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GRISAAS

An Edited Book

Volume-1

Chief Editor : **Dr. S.P. Singh**

Compiled & Edited for

Astha Foundation, Meerut (U.P) INDIA

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Global Research Initiatives for Sustainable Agriculture & Allied Sciences

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Editors

- Dr. Vijay P. Singh, Pantnagar
- Dr. B.V. Tamburne, Raichur
- Dr. Brijendra Singh, East Garo Hills
- Dr. Satish Chand Gaur, Deoria
- Dr. Netrapal Malik, Aligarh
- Dr. P.B. Singh, Udaipur
- Dr. Hiranmayee Nayak, Bhubaneshwar
- Dr. Anil Kumar, Sabour
- Dr. Rohit Rana, Shamli
- Dr. Harish Pal Bhati, Meerut

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National Academy of Agricultural Sciences

Prof. Anil Kumar Singh
Vice-President

PREFACE

Indian Agricultural Production System was able to transform a country from the status of a "Begging Bowl" to that of "Overflowing Granaries" as a consequence of "Green Revolution". However, the emphasis on production only coupled with imbalanced use of fertilizer, indiscriminate use of fertiliser and mismanagement of water led to degradation of natural resources, particularly, soil and water. The rapid pace of development has resulted in excessed emission of GHG's and global warming. All these factors plus the need for feeding a global population with diverse requirement likely to exceed 9 billion by 2050 will result in intensification of agricultural activities. With very little scope of bringing additional area under cultivation, sustainable agricultural production will be a formidable challenge.

Global Research Initiatives for Sustainable Agriculture and Allied Sciences (GRISAAS) has been striving on bringing innovative ideas on sustainable agriculture throughout the world by bringing together researchers, academicians and stake holders from all branches of sciences and related fields on one platform. They have been working since 2015, spreading knowledge and awareness by organizing conferences. This book, one of the publications being brought out by GRISAAS, comprises of 18 chapters which deal with various aspects and ideas of sustainable production systems ranging from organic farming to breeding novel varieties. It also explores practices and management strategies to help producers and policy-makers become more aware about the various dimensions of sustainable production.

I would like to thank Dr. S.P. Singh, Chief Editor, and the editorial team of GRISAAS (Volume 1), who worked dedicatedly and encouraged the researchers to submit their papers. It is our sincere hope that this publication will assist researchers, students, growers and entrepreneurs in moving forward scientifically in cultivation with a view to sustainable agriculture for different crops.

(A.K.Singh)

NASC, Dev Prakash Shastri Marg, P.O. Pusa, New Delhi-110 012
Tel.: 91-11-25846051-52, Fax : 91-11-25846054, Email : naas@vsnl.com, Website : www.naasindia.org

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Chief Editor

Dr. S.P. Singh,

Department of Genetics & Plant Breeding

CSAUAT-Agriculture Research Station, Kalai, Aligarh (U.P.) India

Editors

Dr. Vijay P. Singh : Deptt. of Horticulture, G.B.P. University of Agriculture & Technology, Pantnagar, Uttarakhand

Dr. B.V. Tamburne : Deptt. of Genetics & Plant Breeding, University of Agricultural Sciences, Raichur, Karnataka

Dr. Bijendra Singh : Central Agricultural University, Imphal-Animal Husbandry, KVK, East Garo Hills, Meghalaya

Dr. Satish Chand Gaur : Deptt. of Genetics & Plant Breeding; Baba Raghav Das Post Graduate College, Deoria, U.P.

Dr. Netrapal Malik : CSAUAT, Deptt. of Agriculture Extension, Krishi Vigyan Kendra, Aligarh, U.P.

Dr. P.B. Singh : Deptt. of Genetics & Plant Breeding, Maharana Pratap University of Agriculture & Technology, Udaipur, Raj.

Dr. Hiranmayee Nayak : Deptt. of Agroforestry, Odisha University of Agricultural Sciences, Bhubaneshwar, Odisha

Dr. Anil Kumar : Deptt. of Genetics & Plant Breeding, Bihar Agricultural University, Sabour, Bhagalpur, Bihar

Dr. Rohit Rana : Deptt. of Entomology, Rashtriya Kishan Post Graduate College, Shamli, U.P.

