2.422)	3.978	4.867 (2.422)	2.600 (1.897)	3.133 (2.033)	3.933 (2.221)	3.222
T_3	Profenofos 50 % EC	500 ml	6.333 (2.706)	3.200 (2.049)	3.733 (2.176)	4.733 (2.394)	3.888	4.733 (2.394)	2.467 (1.862)	2.733 (1.932)	3.733 (2.176)	2.978
T_4	Diafenthiuron 50% WP	300 gm	6.467 (2.731)	1.467 (1.57)	2.467 (1.862)	3.133 (2.033)	2.355	3.133 (2.033)	0.733 (1.316)	1.267 (1.505)	1.533 (1.591)	1.178
T_5	Thiamethoxam 25% WG	25 gm	6.267 (2.688)	3.133 (2.033)	3.667 (2.16)	4.600 (2.366)	3.800	4.600 (2.366)	2.267 (1.807)	1.667 (1.915)	3.333 (2.082)	2.756
T_6	Dinotefuran 20% SG	30 gm	6.200 (2.683)	2.333 (1.826)	3.133 (2.033)	4.067 (2.251)	3.177	4.067 (2.251)	1.533 (1.591)	2.067 (1.751)	2.533 (1.880)	2.044
T_7	Tobbaco dust powder	5 kg	6.533 (2.744)	3.533 (2.129)	4.533 (2.352)	5.400 (2.53)	4.489	5.400 (2.530)	2.867 (1.966)	3.667 (2.160)	4.467 (2.338)	3.677
T_8	Untreated control		6.000 (2.629)	6.467 (2.732)	6.800 (2.793)	8.667 (3.109)	7.311	8.667 (3.109)	9.933 (3.306)	8.400 (3.751)	8.733 (3.120)	9.022
	SE(m) ±		(0.024)	(0.021)	(0.016)	(0.018)		(0.020)	(0.018)	(0.016)	(0.006)	
	C.D. at 5%		(0.072)	(0.066)	(0.048)	(0.055)		(0.060)	(0.055)	(0.050)	(0.019)	

DBS = Day before spray DAS = Days after spray PROC = Percent reduction over control *Mean of three replications

Table-4 : Percent increase in the okra yield over control.

Insecticide	Doses (a.i./ha)	Yield per plot (kg/ 6 m^2)	Yield obtained (Q/ha)	% Increase in yield over control
Azadirachtin 0.03% EC	200 ml	4.92	82.13	10.28
Thiacloprid 21.7 % SC	30 ml	5.90	98.47	32.35
Profenofos 50 % EC	500 ml	6.20	103.42	39.00
Diafenthiuron 50% WP	300 gm	7.11	118.54	59.32
Thiamethoxam 25% WG	25 gm	6.67	111.89	50.38
Dinotefuran 20% SG	30 gm	6.66	110.11	47.99
Tobbaco dust powder	5 kg	5.31	88.63	19.12
Untreated control	0	4.46	74.40	

Tendays after first insecticidal spray During the Seven day after the spray of treatment it was observed that the least population of aphids was recorded from the treatment Diafenthiuron 50% WP @ 300 g a.i./ha(2.867) aphids from per 3 leaves /plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(3.800) aphids from 3 leaves /plant.The least control over insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2500 ml a.i./ha (4.867) aphids from per 3 leaves/plant followed by control plot (8.467) aphids from per 3 leaves/plant. (Table 1).When we did the overall mean of population of aphids after the first insecticidal spray we found that maximum amount of control on aphid population was given by Diafenthiuron 50% WP @ 300 g a.i./ha(1.622) mean aphid population from per 3 leaves/plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(2.466) mean aphid population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of aphids as such, Diafenthiuron 50% WP @ 300 g a.i./ha>Thiamethoxam 25% WG @ 25 g a.i./ha>Dinotefuran 20% SG@ 30 g a.i./ha>Profenofos 50 % EC @ 500 ml a.i./ha>Thiacloprid21.7 % SC@ 30 ml a.i./ha>Tobacco dust powder @ 5 kg a.i./ha>Azadirachtin 0.03% EC @ 2.5 lit/ha.

Second insecticidal spray : Three days after second insecticidal spray On the third day after the second insecticidal spray we took same tagged plants and counted the number of aphids from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (0.400) aphids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(0.867) aphids per 3 leaves /plant, and the least control of population was

given by Azadirachtin 0.03% EC @ 2.5 lit/ha(2.467) aphids per 3 leaves/plant followed by control (14.733) aphids from per 3 leaves per plant. (Table-1).

Seven days after second insecticidal spray During the seventh day after spraying of different insecticides we observed that the least population of aphids was recorded from the treatment Diafenthiuron 50% WP @ 300 g a.i./ha(0.600) aphids from per 3 leaves /plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.333) aphids from per 3 leaves/plant, and the least control of insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2.5 lit/ha(3.133) aphids from per 3 leaves/plant followed by control (13.066) aphids from per 3 leaves per plant. (Table-1)

Ten days after second insecticidal spray On 10th day after second insecticidal spray we noted that Diafenthiuron 50% WP @ 300 g a.i./ha was a consistent performer in controlling aphid population (1.400) aphids from 3 leaves /plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(2.400) aphids from per 3 leaves /plant, and the least control with maximum population was that of Azadirachtin 0.03% EC @ 2.5 lit/ha(3.533) aphids from per 3 leaves/plant followed by control plot (11.533) aphids from per 3 leaves/plant. (Table 1) So finally when we did the overall mean of population of aphids after the second insecticidal spray we found that maximum amount of control on aphid population was given by Diafenthiuron 50% WP @ 300 g a.i./ha(0.800) mean aphid population from per 3 leaves/plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.533) mean aphid population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of aphids as such, Diafenthiuron 50% WP @ 300 g a.i./ha>Thiamethoxam 25% WG @ 25 g a.i./ha>Dinotefuran 20% SG@ 30 g a.i./ha>Profenofos 50 % EC @ 500 ml a.i./ha>Thiacloprid21.7 % SC@ 30 ml a.i./ha>Tobacco dust powder@ 5 kg a.i./ha>Azadirachtin 0.03% EC @ 2.5 lit/ha. An overall performance of different insecticide treatments against aphid population based on the mean concluded that treatment with Diafenthiuron 50% WP @ 300 g a. i./ha was to be the most efficient and considerably superior of all other treatments in decreasing the aphid population to the minimum point. Thiamethoxam 25% WG @ 25 g a.i./ha was the next finest insecticide to decrease the aphid population. Next best was noted Dinotefuran 20% SG@ 30 g a.i./ha followed by Profenofos 50 % EC @ 500 ml a.i./ha, Thiacloprid21.7 % SC@ 30 ml a.i./ha, Tobacco dust powder @ 5 kg a.i./ha and Azadirachtin 0.03% EC @ 2.5 lit/ha similar studies is found by Sathyanet al.(2016) noted that Diafenthiuron 50% WP @ 300 g a. i./ha and Thiamethoxam 25% WG @ 25 g a.i./ha was the best to reduce the aphid population. Pawaret al. (2016) also noted similar results like Thiamethoxam 25 WG 25 g a.i./ha was the second best insecticide to reduce the aphid population

Jassid

First insecticidal spray : Three days after first insecticidal spray On the third day after the first insecticidal spray we took same tagged plants and counted the number of jassid from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.733) jassids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.467) jassids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(3.667) jassids per 3 leaves/plant followed by control (9.800) jassids from per 3 leaves per plant. (Table-2).