Dr. Harish Pal Bhati : Deptt. of Botany, Swami Vivekanand Subharti University, Meerut, U.P.

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Astha Foundation
Suman Villa, 85, Phool Bagh Colony, Meerut-250002 (U.P.) India
Mob. : 9450068438, 8273775051
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From Chief Editor's Desk

GRISAAS : An Initiative towards Sustainable Agriculture & Allied Sciences

S.P. Singh
Sr. Scientist (GPB), ARS, Kalai, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.) India
Chief Editor, *GRISAAS Series of Edited Books and Souvenior*
President, *Astha Foundation, Meerut (U.P.) India*
Secretary, *Society for Scientific Development in Agriculture and Technology, Meerut (U.P.) India*
Chief Editor, *Frontiers in Crop Improvement Journal, NAAS Accridated Journal (NAAS Rating **4.67**)*
Editor-in-Chief, *Progressive Research–An International Journal, NAAS Accridated Journal (NAAS Rating **3.78**)*

About GRISAAS

Global research initiatives for sustainable agriculture and allied sciences (GRISAAS), a brain child of **Astha Foundation** to bring scientists, researchers, academicians and all stake holders from throughout the globe for the betterment of humanity with the involvement of all the branches of sciences and related field is organizing the conferences since last six years. The eleven different themes of sessions were planned for the GRISAAS and these themes itself explains the vision of GRISAAS are :

1. Innovative technology for crop improvement, biotechnology and genetic engineering
2. Impact of climate change on biodiversity, food security and IPR issues
3. Precision horticulture for augmenting farmer's income
4. New frontiers in disease and pest management
5. Food processing, value addition and post harvest technology
6. Agroforestry, livelihood and sustainable management practices
7. Cropping system indigenous technical knowledge : Policies and economics of profitable agriculture
8. Integrates approaches in physical, chemical and biological sciences
9. Soil health management and practices : Key factor for crop productivity
10. Animal health, animal husbandry and dairy technology
11. Social sciences, library, information science and humanities

The **first GRISAAS** conference was organized during 12-13th December, 2015 at Rajmata Vijayaraje Scindia Krishi Viswa Vidhyalay, Gwalior (M.P.). It received overwhelming response with the registration of more than **1000** participants. The **second GRISAAS** International Conference was organized during 02-04th December, 2017 at Maharana Pratap University of Agriculture and Technology, Udaipur Rajasthan with the registration of more than **1200** participants. The **third GRISAAS** International Conference was organized during 28-30th October, 2018 at Rajasthan Agricultural Research Institute, Durgapura, Jaipur, Rajasthan with the registration of more than **1000** participants. The **fourth GRISAAS** International Conference was organized during 20-22nd October, 2019 at ICAR-National Academy of Agricultural Research Management (NAARM), Rajendranagar, Hyderabad, Telangana with the registration of more than **1000** participants. During the pandemic era, **fifth GRISAAS** one was organized in online mode on 28-30th December, 2020 from the headquarter of Astha foundation, Meerut, U.P. with the registration of more than **1000** participants. Again to stick with corona guidelines the **sixth GRISAAS** International Conference was scheduled in hybrid mode during 13-15th December, 2021 at Swami Keshwanand

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Rajasthan Agricultural University, Bikaner, Rajasthan. However, due to COVID new guidelines and restrictions due to OMICRON variant of corona, university showed its inability to host it in physical mode so it was also being organized from the headquarter of Astha foundation, Meerut, U.P. with the registration of more than **1500** participants One thing was common in all the conferences that in all the conferences the registrations from the scientific communities and students crossed the ***1000 mark limit*** and it ***reached to 1500*** in online mode. It shows the linkage and faith of scientific community in the Astha Foundation and SSDAT.

Thus the society is serving the scientific and farming community through sharing a common platform with the publication of literature on recommendations based on the conferences organized and problem solving of the stake holders.

GRISAAS : The beginning

Worldwide demands for food increases (population of over 8 billion by 2025) while land and water become increasingly scarce and human health issues rise and threaten food systems and their sustainability. There will be no sustainable future without eradicating poverty and hunger. Ensuring food security for all is both a key function and a challenge for agriculture, which faces ever-increasing difficulties–as populations and urbanization. The agricultural sector will be under mounting pressure to meet the demand for safe and nutritious food. Agriculture has to generate decent jobs and support the livelihoods of billions of rural people across the globe, especially in developing countries where hunger and poverty are concentrated. Furthermore, the sector has a major role to play in ensuring the sustainability of the world's precious natural resources and biodiversity, particularly in light of a changing climate. Climate change will have an increasingly adverse impact on many regions of the world, with those in low latitudes being hit the hardest. Developing countries, in particular, will need support from the global community to facilitate their adaptation and mitigation efforts in relation to climate change and to transform their agriculture and food systems sustainably. As the migration crisis of recent years has shown, no country stands unaffected. What happens in one part of the globe will undoubtedly affect other parts, and domestic and foreign policies must take account of this.

Global Agriculture Research institutes

At global level only mandated international agricultural research organization is the CGIAR. The CGIAR Fund supports 15 international agricultural research centers such as the International Water Management Institute (IWMI), International Rice Research Institute (IRRI), the International Institute of Tropical Agriculture (IITA), the International Livestock Research Institute (ILRI), the International Food Policy Research (IFPRI) and the Center for International Forestry Research (CIFOR) that form the CGIAR Consortium of International Agricultural Research Centers and are located in various countries worldwide (as of 2011), The centers carry out research on various agricultural commodities, livestock, fish, water, forestry, policy and management. Some other international agricultural organizations include the United Nations Food and Agriculture Organization, Global Forum on Agricultural Research (GFAR), The International Agriculture Center (Netherlands), The World Bank, International Fund for Agricultural Development, The Center for International Food and Agriculture Policy at the University of Minnesota. The CGIAR (Consultative Group on International Agricultural Research) is a small but significant component of the global agricultural research system. With its limited financial resources, it has to be selective in its role and choice of research portfolio. An updated report on CGIAR priorities and strategies is produced every five years by TAC (Technical Advisory Committee to the CGIAR) to guide system-wide resource allocation taking into consideration an appropriate balance between centers, activities, commodities, regions and agro-ecological zones. In considering priorities, TAC is guided by several important factors such as the CGIAR mission and goal, emerging trends in world agriculture, and the evolution of scientific capacity in developing countries. The current approach has been modified to account for the expanded mandate of the CGIAR, greater emphasis on sustain-ability and resource management issues, allow for meaningful interactions with stakeholders, ensure transparency in decision making, and develop mechanisms which facilitate CGIAR priority setting as a continuing activity.

What is Sustainable Agriculture : Every day, farmers and ranchers around the world develop new, innovative strategies to produce and distribute food, fuel and fiber sustainably. While these strategies vary greatly, they all embrace three broad goals, or what SARE calls the 3 Pillars of Sustainability: Profit over the long term, Stewardship of nation's land, air and water and Quality of life for farmers, ranchers and their communities. The phrase 'sustainable agriculture' was reportedly coined by the Australian agricultural scientist Gordon McClymont Wes Jackson is credited with the first publication of the expression in his 1980 book *New Roots for Agriculture*. The term became popular in the late 1980s. It has been defined as "an integrated system of plant and animal production practices having a site-specific application that will last over the long term, for example to satisfy human food and fiber needs, to enhance environmental quality and the natural resource base upon which the agricultural economy depends, to make the most efficient use of non-renewable and on-farm resources and integrate natural biological cycles and controls, to sustain the economic viability of farm operations, and to enhance the quality of life for farmers and society as a whole.

There are several key principles associated with sustainability in agriculture.

The incorporation of biological and ecological processes into agricultural and food production practices. For example, these processes could include nutrient cycling, soil regeneration, and nitrogen fixation.

Using decreased amounts of non-renewable and unsustainable inputs, particularly the ones that are environmentally harmful.

Using the expertise of farmers to both productively work the land as well as to promote the self-reliance and self-sufficiency of farmers.

Solving agricultural and natural resource problems through the cooperation and collaboration of people with different skills. The problems tackled include pest management and irrigation.

Sustainable agriculture can be understood as an ecosystem approach to agriculture. Practices that can cause long-term damage to soil include excessive tilling of the soil (leading to erosion) and irrigation without adequate drainage (leading to salinization). Long-term experiments have provided some of the best data on how various practices affect soil properties essential to sustainability. In the United States a federal agency, USDA-Natural Resources Conservation Service, specializes in providing technical and financial assistance for those interested in pursuing natural resource conservation and production agriculture as compatible goals.