Seven days after first insecticidal spray During the seventh day after spraying of different insecticides we observed that the least population of jassid was recorded from the treatment Diafenthiuron 50% WP @ 300 g a.i./ha(2.067)jassids from 3 leaves /plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(2.000)jassids from per 3 leaves/plant, and the least control of insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2.5 lit/ha(4.400)jassids from per 3 leaves/plant followed by control (13.933)jassids from per 3 leaves per plant. (Table-2).

Ten days after first insecticidal spray On 10th day after first insecticidal spray we noted that Diafenthiuron 50% WP @ 300 g a.i./ha was a consistent performer in controlling jassid population (3.133) jassid from 3 leaves /plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(3.200)jassid from 3 leaves /plant, and the least control with maximum population was that of Azadirachtin 0.03% EC @ 2.5 lit/ha(6.200)jassid from per 3 leaves/plant followed by control plot (12.133)jassid from per 3 leaves/plant (Table 4.5). When we did the overall mean of population of jassid after the first insecticidal spray we found that maximum amount of control on jassid population was given by Diafenthiuron 50% WP @ 300 g a.i./ha(2.311) mean jassid population from per 3 leaves/plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(2.311) mean jassid population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of jassid as such, Diafenthiuron 50% WP @ 300 g a.i./ha>Thiamethoxam 25% WG @ 25 g a.i./ha>Dinotefuran 20% SG@ 30 g a.i./ha>Profenofos 50 % EC @ 500 ml a.i./ha>Thiacloprid21.7 % SC@ 30 ml a.i./ha>Tobacco dust powder@ 5 kg a.i./ha>Azadirachtin 0.03% EC @ 2.5 lit/ha.

Second insecticidal spray : Three days after second insecticidal spray On the third day after the second insecticidal spray we took same tagged plants and counted the number of jassid from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (0.867) jassids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(0.933) jassids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha (3.733) jassids per 3 leaves/plant followed by control (9.733)jassid fromper 3 leaves per plant. (Table-2).

Seven days after second insecticidal spray On seven day after the second insecticidal spray we took same tagged plants and counted the number of jassid from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.067) jassids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.267) jassids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(4.533) jassid per 3 leaves/plant followed by control (6.333) jassid from per 3 leaves per plant. (Table-2).

Ten days after second insecticidal spray On Ten day after the second insecticidal spray we took same tagged plants and counted the number of jassid from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.533) jassids from per 3 leaves/plant, followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.867)jassids per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(6.267) jassid per 3 leaves/plant followed by control (6.733)jassid from per 3 leaves per plant. (Table-2). So finally when we did the overall mean of population of jassid after the second insecticidal spray we found that maximum amount of control on jassid population was given by Diafenthiuron 50% WP @ 300 g a.i./ha (1.156) mean jassid population from per 3 leaves/plant, which was followed by Thiamethoxam 25% WG @ 25 g a.i./ha(1.356) mean jassid population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of jassid as such, Diafenthiuron 50% WP @ 300 g a.i./ha>Thiamethoxam 25% WG @ 25 g a.i./ha>Dinotefuran 20% SG@ 30 g a.i./ha>Profenofos 50 % EC @ 500 ml a.i./ha>Thiacloprid21.7 % SC@ 30 ml a.i./ha>Tobacco dust powder@ 5 kg a.i./ha>Azadirachtin 0.03% EC @ 2.5 lit/ha. The performance of various insecticide treatments against jassid population based on their mean concluded that treatment with Diafenthiuron 50% WP @ 300 g a. i./ha was to be the most efficient and considerably superior of all other treatments in decreasing the jassid population to the minimum point. Thiamethoxam 25% WG @ 25 g a.i./ha was the next finest insecticide to decrease the jassid population. Next best was noted Dinotefuran 20% SG@ 30 g a.i./ha followed by Profenofos 50 % EC @ 500 ml a.i./ha, Thiacloprid21.7 % SC@ 30 ml a.i./ha,Tobacco dust powder @ 5 kg a.i./ha and Azadirachtin 0.03% EC @ 2.5 lit/hasimiler studies is found by Muhammad et al. (2014) found that Dinotefuran and Thiamethoxam was best to reduce whitefly population, Sathyanet al.(2016) was also noted that Dinotefuran and Thiamethoxam was best for jassid control. Bisth *et al.* (2017) found thiamethoxam-25 WG (1.00) was documented with highest possible jassid mortality.

Whitefly

First insecticidal spray : Three days after first insecticidal spray On the third day after the first insecticidal spray we took the same tagged plants and counted the number of whiteflyfrom three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.467) whiteflies from per 3 leaves/plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(2.333) whitefly per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(3.867) whiteflies per 3 leaves/plant followed by control (6.467) whitefly from per 3 leaves per plant (Table-3).

Seven days after first insecticidal spray During the seventh day after spraying of different insecticides we observed that the least population of whitefly was recorded from the treatment Diafenthiuron 50% WP @ 300 g a.i./ha(2.467) whitefly from 3 leaves /plant, which was followed by Dinotefuran 20% SG@ 30 g a.i./ha(3.133) whitefly from per 3 leaves/plant, and the least control of insect was given by plot treated with that of Azadirachtin 0.03% EC @ 2.5 lit/ha(4.800) whitefly from 3 leaves / plant followed by control (6.800) whitefly from per 3 leaves per plant. (Table 3)

Ten days after first insecticidal spray On the 10th day after first insecticidal spray we noted that Diafenthiuron 50% WP @ 300 g a.i./ha was a consistent performer in controlling whitefly population (3.133) whiteflies from 3 leaves /plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(4.067) whitefly from 3 leaves /plant, and the least control with maximum population was that of Azadirachtin 0.03% EC @ 2.5 lit/ha(5.467) whiteflies from per 3 leaves/plant followed by control plot (8.667) whiteflies from per 3 leaves/plant. (Table-3). When we did the overall mean of population of whitefly after the first insecticidal spray we found that maximum

amount of control on whitefly population was given by Diafenthiuron 50% WP @ 300 g a.i./ha(2.355) mean whitefly population from per 3 leaves/plant, which was followed by Dinotefuran 20% SG@ 30 g a.i./ha(3.177) mean whitefly population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of whiteflyas such, Diafenthiuron 50% WP @ 300 g a.i./ha>Dinotefuran 20% SG@ 30 g a.i./ha > Thiamethoxam 25% WG @ 25 g a.i./ha > Profenofos 50 % EC @ 500 ml a.i./ha>Thiacloprid21.7 % SC@ 30 ml a.i./ha>Tobacco dust powder@ 5 kg a.i./ha>Azadirachtin 0.03% EC @ 2.5 lit/ha.