Initiatives by United Nations for sustainable development

The year 2015 signalled the arrival of two landmark initiatives that recognized the need for countries to take collective action to promote sustainable development and combat climate change: the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs), and the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC). Both initiatives reflect evolving thinking around global issues, and both call for a fair and transparent international trade system. In food and agriculture, trade can play a role and contribute to meeting the targets of both the 2030 Agenda and the Paris Agreement.

In the meeting at the United Nations Headquarters in New York from 25-27 September 2015 as the Organization celebrated its seventieth anniversary, have decided on new global Sustainable Development Goals. UN adopted a historic decision on a comprehensive, far-reaching and people-centred set of universal and transformative Goals and targets and committed to working tirelessly for the full implementation of this Agenda by 2030.

The sustainable development goals : The sustainable development goals (SDGs) are a new, universal set of goals, targets and indicators that UN member states will be expected to use to frame their agendas and political policies over the next 15 years. The SDGs follow and expand on the millennium development goals (MDGs), which were agreed by governments in 2001 and are due to expire at the end of this year.

Need for set of goals : There is broad agreement that, while the MDGs provided a focal point for governments– a framework around which they could develop policies and overseas aid programmes designed to end poverty and improve the lives of poor people – as well as a rallying point for NGOs to hold them to account, they were too narrow.

The eight MDGs: reduce poverty and hunger; achieve universal education; promote gender equality; reduce child and maternal deaths; combat HIV, malaria and other diseases; ensure environmental sustainability; develop global partnerships – failed to consider the root causes of poverty and over-looked gender inequality as well as the holistic nature of development. The goals made no mention of human rights and did not specifically address economic development. While the MDGs, in theory, applied to all countries, in reality they were considered targets for poor countries to achieve, with finance from wealthy states. Conversely, every country will be expected to work towards achieving the SDGs.

Proposed 17 Sustainable Development Goals (SDGs)

End poverty in all its forms everywhere

End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

Ensure healthy lives and promote wellbeing for all at all ages

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Achieve gender equality and empower all women and girls

Ensure availability and sustainable management of water and sanitation for all

Ensure access to affordable, reliable, sustainable and modern energy for all

Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all

Build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation

Reduce inequality within and among countries

Make cities and human settlements inclusive, safe, resilient and sustainable

Ensure sustainable consumption and production patterns

Take urgent action to combat climate change and its impacts (taking note of agreements made by the UNFCCC forum)

Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation, and halt biodiversity loss

Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Strengthen the means of implementation and revitalise the global partnership for sustainable development

Within the goals are 169 targets, to put a bit of meat on the bones. Targets under goal one, for example, include reducing by at least half the number of people living in poverty by 2030, and eradicating extreme poverty (people living on less than $1.25 a day). Under goal five, there's a target on eliminating violence against women, while goal 16 has a target to promote the rule of law and equal access to justice.

The Global Research Alliance (GRA) : Is an international network of nine applied research organizations that works to promote application of science and technology to solve large scale issues facing developing countries. The alliance was formed in 2000 in Pretoria, South Africa. Today, the GRA has access to over 60,000 people across its membership. Vision is for a world where the application of innovative science and technology, through collaboration and co-creation, delivers access equality, improves lives, and solves global development challenges.The GRA uses the best science and technology to solve some of the biggest problems in the developing world. These global issues span borders, cultures and religions and require a cross-boundary response. They address these problems by :

Mobilising the creative energy of our globally and culturally diverse researchers to address global development challenges through innovation

Saring the breadth and depth of our science and technology resources and uniting with local partners, communities, industry and collaborators

Generating and implementing appropriate, affordable and sustainable solutions with positive and lasting impact

The GRA is a dynamic alliance of nine knowledge intensive research and technology organizations from around the world. Its goal is to create 'A Global Knowledge Pool for Global Good'. The focus is to apply science, technology and innovation in the pursuit of solving some of world's gravest challenges.

GRA and Inclusive Innovation : The Global Research Alliance (GRA) believes Inclusive Innovation requires a holistic and new way of approaching demand-driven projects and co-creation with partners such as end-users, technology organizations and both the private and public sectors. This includes: success through technical innovation (products), social innovation (interaction/co-creation), management innovation (business models); and chain innovation (relationships in the value chain). Inclusive Innovation is not new to the GRA. Over the last few years, the GRA has systematically addressed global challenges through the deployment of Inclusive Innovation initiatives.

Why do we need climate-smart agriculture : The UN Food and Agriculture Organization (FAO) estimates that feeding the world population will require a 60 percent increase in total agricultural production. With many of the resources needed for sustainable food security already stretched, the food security challenges are huge. At the same time climate change is already negatively impacting agricultural production globally and locally. Climate risks to cropping, livestock and fisheries are expected to increase in coming decades, particularly in low-income countries where adaptive capacity is weaker. Impacts on agriculture threaten both food security and agriculture's pivotal role in rural livelihoods and broad-based development. Also the agricultural sector, if emissions from land use change are also included, generates about one-quarter of global greenhouse gas emissions.

Practical adaptation options to improve food security and resilience : What practical steps can smallholder farmers take to adapt their agricultural practices to secure dependable food supplies and livelihoods? And can they do this while also decreasing greenhouse gas emissions or increasing carbon sequestration, thereby decreasing future climate change?

The Global Water Partnership's : vision is for a water secure world. Its mission is to support the sustainable development and management of water resources at all levels GWP was founded in 1996 by the World Bank, the United Nations Development Programme (UNDP), and the Swedish International Development Cooperation Agency (SIDA) to foster integrated water resource management (IWRM).

IWRM is a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare without compromising the sustainability of ecosystems and the environment. The network is open to all organisations involved in water resources management : developed and developing country government institutions, agencies of the United Nations, bi- and multi-lateral development banks, professional associations, research institutions, non-governmental organisations, and the private sector. In the "Our Approach" section one can read about GWP's global strategy - Towards 2020 - how GWP are currently pursuing vision of water security. Dealing with water issues requires commitment at the highest political level. Water security will only be reached when political leaders take the lead, make the tough decisions about the different uses of water and follow through with financing and implementation. GWP sees its role as having the technical expertise and convening power to bring together diverse stakeholders who can contribute to the social and political change processes that help bring the vision of a water secure world closer to reality. GWP regularly reports on outcomes at the national, regional, and global level. GWP is implementing its strategy and up-to-date information on activities across the globe.

The Global Water Partnership (GWP) has announced the launch of its new 2014-2019 global strategy. The strategy, Towards 2020, outlines a new direction for GWP with the goals of catalyzing change, sharing knowledge, and

Strengthening partnerships for a water secure world : The 2014-2019 Strategy builds on GWP's previous work and achievements. It was developed through a year-long process of regional dialogues and consultations with GWP's growing network of over 2,900 Partner Organizations across 172 countries. "The strategy Towards 2020 stresses the need for innovative and multi-sectoral approaches to adequately address the manifold threats and opportunities relating to sustainable water resource management in the context of climate change, rapid urbanization, and growing inequalities," Knowledge generation and communication continues to be a central part of GWP's work with this strategy. "Knowledge and new tools are needed to support policy development and decision making and enable the effective and sustainable management of water resources," "Knowledge can stimulate behavioural change towards a new 'water culture'. New to this strategy is a thematic approach in six key areas of development–climate change, transboundary cooperation, food, urbanisation, energy, and ecosystems. "Integrated water management is fundamental to all of these areas of the global development agenda. Our new thematic approach will ensure the crucial link to water security is made across these thematic focus areas for meeting sustainable development goals," explains GWP Executive Secretary Dr Ania Grobicki.

The global launch of the strategy took place at the Official United Nations World Water Day celebrations in Tokyo, Japan, on 21 March 2014.

Global Soil Partnership : Soil is under pressure. The renewed recognition of the central role of soil resources as a basis for food security and their provision of key ecosystem services, including climate change adaptation and mitigation, has triggered numerous regional and international projects, initiatives and actions. Despite these numerous emergent activities, soil resources are still seen as a second-tier priority and no international governance body exists that advocates for and coordinates initiatives to ensure that knowledge and recognition of soils are appropriately represented in global change dialogues and decision making processes. At the same time, there is need for coordination and partnership to create a unified and recognized voice for soils and to avoid fragmentation of efforts and wastage of resources.