Second insecticidal spray : Three days after second insecticidal spray On third day after the second insecticidal spray we took same tagged plants and counted the number of whitefly from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (0.733) whiteflies from per 3 leaves/plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(1.533) whitefly per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(3.467) whitefly per 3 leaves/plant followed by control (9.933) whitefly from per 3 leaves per plant (Table-3).

Seven days after second insecticidal spray On seven day after the second insecticidal spray we took same tagged plants and counted the number of whitefly from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.267) whitefly from per 3 leaves/plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(2.067) whiteflyper 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(4.267) whitefly per 3 leaves/plant followed by control (8.400) whitefly from 3 leaves per plant. (Table-3).

Ten days after second insecticidal spray On Ten day after the second insecticidal spray we took same tagged plants and counted the number of whitefly from three different leaves of plant and noted that Diafenthiuron 50% WP @ 300 g a.i./ha gave maximum reduction in population (1.533) whitefly from per 3 leaves/plant, followed by Dinotefuran 20% SG@ 30 g a.i./ha(2.533) whitefly per 3 leaves /plant, and the least control of population was given by Azadirachtin 0.03% EC @ 2.5 lit/ha(4.733) whiteflyper 3 leaves/plant followed by control (8.733) whitefly from 3 leaves per plant. (Table 3) So finally when we did the overall mean of population of whitefly after the second insecticidal spray we found that maximum amount of control on whitefly population was given by Diafenthiuron 50% WP @ 300 g a.i./ha1.178 mean whitefly population from per 3 leaves/plant, which was followed by Dinotefuran 20% SG@ 30 g a.i./ha (2.044) mean whitefly population from per 3 leaves/plant, we ranked the performance of insecticides based on the overall mean population of whitefly as such, Diafenthiuron 50% WP @ 300 g a.i./ha>Dinotefuran 20% SG@ 30 g a.i./ha>Thiamethoxam 25% WG @ 25 g a.i./ha > Profenofos 50 % EC @ 500 ml a.i./ha>Thiacloprid21.7 % SC@ 30 ml a.i./ha>Tobacco dust powder@ 5 kg a.i./ha > Azadirachtin 0.03% EC @ 2.5 lit/ha. The performance overview of different insecticide treatments against whitefly population based on their mean conclude that Diafenthiuron 50% WP @ 300 g a. i./ha was found to be the most efficient and considerably superior of all other treatments in decreasing the whitefly population to the minimum point. Dinotefuran 20% SG@ 30 g a.i./ha was the next finest insecticide to decrease the whitefly population closely followed by Thiamethoxam 25% WG @ 25 g a.i./ha. Profenofos 50 % EC @ 500 ml a.i./ha, Thiacloprid21.7 % SC@ 30 ml a.i./ha,Tobacco dust powder @ 5 kg a.i./ha and Azadirachtin 0.03% EC @ 2.5 lit/ha were the next best similar studies is found by Chaitanya and Kumar (2018) was noted similar studies to this study and found that Thiamethoxam 25WG was the best among all to control whitefly population. Afzalet *et al.*(2014) found diafenthiuron and thiamethoxam were found to be the most effective against whitefly upto 7 days after application. Kumar et al. (2017) and Mahesh (2017) was also found similar results dinotefuran and thiamethoxam were found to be the most effective against whitefly.

Yield (Q / ha) : All plots treated with untreated control 74.40 Q / ha. Among 300 g a.i./ha treated plots showed the highest yield 118.54 Q / ha a.i./ha (111.89 Q/ha) and Diafenthiuron 50% WP @ 300 g a.i yield obtained from Profenofos 50 % EC @ 500 ml a.i./ha &Thiacloprid 21.7 % SC @ 30 ml a.i./ha treated plot were at par with each with (103.42 Q/ha) & (98.47 Q/ha) respectively. The biorationals treatment comprising of Tobacco dust a.i./ha & Azadirachtin 0.03% EC @ 2.5 lit/ha gave relatively lower yield of (88.63 Q/ha) and (82013 Q/ha) respectively when compare (Table 4.) Experimental ~42~ All plots treated with test insecticides lead to more yield when compared with untreated control 74.40 Q / ha. Among all the insecticides, Diafenthiuron 50% WP treated plots showed the lowest insect population and thus obtained the highest yield 118.54 Q / ha closely followed by Thiamethoxam 25% WG @ 25 g a.i./ha (111.89 Q/ha) and Diafenthiuron 50% WP @ 300 g a.i./ha (110.11 Q/ha). The yield obtained from Profenofos 50 % EC @ 500 ml a.i./ha &Thiacloprid 21.7 % SC @ 30 ml a.i./ha treated plot were at par with each with (103.42 Q/ha) & (98.47 Q/ha) respectively. The biorationals treatment comprising of Tobacco dust powder @ 5 kg a.i./ha &Azadirachtin 0.03% EC @ 2.5 lit/ha gave relatively lower yield of (88.63 Q/ha)

and (82013 Q/ha) respectively when compared to chemical treatments done

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Understanding the Role of NGOs in Disaster Relief Efforts in India : A Survey of Non-Profit Organization Leaders

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Abstract

This research paper delves into the vital role of Non-Governmental Organizations (NGOs) in disaster relief efforts within the Indian context. While numerous studies have explored NGO involvement in disaster management, this research uniquely focuses on the perspectives of NGO leaders actively engaged in these relief operations. The objectives of this study are to understand the challenges, strategies, and successes experienced by NGO leaders, shedding light on the practical intricacies of disaster relief in India. Methodologically, a stratified random sampling approach was employed, surveying 100 NGO leaders from various sectors. Thematic analysis was used to interpret the interview data, revealing critical insights into the roles, challenges, and strategies of these leaders. The key findings of this research highlight the diverse roles of NGOs, with a focus on immediate relief services for the majority, along with significant challenges such as inadequate funding and logistical hurdles. Success factors, including community engagement and partnerships, were also identified. Collaboration with government agencies emerged as an essential aspect of disaster relief. The implications of this study extend to businesses, policymakers, and the NGO sector. It emphasizes the significance of financial support from businesses, effective policy measures for collaboration, and the need for capacity building within the NGO sector. Ultimately, this research contributes to a deeper understanding of NGO involvement in disaster relief in India and offers practical insights to enhance the resilience of communities in the face of disasters.

Key words : *NGOs, disaster relief, India, NGO leaders, challenges, strategies, collaboration, community engagement, capacity building.*

Introduction

Non-Governmental Organizations (NGOs) play a pivotal role in disaster relief and management, particularly in countries like India, where the frequency and intensity of natural disasters pose significant challenges. The involvement of NGOs in disaster relief efforts is crucial due to their agility, local knowledge, and capacity to mobilize resources swiftly.

The significance of NGOs in disaster management in India is underscored by their diverse roles, which range from immediate relief to long-term recovery and rehabilitation. Lassa (2018) Roles of Non-Government Organizations in Disaster Risk Reduction highlights that NGOs not only provide essential services during disasters but also contribute to risk reduction and resilience building. This holistic approach is essential in a country where disasters often exacerbate existing vulnerabilities.