Maintaining healthy soils required for feeding the growing population of the world and meeting their needs for biomass (energy), fiber, fodder, and other products can only be ensured through a strong partnership. This is one of the key guiding principles for the establishment of the Global Soil Partnership.

Responses to soils today

Soil data : fragmented, partly outdated (fertility, SOC, etc.) heterogeneous and difficult to compare, not easily accessible, not responding to users needs

Soil capacities : increasingly a scarce resources (loss of soil expertise and skills)

Soil knowledge and research : fragmented (fertility, CC, ecology), domain of soil scientists, not accessible for use by various disciplines and for decision making, not tailored to address problems/ development agendas of today

Awareness and investments in soil management : extremely low compared to the needs that soil is a precarious resource and requires special care from its users.

Soil policy : Often received as a second tier priority; lack of international governance body to support coordinated global action on their management.

Need for compatible and coordinated soil policies : a unified and authoritative voice is needed to better coordinate efforts and pool limited resources (for agriculture, forestry, food security, UNCCD, CBD, UNFCCC, disaster and drought management, land competition, rural and urban land use planning and development).

Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts. In the same year, the UN General Assembly endorsed the action by WMO and UNEP in jointly establishing the IPCC. The IPCC is a scientific body under the auspices of the United Nations (UN). It reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. It does not conduct any research nor does it monitor climate related data or parameters. Thousands of scientists from all over the world contribute to the work of the IPCC on a voluntary basis. Review is an essential part of the IPCC process, to ensure an objective and complete assessment of current information. IPCC aims to reflect a range of views and expertise. The Secretariat coordinates all the IPCC work and liaises with Governments. It is established by WMO and UNEP and located at WMO headquarters in Geneva. Because of its scientific and intergovernmental nature, the IPCC embodies a unique opportunity to provide rigorous and balanced scientific information to decision makers. By endorsing the IPCC reports, governments acknowledge.

The Intergovernmental Technical Panel on Soils (ITPS) was established at the first Plenary Assembly of the Global

Soil Partnership held at FAO Headquarters on 11 and 12 of June, 2013. The ITPS is composed of 27 top soil experts representing all the regions of the world. The main function of the ITPS is to provide scientific and technical advice and guidance on global soil issues to the Global Soil Partnership primarily and to specific requests submitted by global or regional institutions. The ITPS will advocate for addressing sustainable soil management in the different sustainable development agendas.

Functions of ITPS : The ITPS have the following functions :

provide scientific and technical advice on global soil issues primarily to the GSP and in relation to specific requests submitted by global or regional institutions.

advocate for the inclusion of sustainable soil management into different development agendas.

review and follow up on the situation and issues related to soils in the contexts of food security, use and management of natural resources, ecosystem services provision, climate change adaptation and mitigation, and other relevant areas.

review and endorse from a technical viewpoint the GSP Plans of Action.

Follow up on the implementation of these Plans of Action with due attention to their impact and contributions to different global policies and initiatives related to sustainable development, MDGs, food security, climate change adaptation and other subject matters.

in exceptional cases, when complex technical matters arise, request the Plenary Assembly and the Secretariat to form technical committees aiming to gather specific advice.

Intergovernmental Platform on Biodiversity and Ecosystem Services : The Intergovernmental Platform on Biodiversity and Ecosystem Services is a mechanism proposed to further strengthen the science-policy interface on biodiversity and ecosystem services, and add to the contribution of existing processes that aim at ensuring that decisions are made on the basis of the best available scientific information on conservation and sustainable use of biodiversity and ecosystem services. It was established in 2012 as an independent intergovernmental body open to all member countries of the United Nations. The members are committed to building IPBES as the leading intergovernmental body for assessing the state of the planet's biodiversity, its ecosystems and the essential services they provide to society.

What is the science-policy interface : Science-policy interfaces are social processes which encompass relations between scientists and other actors in the policy process, and which allow for exchanges, co-evolution, and joint construction of knowledge with the aim of enriching decision-making at different scales. This includes 2 main requirements :

that scientific information is relevant to policy demands and is formulated in a way that is accessible to policy and decision makers; and

that policy and decision makers take into account available scientific information in their deliberations and that they formulate their demands or questions in a way that are accessible for scientists to provide the relevant information.

Need for IPBES : There are already several mechanisms and processes at national, regional and global level that are designed to ensure that scientific information is considered when designing policies or making decisions (examples of this are technical bodies/panels under the environmental agreements or national research institutions attached to ministries, among many others). However, there is no global ongoing mechanism recognized by the scientific and policy communities, that pulls this information together, synthesizes and analyzes it for decision making in a range of policy fora.

We have listed some of the numerous global alliances which have been established to address the global research platforms. This is in brief and there are others also across the globe taking shapes : One of the fundamental lessons learned through the past half century of agricultural research is that there are no "one size fits all" sustainable management practices and a holistic approach is the need of the hour.

Sustainable development in Indian Agriculture

Agriculture is the main occupation in India as large population is living in the rural areas and having agriculture as their livelihood. Sustainable development in the agriculture sector aims to increase the productivity, efficiency and level of employment and further aims to protect and preserve the natural resources by the over utilization. Agriculture faces many challenges, making it more and more difficult to achieve its primary objective – feeding the world – each year. Agriculture must change to meet the rising demand, to contribute more effectively to the reduction of poverty and malnutrition, and to become ecologically more sustainable India has been witnessing a blinding pace of growth and development in recent times. Experts are now calling for "sustainable development" and the term has gained currency in the last few years. In spite of fast growth in various sectors, agriculture remains the backbone of the Indian economy. Sustainable agricultural development seeks not only to preserve and maintain natural resources, but also to develop them, as future generations would have much more demand quantity-wise and quality-wise for agricultural and food products. Such goals should ensure a balance with the development of livelihoods enjoyed by the individuals concerned. Agriculture plays a crucial role in sustainable development and in hunger and poverty eradication. The challenges faced by agriculture in sustainable development is in working out ways of bringing about a society that is materially sufficient, socially equitable, and ecologically sustainable and one that is not obsessed by growth only, but motivated by satisfying human needs and equity in resource allocation and use. Sustainable agriculture must meet economic, social and ecological challenges. All 4 these challenges are closely related. Sustainable agriculture needs to protect the natural resource base, prevent the degradation of soil and water; conserve biodiversity; contribute to the economic and social well-being of all; ensure a safe and high-quality supply of agricultural products; and safeguard the livelihood and well-being of agricultural workers and their families. The main tools towards sustainable agriculture are policy and agrarian reform, participation, income diversification, land conservation and improved management of inputs. This policy document is an effort to identify the strategies, guidelines and practices that constitute the Indian concept of sustainable agriculture. This is done in order to clarify the research agenda and priorities thereof, as well as to suggest practical steps that may be appropriate for moving towards sustainable agriculture. Some tend to confuse sustainable agriculture with organic farming. But both are very different form each other. Sustainable agriculture means not only the withdrawal of synthetic chemicals, hybrid-genetically modified seeds and heavy agricultural implements (as in organic farming). Sustainable agriculture involves multiculture, intercropping, use of farmyard manure and remnants, mulching and application of integrated pest management. If this is followed then there is no reason why agriculture cannot be an economically viable activity in addition to being environmentally sustainable.

In India, the crop yield is heavily dependent on rain, which is the main reason for the declining growth rate of agriculture sector. These uncertainties hit the small farmers and laborers worst, which are usually leading a hand to mouth life. Therefore, something must be done to support farmers and sufficient amount of water and electricity must be supplied to them as they feel insecure and continue to die of drought, flood, and fire. India is the second largest country of the world in terms of population; it should realize it is a great resource for the country. India has a huge number of idle people. There is a need to find ways to explore their talent and make the numbers contribute towards the growth. Especially in agriculture, passive unemployment can be noticed. The sustainable development in India can also be achieved by full utilization of human resources .A large part of poor population of the country is engaged in agriculture, unless we increase their living standard, overall growth of this country is not possible. If we keep ignoring the poor, this disparity will keep on increasing between classes. Debt traps in country are forcing farmers to commit suicides. People are migrating towards city with the hope of better livelihood but it is also increasing the slum population in cities. Therefore, rural population must be given employment in their areas and a chance to prosper. India has been carrying the tag of "developing" country for quite long now; for making the move towards "developed" countries, we must shed this huge dependence on agriculture sector.