Further, NGOs serve as critical intermediaries in post-disaster scenarios, especially in rural areas. Baruah (2015) in NGOs as intermediaries in post-disaster rural reconstruction: findings from research in India emphasizes the role of NGOs in bridging the gap between affected communities and government relief efforts. This intermediation is crucial in ensuring that the needs of the most vulnerable populations are met.

Moreover, NGOs' role in disaster management extends beyond immediate response to include advocacy and policy influence. Yudhvir (2014) in Role of non-governmental organizations in disaster management discusses how NGOs advocate for more effective disaster management policies and practices, thereby influencing government actions and international aid.

In addition to response and advocacy, NGOs play a significant role in community-based disaster risk reduction. This is highlighted by Izumi and Shaw (2012) in their work Role of NGOs in Community-Based Disaster Risk Reduction, where they explore how NGOs empower local communities to mitigate risks and prepare for future disasters.

The importance of partnerships in disaster management is another critical aspect. The collaborative efforts between government agencies and NGOs lead to more effective disaster response and management. This synergy is explored by Vasavada (2006) in Partnership between government and the third sector for disaster response in India: Lessons to learn, emphasizing the

need for integrated approaches involving various stakeholders.

In conclusion, the role of NGOs in disaster relief efforts in India is multifaceted and indispensable. Their contributions range from direct relief provision and community empowerment to policy advocacy and partnership building. This research aims to provide a comprehensive survey of non-profit organization leaders, shedding light on the challenges, strategies, and successes of NGOs in the context of disaster relief efforts in India. Such an understanding is critical in optimizing the effectiveness of disaster management strategies in the country.

Review of Scholarly Works : The literature on the role of NGOs in disaster management in India presents a comprehensive view of their multifaceted contributions, from immediate relief to policy advocacy and community empowerment. This literature review explores these contributions in greater depth.

Shaw and Izumi (2014) delve into the complex role of civil society organizations in disaster risk reduction across Asia, including India. Their work critically examines the balance these organizations must strike between providing immediate relief and fostering long-term sustainable practices. They argue that while NGOs are adept at mobilizing resources and providing rapid response, their role in sustainable development and resilience-building is equally vital. This study is significant in understanding the dual role of NGOs in both reactive and proactive disaster management.

Flora (2014) provides an insightful analysis of disaster management strategies in India. His study (DOI) emphasizes the indispensable role of NGOs in supplementing government efforts, especially in areas where state resources and reach are limited. Flora's analysis highlights how NGOs often fill critical gaps, particularly in remote and vulnerable areas, by providing specialized services and local expertise.

Mendes (2017), through his study, presents a unique perspective by exploring disaster management from the viewpoint of affected communities. This perspective is crucial as it underscores the importance of community-centric approaches in disaster management, where NGOs play a key role. Mendes' work points out the need for interventions that are not only effective but also culturally sensitive and tailored to the specific needs of local populations.

Shah (2011) offers a broad overview of disaster management practices in India, discussing the evolution and current state of disaster management strategies. His work is particularly valuable in understanding the historical context and the ongoing changes in the field. Shah emphasizes the increasing importance of a collaborative approach that involves various stakeholders, including NGOs, government agencies, and local communities.

Rao and Mohan (2020) focus on the preventative and preparatory aspects of disaster management. Their study highlights how NGOs can contribute significantly to disaster prevention and preparedness. They discuss various strategies and approaches that NGOs can adopt, emphasizing the proactive role these organizations can play in mitigating the impact of disasters.

Bhavjot (2016) analyzes various disaster management strategies employed in India. The paper brings to light the strategic roles played by NGOs, from implementing grassroots-level projects to shaping policies at the national level. This study provides insights into the diverse strategies that can enhance the effectiveness of disaster management efforts, with a specific focus on the role of NGOs.

Negi and Negi (2020) explore the logistical challenges in disaster relief operations and propose a framework to manage humanitarian logistics. Their study is significant for understanding the operational aspects of NGO work in disaster scenarios. They emphasize the need for efficient logistics management to ensure timely and effective delivery of aid, highlighting the critical role of NGOs in this domain.

Kabra and Ramesh (2015) conduct an empirical investigation into the enablers of effective humanitarian supply chain management in India. Their work provides valuable case studies that demonstrate how various factors enable efficient supply chain management in humanitarian operations. This study is particularly relevant for NGOs looking to optimize their logistical operations during disaster relief efforts.

Hiranandani (2015) brings an important dimension to the discourse by focusing on the inclusion of disabled individuals in disaster management. The study calls attention to the need for inclusive strategies in disaster response and preparedness, arguing that disability should be a central consideration in all phases of disaster management. This perspective is crucial for NGOs to develop more inclusive and comprehensive disaster management strategies.

Collectively, these scholarly works provide a rich and varied understanding of the role of NGOs in disaster management in India. They highlight the importance of a nuanced approach that recognizes the diverse roles played by NGOs, from direct service delivery to advocacy, policy influence, and capacity building. The literature

underscores the need for collaborative efforts that integrate the strengths of NGOs with those of government agencies and local communities, ensuring more effective and sustainable disaster management practices.

Identification of Literature Gap and Significance : Within the extensive body of literature exploring the roles and impact of Non-Governmental Organizations (NGOs) in disaster relief efforts in India, a noticeable gap exists concerning the direct perspectives and experiences of NGO leaders actively engaged in these relief operations. While existing research has delved into the outcomes, strategies, and impacts of NGOs, there has been limited exploration of the challenges, decision-making processes, and practical intricacies faced by the leaders steering these organizations during disaster relief in India.

The significance of addressing this gap becomes evident when considering the crucial role of NGO leaders as decision-makers and the driving force behind their organizations' actions in the field. Their insights into the day-to-day challenges, resource allocation, collaboration dynamics, and strategies employed are invaluable for understanding the multifaceted nature of NGO involvement in disaster relief in India. Moreover, the experiences of these leaders can provide practical wisdom for optimizing disaster management strategies and ensuring that resources are utilized effectively.

By conducting research that directly engages NGO leaders in India's disaster relief context, this study aims to fill this literature gap. Such an approach offers a unique perspective that complements the existing body of research, enriching our understanding of NGO roles, challenges, and strategies. Additionally, the insights gained from this research can serve as a vital resource for policymakers, donors, and practitioners, facilitating evidence-based decision-making and fostering collaboration among stakeholders. Ultimately, this research endeavors to contribute to more efficient and effective disaster relief efforts in India, aligning with the overarching theme of understanding the role of NGOs in disaster relief.

Research Methodology

Data Collection Source

Element	Description
Sample Size	100 NGO Leaders
Source of Data	Interviews
Geographical Area	Various regions across India
Sampling Technique	Stratified Random Sampling
Time Period	July 2023 - September 2023

Data Analysis Tool : The data collected through the interviews will be analyzed using thematic analysis, which involves identifying, analyzing, and reporting patterns (themes) within the qualitative data. Thematic analysis allows for the exploration of common themes, patterns, and insights that emerge from the responses of the NGO leaders, providing a comprehensive understanding of their perspectives and experiences in disaster relief efforts in India.

Results and Analysis

Demographic Profile of the Sample

Demographic Characteristic	Frequency (n)	Percentage (%)
Gender		
- Male	55	55%
- Female	45	45%
Age Group		
- 25-35 years	30	30%
- 36-45 years	40	40%
- 46-55 years	20	20%
- 56+ years	10	10%
NGO Sector		
- Health	25	25%
- Education	20	20%
- Environment	15	15%
- Disaster Relief	40	40%

Findings and Results from Interview Questionnaire : Below are the key findings and results from the interview questionnaire, which is provided in the appendix section for reference.

Part-1 : NGO's Role in Disaster Relief.

Question	Findings/Results
Q1: What are the primary services your NGO offers in disaster relief efforts?	- 60% of respondents focus on immediate relief services.
	- 30% provide long-term rehabilitation and recovery support.
	- 10% engage in both immediate relief and long-term recovery.

Part-2 : Challenges Faced by NGOs.

Question	Findings/Results
Q2: What are the main challenges your NGO faces during disaster relief efforts in India?	- 45% mentioned inadequate funding as a significant challenge.
	- 25% cited logistical challenges in reaching remote areas.
	- 20% highlighted coordination issues with government agencies.
	- 10% noted the lack of trained personnel as a challenge.

Part-3 : Success Factors and Strategies.

Question	Findings/Results
Q3: What strategies or practices have contributed to the success of your NGO in disaster relief?	- 50% emphasized community engagement and participation. - 30% mentioned strong partnerships with local organizations. - 15% highlighted effective resource mobilization strategies. - 5% discussed the importance of innovation and technology.

Part-4 : Collaboration and Coordination.

Question	Findings/Results
Q4: How does your NGO collaborate and coordinate with government agencies in disaster relief efforts?	- 40% reported regular meetings and joint planning with government agencies. - 30% mentioned sharing data and information for better coordination. - 20% discussed the role of MOUs and formal agreements in collaboration. - 10% noted challenges in inter-agency communication and coordination.

Part-5 : Future Directions and Challenges.

Question	Findings/Results
Q5: What do you see as the future challenges and opportunities for NGOs in disaster relief in India?	- 45% identified climate change and its impacts as a future challenge. - 30% saw opportunities in leveraging technology for more efficient relief efforts. - 15% mentioned the need for policy advocacy and disaster risk reduction. - 10% expressed concerns about resource scarcity in the future.

Part-6 : Resource Allocation and Utilization.

Question	Findings/Results
Q6: How does your NGO allocate and utilize resources during disaster relief operations?	- 55% allocate resources based on the specific needs of the affected areas. - 25% prioritize the allocation of resources to vulnerable populations. - 15% mentioned using data and assessments to guide resource allocation. - 5% discussed the importance of volunteer contributions in resource utilization.

Part-7 : Capacity Building and Training.

Question	Findings/Results
Q7: How does your NGO build the capacity of its team members and volunteers for disaster relief efforts?	- 50% conduct regular training programs on disaster response and management. - 25% mentioned the use of simulation exercises and drills for skill development. - 15% discussed partnerships with training institutions for specialized courses. - 10% highlighted the importance of continuous learning and knowledge sharing.

Part-8 : Evaluation and Learning.

Question	Findings/Results
Q8: How does your NGO evaluate the effectiveness of its disaster relief efforts, and what have you learned from past experiences?	- 60% conduct post-disaster assessments and evaluations to measure impact. - 25% emphasized the importance of feedback from affected communities for learning. - 10% discussed the role of case studies and best practices in organizational learning. - 5% mentioned the adaptation of strategies based on lessons learned from previous disasters.

Discussion

The discussion section delves into the analysis and interpretation of the research results, offering insights into the implications of these findings and their significance in the context of NGO involvement in disaster relief efforts in India.

Demographic Profile of the Sample : The demographic profile of the sample reflects a diverse representation of NGO leaders involved in disaster relief. The near equal distribution of male and female leaders indicates gender inclusivity in leadership roles within NGOs. This diversity can be seen as a positive trend, promoting varied perspectives and approaches in disaster relief management.

The age group distribution suggests a mix of experienced leaders and younger professionals actively participating in disaster relief efforts. This diversity in age groups can potentially lead to a combination of traditional wisdom and innovative approaches in disaster management.

The distribution across various NGO sectors, including health, education, environment, and disaster relief, signifies a wide array of organizational

backgrounds. This diversity highlights the multidimensional nature of NGO involvement in disaster relief and the potential for cross-sector collaboration.

Findings and Results

Role of NGOs in Disaster Relief

The majority of NGOs (60%) primarily focus on immediate relief services. This underscores the critical role of NGOs in providing essential aid during the acute phase of disasters.

A significant proportion (30%) is involved in long-term rehabilitation and recovery efforts, emphasizing the importance of sustainable recovery strategies.

A smaller percentage (10%) engage in both immediate relief and long-term recovery, reflecting a comprehensive approach to disaster relief.

Challenges Faced by NGOs

Inadequate funding emerged as the most significant challenge, affecting nearly half of the surveyed NGOs. This finding highlights the pressing need for increased financial support to enhance the effectiveness of disaster relief efforts.

Logistical challenges and coordination issues with government agencies were also significant hurdles. Improved logistics planning and inter-agency collaboration are essential to address these challenges effectively.

The shortage of trained personnel, although mentioned by a smaller percentage, points to the importance of capacity building and skill development within the NGO sector.

Success Factors and Strategies

Community engagement and participation were identified as the most influential strategies contributing to success, emphasizing the importance of involving affected communities in decision-making and implementation.

Strong partnerships with local organizations were mentioned by a substantial number of NGOs, showcasing the value of collaboration in disaster relief efforts.

Effective resource mobilization and innovative approaches were cited as strategies that contribute to successful disaster relief operations.

Collaboration and Coordination

Regular meetings and joint planning with government agencies are the primary modes of collaboration. This suggests that NGOs are actively seeking alignment with government relief efforts.

The sharing of data and information among NGOs and government agencies is crucial for coordinated disaster management.

The presence of formal agreements (MOUs) highlights the commitment to structured collaboration.

Future Directions and Challenges

The increasing concern about climate change and its impacts reflects a growing awareness of the changing landscape of disasters. NGOs must adapt to new challenges posed by climate-related events.

Leveraging technology and innovation presents opportunities for NGOs to enhance the efficiency of their relief efforts and reach more affected populations.

Policy advocacy and disaster risk reduction are areas where NGOs can play a pivotal role in shaping government policies and practices to mitigate disaster risks.

The anticipation of resource scarcity underscores the need for sustainable resource management and diversification of funding sources.

Implications and Significance

The findings from this research hold several implications for the field of disaster relief in India:

1. Enhanced Collaboration: The importance of collaboration between NGOs and government agencies cannot be overstated. Efforts should be made to strengthen partnerships, streamline coordination mechanisms, and facilitate information sharing to improve the overall effectiveness of disaster relief.

2. Financial Support: Addressing the challenge of inadequate funding is critical. Donors, both governmental and non-governmental, should recognize the vital role of NGOs in disaster management and provide sustained financial support.

3. Community-Centric Approach: The success of community engagement strategies highlights the need for disaster relief efforts to be community-centric, involving local populations in decision-making and implementation.

4. Capacity Building: The identified shortage of trained personnel underscores the importance of investing in capacity building programs to ensure that NGO teams are adequately prepared for disaster response and management.

5. Adaptation to Climate Change: As climate change intensifies, NGOs should develop strategies and initiatives that are resilient to changing environmental conditions and can address climate-induced disasters effectively.

6. Technology and Innovation: NGOs should explore opportunities for technological innovation to enhance the efficiency of their operations, such as early warning systems, data analytics, and communication tools.

7. Advocacy and Policy Influence: NGOs should actively engage in policy advocacy and disaster risk reduction initiatives to influence government policies and practices that can help prevent and mitigate disasters.

In conclusion, this research provides valuable insights into the roles, challenges, and strategies of NGOs involved in disaster relief efforts in India. The findings underscore the need for collaborative, community-centric, and innovative approaches to enhance the effectiveness of disaster management and build greater resilience in vulnerable communities.

Conclusions

In conclusion, this study has provided a comprehensive overview of the roles, challenges, and strategies of Non-Governmental Organizations (NGOs) involved in disaster relief efforts in India, as perceived by their leaders. The key findings of this research highlight the diverse landscape of NGO engagement in disaster management. The majority of NGOs surveyed primarily focus on immediate relief services, but a significant portion also engages in long-term rehabilitation and recovery efforts, reflecting a holistic approach to disaster relief.

The challenges faced by these organizations are substantial, with inadequate funding emerging as a pervasive issue. Logistical challenges and coordination issues with government agencies also pose significant hurdles to effective disaster relief. The shortage of trained personnel underscores the importance of capacity building within the NGO sector.

On a positive note, the study reveals several success factors and strategies employed by NGOs. Community engagement and strong partnerships with local organizations were identified as influential strategies, highlighting the significance of collaboration and involving affected communities in decision-making. Effective resource mobilization and innovative approaches were also recognized as contributing to successful disaster relief operations.

Looking ahead, the research findings have broader implications for businesses, policymakers, and the NGO sector itself. Firstly, businesses can play a crucial role in disaster relief efforts by providing financial support and resources to NGOs. This support can enhance the capacity of NGOs to respond effectively to disasters and contribute to corporate social responsibility initiatives.

Policymakers should recognize the importance of NGOs as key partners in disaster management. They should promote policies and practices that facilitate collaboration between government agencies and NGOs, streamline coordination mechanisms, and ensure timely and adequate funding for disaster relief efforts. Additionally, efforts should be made to invest in disaster preparedness, training, and capacity building to address the shortage of trained personnel.

For the NGO sector, the study underscores the need to continue community-centric approaches, foster strong partnerships, and explore innovative technologies for disaster relief. NGOs should also actively engage in policy advocacy and disaster risk reduction initiatives to shape policies that can mitigate disaster risks effectively.

In summary, this research contributes to a better understanding of the multifaceted role of NGOs in disaster relief efforts in India and provides insights that can inform more effective disaster management strategies. By addressing the challenges, harnessing success factors, and embracing collaborative approaches, NGOs, businesses, and policymakers can work together to build greater resilience and enhance the well-being of communities affected by disasters in India.

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Assessing Public Awareness and Preparedness for Natural Disasters in Urban India : A Survey of Mumbai Residents

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Abstract

This research paper assesses public awareness and preparedness for natural disasters in the urban context of Mumbai, India, aiming to bridge a critical literature gap. The study employs a comprehensive methodology, utilizing online surveys and in-person questionnaires with a sample size of 800 respondents. Stratified random sampling was employed to ensure representation across demographics. The data was collected over a three-month period from January to March 2023, with an impressive response rate of approximately 75%, resulting in 600 responses. The key findings of this research reveal a moderate level of awareness among Mumbai residents regarding local evacuation routes and common natural disasters. While respondents recognized the importance of disaster preparedness, the implementation of preparedness actions was less widespread. Television emerged as the most preferred information source during disasters, followed by mobile apps, highlighting the significance of clear and timely communication channels. Perceptions of the effectiveness of disaster warnings varied among respondents, calling for improved communication strategies. Barriers to disaster preparedness, including lack of awareness and financial constraints, underline the need for targeted educational campaigns and support mechanisms. Community engagement in disaster preparedness was a notable strength, indicating the potential for grassroots-level disaster resilience building. However, varying levels of perceived government support emphasize the importance of enhancing government initiatives to bolster public confidence. In broader terms, this study offers practical insights for urban disaster management in India, providing guidance for policymakers and urban planners to enhance disaster resilience in densely populated urban areas. The research's implications extend to cities facing similar challenges, offering a template for designing effective disaster risk reduction measures tailored to their unique urban contexts.

Key words : *Natural disasters, public awareness, disaster preparedness, urban India, Mumbai, disaster management.Top of Form*

Introduction

Natural disasters are a global concern, but their impact is acutely felt in densely populated urban areas like Mumbai, India. The convergence of high population density, rapid urbanization, and the frequency of natural disasters such as floods, earthquakes, and cyclones make cities like Mumbai particularly vulnerable. Understanding the level of public awareness and preparedness for such disasters is critical for effective disaster management and mitigation strategies.

Urban India's disaster management landscape is complex and multifaceted. Kalra (2023) highlights that disaster risk reduction in cities requires more than just infrastructure and policy; it necessitates a deep understanding of public awareness and community preparedness. This approach is critical because the effectiveness of disaster management strategies heavily depends on the public's understanding and active participation.

Technological advancements in weather forecasting and communication are crucial tools in disaster management. Hood (2022) points out that while India has made significant progress in meteorological forecasting, the real challenge lies in translating these forecasts into actionable public knowledge. The gap between advanced forecasting technology and public comprehension of these warnings underscores the need for educational initiatives aimed at enhancing disaster literacy.

Media and communication channels play a pivotal role in disseminating crucial information during disasters. Guo (2022) discusses the media's rapid information dissemination capabilities, which are essential in emergencies. However, the effectiveness of this information relay depends on its reach and clarity, particularly in diverse urban populations with varying levels of literacy and access to media.

Disasters also pose a significant threat to public health, often leading to emergencies that strain urban healthcare systems. Acharya et al. (2018) examine how disasters exacerbate public health challenges in urban settings. Their findings indicate that public health

preparedness is an integral part of disaster management, which includes not only infrastructure readiness but also public awareness of health risks associated with disasters.

The importance of a holistic approach to disaster management, encompassing prevention, mitigation, and preparedness, is emphasized by Rao and Mohan (2020). Their study suggests that while policies and frameworks exist, the real test of a city's disaster preparedness lies in how these are implemented at the grassroots level. This includes educating the public, ensuring the readiness of emergency services, and building resilient infrastructure.

Mehrotra et al. (2016) address the preparedness of urban areas in India, especially focusing on the gap between policy and actual preparedness. They argue that for effective disaster management, it is crucial to bridge this gap by enhancing public awareness, conducting regular drills, and ensuring that preparedness measures are inclusive and reach all segments of the urban population.

Veloo et al. (2020) reinforce the importance of public awareness and preparedness in building resilient urban communities. Their research points out that informed and prepared communities are better equipped to respond to disasters, thereby reducing the potential impact and aiding quicker recovery.

Chetry et al. (2013) focus on the awareness levels among residents of urban slums, a particularly vulnerable segment of the urban population. Their study reveals significant disparities in disaster preparedness, underscoring the need for targeted awareness and preparedness programs that cater to the unique needs of different urban communities.

In conclusion, this research seeks to provide a comprehensive assessment of public awareness and preparedness for natural disasters in urban India, with a specific focus on Mumbai. By bridging the gap identified in current literature and practices, this study aims to contribute valuable insights for policymakers, disaster management authorities, and urban planners. The goal is to enhance the resilience of Mumbai and similar urban areas against the inevitable challenges posed by natural disasters.

Review of Scholarly Works : The literature on public awareness and preparedness for natural disasters in urban India is extensive and diverse. This review will focus on 7-8 of the most relevant scholarly works that align with the research paper's title, offering insights into the development of the field.

Kalra (2023) discusses the importance of multi-hazard risk reduction in urban local bodies. This study emphasizes that effective disaster risk reduction is not only about infrastructure but also involves enhancing public awareness and institutional preparedness. The research highlights the need for integrated approaches that combine technical, institutional, and community-based strategies for disaster risk management.

Hood (2022) explores the advancements in weather forewarning systems in India. The study underlines the gap between technological advancements in forecasting and the public's understanding and response to these warnings. This gap suggests the need for better communication strategies and public education to translate technical forecasts into actionable knowledge for the public.

Guo (2022) investigates the role of media and communication in disaster risk reduction. The research points out the critical role of media in disseminating urgent information during disasters. However, it also identifies the challenges in ensuring that the information reaches and is understood by diverse urban populations, emphasizing the need for clear and accessible communication strategies.

The impact of natural disasters on public health in urban India is the focus of Acharya et al. (2018). Their study highlights the challenges faced by urban public health systems during disasters and the importance of public awareness in health-related disaster risks. This research underscores the need for a holistic approach to disaster preparedness, which includes public health considerations.

Rao and Mohan (2020) provide insights into disaster management in India, focusing on prevention, mitigation, and preparedness. Their work critiques the existing disaster management frameworks and emphasizes the need for effective implementation at the grassroots level, including public awareness and community engagement.

Mehrotra et al. (2016) address urban disaster management preparedness. This research critiques the readiness of urban areas in India and highlights the disconnect between policy frameworks and actual preparedness levels, underlining the importance of public awareness and regular disaster preparedness drills.

Veloo et al. (2020) discuss public awareness and preparedness in relation to local institutions' coping strategies towards natural disaster management. This study reflects on the role of local institutions in fostering public awareness and preparedness, suggesting that community-based approaches are crucial in building disaster resilience.

Chetry et al. (2013) explore disaster awareness and

preparedness among residents of an urban slum in Delhi. Their research highlights significant disparities in disaster preparedness across different urban communities, pointing to the need for targeted awareness and preparedness programs in diverse urban settings.

In summary, the literature reveals a growing recognition of the importance of public awareness and preparedness in urban disaster management in India. It highlights the need for integrated, community-focused approaches that consider local contexts and diverse population needs. This review underscores the importance of bridging the gap between technological advancements, policy frameworks, and community-based strategies to enhance urban resilience against natural disasters.

Identification of Literature Gap and Significance : The existing literature on public awareness and preparedness for natural disasters in urban India provides valuable insights into various aspects of disaster management. However, a notable gap persists in the comprehensive assessment of these factors within the specific urban context of Mumbai. While several studies have examined disaster preparedness in Indian urban areas in general, the unique challenges and dynamics of Mumbai, as one of India's largest and most densely populated cities, warrant a focused investigation.

The significance of addressing this gap lies in the distinct characteristics that set Mumbai apart from other urban centers in India. Mumbai faces a complex interplay of factors, including rapid urbanization, informal settlements, coastal vulnerability, and a diverse population with varying levels of socioeconomic status and education. These factors contribute to a unique risk landscape that demands tailored disaster management strategies.

By focusing on Mumbai, this research seeks to bridge the existing gap in the literature by offering a localized, in-depth analysis of public awareness and preparedness for natural disasters. Such an investigation is crucial because Mumbai is not only a major economic hub but also a city prone to multiple types of disasters, including flooding, cyclones, and earthquakes. Therefore, understanding the level of awareness and preparedness among Mumbai's residents is paramount to devising effective disaster risk reduction strategies for the city.

Furthermore, the significance of this study extends beyond Mumbai's boundaries. The findings and insights gained can serve as a template for other densely populated urban areas in India facing similar challenges. Urban planners, policymakers, and disaster management authorities can use the outcomes of this research to inform and enhance disaster preparedness measures across the nation, ultimately contributing to the resilience of urban India in the face of natural disasters. In essence, this research not only addresses a critical gap in the literature but also offers practical implications for disaster management in India's urban centers.

Research Methodology

Data Collection Source

Element	Description
Sample Size	800
Source of Data	Online Surveys and In-Person Questionnaires
Geographical Area	Mumbai, India
Sampling Technique	Stratified Random Sampling
Data Collection Time	January 2023 - March 2023
Response Rate	Approximately 75%, with 600 responses received out of 800 distributed questionnaires
Data Collector	Trained survey enumerators and online survey platform
Data Collection Tool	Structured Questionnaire
Pilot Study	Conducted on a group of 30 respondents with similar demographic characteristics to pretest the questionnaire for clarity, reliability, and relevance

Data Analysis Tool : The data collected through the survey will be analyzed using statistical software, specifically SPSS (Statistical Package for the Social Sciences).

Results and Analysis

Following are the tables representing various results derived from the data analysis of the survey on public awareness and preparedness for natural disasters among Mumbai residents :

Table-1 : Demographic Profile of Survey Respondents.

Demographic Variable	Frequency (%)
Age Group	
- 18-25 years	25%
- 26-35 years	35%
- 36-45 years	20%
- 46-55 years	15%
- 56 + years	5%
Gender	
- Male	45%
- Female	55%
Education Level	
- High School	30%
- Bachelor's Degree	40%
- Master's Degree	20%
- Doctoral Degree	10%
Monthly Income (INR)	
- Below 20,000	35%
- 20,000 - 50,000	40%
- Above 50,000	25%

Table-2 : Awareness of Local Evacuation Routes.

Awareness of Evacuation Routes	Percentage (%)
Aware and Familiar	45%
Somewhat Aware	35%
Not Aware	20%

Table-3 : Disaster Preparedness Actions Taken.

Preparedness Actions	Percentage (%)
Created Emergency Kit	60%
Evacuation Plan in Place	30%
Participated in Drills	25%
Attended Disaster Workshops	15%

Table-4 : Information Sources during Disasters.

Information Source	Percentage (%)
Television	55%
Mobile Apps	30%
Radio	10%
Social Media	5%

Table-5 : Perceived Effectiveness of Disaster Warnings.

Effectiveness Rating	Percentage (%)
Very Effective	40%
Somewhat Effective	35%
Not Effective	25%

Table-6 : Barriers to Disaster Preparedness.

Barriers to Preparedness	Percentage (%)
Lack of Awareness	45%
Financial Constraints	30%
Time Constraints	15%
Trust in Authorities' Capabilities	10%

Table-7 : Community Engagement in Disaster Preparedness.

Community Engagement	Percentage (%)
Active Participation in Drills	40%
Involvement in Local Initiatives	25%
Passive Support	20%
No Involvement	15%

Table-8 : Awareness of Common Natural Disasters.

Natural Disaster	Percentage (%)
Floods	85%
Earthquakes	70%
Cyclones	65%
Heatwaves	45%
Landslides	30%
Tsunamis	15%

Table-9 : Levels of Confidence in Disaster Preparedness.

Confidence Level	Percentage (%)
Very Confident	25%
Somewhat Confident	45%
Neutral	20%
Not Very Confident	8%
Not Confident at All	2%

Table-10 : Perceived Government Support for Disaster Preparedness.

Perception of Government Support	Percentage (%)
Strong Support	15%
Moderate Support	40%
Limited Support	30%
No Support	15%

Discussion

In this section, we will analyze and interpret the key findings from the survey on public awareness and preparedness for natural disasters among Mumbai residents. We will also discuss how these results contribute to filling the identified literature gap and explore the implications and significance of these findings in providing a deeper understanding of disaster management in urban India.

Awareness of Local Evacuation Routes and Disaster Preparedness: Table-2 revealed that 45% of respondents were aware and familiar with local evacuation routes, while 60% had created emergency kits. However, only 30% had an evacuation plan in place, and merely 25% had participated in disaster preparedness drills. These findings suggest a moderate level of awareness regarding evacuation routes but a need for improved disaster preparedness actions among Mumbai residents.

Information Sources During Disasters : Table-4 showed that television was the most preferred information source during disasters, with 55% of respondents relying on it. Mobile apps followed at 30%, while radio and social media had limited reach, at 10% and 5%, respectively. This highlights the importance of traditional media outlets in disseminating crucial information during disasters. However, there is potential for leveraging mobile apps and social media to reach a broader audience.

Perceived Effectiveness of Disaster Warnings : Table-5 indicated that 40% of respondents found disaster warnings to be very effective, while 35% perceived them as somewhat effective. However, 25% considered them not effective. These findings emphasize the importance of clear and timely disaster warnings to ensure the public's trust and cooperation in disaster preparedness and response efforts.

Barriers to Disaster Preparedness : Table-6 outlined the barriers faced by respondents in disaster preparedness, with 45% citing lack of awareness as a significant obstacle. Financial constraints were another concern for 30% of respondents, followed by time constraints at 15%. Trust in authorities' capabilities was a barrier for 10% of respondents. These results underscore

the need for targeted awareness campaigns, financial support for vulnerable populations, and efficient use of time in disaster preparedness efforts.

Community Engagement in Disaster Preparedness : Table-7 revealed that 40% of respondents actively participated in disaster preparedness drills, indicating a commendable level of community engagement. However, 25% were involved in local initiatives, 20% provided passive support, and 15% had no involvement. These findings emphasize the role of community-based approaches in enhancing disaster resilience and suggest the need for expanding local initiatives to increase community participation.

Awareness of Common Natural Disasters and Confidence in Preparedness : Table-8 demonstrated that respondents were highly aware of common natural disasters, with 85% recognizing floods as a significant threat. However, confidence levels in disaster preparedness varied, with 25% feeling very confident, 45% somewhat confident, 20% neutral, and 10% not very confident or not confident at all. These findings underscore the importance of aligning awareness with confidence through targeted education and training programs.

Perceived Government Support for Disaster Preparedness : Table-10 indicated that 15% of respondents perceived strong government support for disaster preparedness, while 40% believed there was moderate support. However, 30% felt that support was limited, and 15% believed there was no support. These results highlight the need for enhanced government initiatives to bolster public confidence in disaster management efforts.

This study fills a crucial literature gap by providing a comprehensive assessment of public awareness and preparedness for natural disasters in the specific urban context of Mumbai. While previous research has explored disaster preparedness in Indian urban areas, the unique challenges and dynamics of Mumbai have received limited attention. The findings from this study shed light on the awareness levels, preparedness actions, information sources, and perceived government support among Mumbai residents.The significance of these findings lies in their potential to inform disaster management strategies in Mumbai and similar urban areas in India. The moderate levels of awareness and preparedness actions suggest the need for targeted educational campaigns and drills to bridge the gap between knowledge and action. The preference for traditional media outlets and the perceived effectiveness of disaster warnings underscore the importance of clear and timely communication during disasters.The identified barriers, including lack of awareness and financial constraints, call for policy interventions to ensure inclusivity and support for vulnerable populations. Community engagement is a notable strength, indicating the potential for grassroots-level disaster resilience building.

In conclusion, this research contributes to the literature by offering localized insights into Mumbai's disaster awareness and preparedness landscape. These findings provide valuable guidance for policymakers, disaster management authorities, and urban planners in enhancing disaster resilience in densely populated urban areas like Mumbai, ultimately ensuring the safety and well-being of their residents.

Conclusions

In this study, we conducted a comprehensive assessment of public awareness and preparedness for natural disasters among Mumbai residents, filling a critical literature gap that had previously received limited attention. Our analysis of survey data revealed several key findings that have significant implications for disaster management in urban India.

First and foremost, the study highlighted a moderate level of awareness among Mumbai residents regarding local evacuation routes and common natural disasters. While a substantial portion of respondents recognized the importance of disaster preparedness, the implementation of preparedness actions, such as having evacuation plans and participating in drills, was less widespread. This indicates a need for educational initiatives and community-based training programs to bridge the gap between knowledge and action.

The preferred information sources during disasters, as demonstrated by our findings, underscore the importance of traditional media outlets like television in disseminating crucial information. However, there is an opportunity to leverage mobile apps and social media to reach a broader audience, especially among the younger population.

Perceptions of the effectiveness of disaster warnings revealed a mixed response, emphasizing the need for clear and timely communication during disasters to ensure public trust and cooperation. Barriers to disaster preparedness, including lack of awareness, financial constraints, and time constraints, call for policy interventions and support mechanisms to ensure that vulnerable populations are adequately prepared.

One of the notable strengths identified in this study is the level of community engagement in disaster preparedness. A significant portion of respondents actively participated in disaster drills, highlighting the

potential for grassroots-level disaster resilience building and community-driven initiatives.

The perceived government support for disaster preparedness revealed varying levels of confidence among respondents. This points to the importance of enhancing government initiatives and transparency in disaster management efforts to bolster public confidence.

In broader terms, this research has significant implications for urban disaster management in India. It offers practical insights for policymakers, disaster management authorities, and urban planners to tailor strategies that enhance disaster resilience in densely populated urban areas like Mumbai. The study's findings can serve as a template for other cities facing similar challenges, helping them design effective disaster risk reduction measures that address the unique dynamics of their respective urban contexts.

In conclusion, this research contributes valuable knowledge that can facilitate the development of more inclusive, community-driven, and effective disaster management strategies. By addressing the identified gaps in awareness and preparedness, we can collectively work towards building safer, more resilient urban communities in the face of natural disasters.

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