For promoting sustainable agriculture, following components can be considered :

Yield increase : India need to focus on improving its yields. Currently, yield level of food crops is 2,056 kg/ha, which is far below the yields of many countries. The current average yield of paddy in India is around 3.5 tonnes/ha, while China's yield is more than 6 tonnes/ha. Similar is the case with wheat and other major crops. This is despite increase in fertilizers and pesticides by several folds.

Water-use efficiency : India is still focusing on supply side management of water. This is leading to major investments while causing degradation of ecosystems without any major benefit to farmers. The investments have to be clearly on reducing the water per unit of production. Currently, the focus of drip irrigation is only on material supply rather than the entire process and training. Creating specific incentives for using less water while improving the productivity have not even initiated. With modern technology, it is possible to create incentives to use less water and set up mechanisms to monitor water use at farm level. Budget should be allocated for creating well-designed projects with institutional mechanisms to implement and monitor. The goal is to use the existing infrastructure far more efficiently—both at system level and individual farm level.

Diversity of food grains : Consumers are aware of the benefits of eating coarse grains such as jowar and bajra. But there are no specific programmes to produce and market these food grains. Farmers need income, not just production. So, incentivising farmers to produce these grains will not only save water and ecosystems but promote healthy eating habits.

Farm-based approaches : In India, farmers are receptive to experimenting with farm-based approaches. For example, the System of Rice Intensification (SRI), Sustainable Sugarcane Initiative (SSI), and System of Crop Intensification (SCI) of wheat, millets and mustard are very popular with farmers. It is time we had Centre-sponsored scheme to promote these approaches in large scale with large budget provisions and institutional mechanisms.

Organic agriculture : India needs to slowly move from chemical-based farming to organic farming. Phase-wise approach towards removing subsidies to chemical fertilizers and introducing incentives to organic agriculture through budget provisions is the way to go about it.

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Chapter 1

Gamma Radiation : A Potential Mutagen for Fruit Crops

Mandeep Rawat and Vijay P. Singh*
Department of Horticulture, College of Agriculture, G.B.P. University of Agric. and Tech., Pantnagar-263145 Uttarakhand
**Corresponding Author Email : hortvp@gmail.com*

Abstract

Induced mutagenesis through gamma is widely popularized among the breeders for creating variability. In fruit crops, presence of long juvenile period serves major hindrance for breeders but mutation breeding has the potential to narrow it down and when coupled with DNA sequencing, it enables us to study forward and reverse genetics. In order to meet the demand of growing population there is a need to increase the production and nutrient content of the fruits. Unlike Genetically Modified Organisms (GMOs), there is no foreign insertion of genes but mutagenesis provides the opportunity to induce variability in the existing genotypes. Through mutagenesis, one can develop the varieties with superior quality like longer shelf-life, attractive appearance, enhanced flavour, higher nutrient content etc. Desirable characters like dwarf statured cultivars and tolerance to biotic and abiotic stresses can be developed through mutation breeding in the germplasm pool where otherwise these traits are not available. Among the various mutagens, gamma irradiation is the most frequently used due to its high penetrating ability and effectiveness. Furthermore, gamma rays are eco-friendly and posses no harm to mankind when used as a mutagen in crop improvement. It is easy to handle and contains no carcinogenic effect like chemical mutagens. Gamma radiation has been proven a potential mutagen after development of Pusa Nanha, a popular variety of papaya, developed by India using it. So, more such possibilities are needed to be explored in the area of fruit crops. Radiation applied in low doses can create variability to a greater extent that is why it is better than conventional breeding method. Plant varieties developed through gamma induction are coming up for worldwide food as well as nutritional security and betterment of livelihood.

Key words : *Gamma rays, mutagen, variability, induced mutation, fruit crops.*

Introduction

Fruits are the rich source of nutrients, minerals, vitamins and some contain anti-oxidants. Fruits like Bael, mango, raspberry, aonla etc., are rich in fibre which helps in keeping digestive system healthy. They are low in fat and calories (except avocado and olives), contain no cholesterol, high in carbohydrates, carotene and vitamin-C. They are low in sodium but rich in potassium. Fruits, those containing citric acid as citrus, help in supplement the bioavailability of iron in diet. Due to these attributes, fruits are the essential part of human diet. As the rate of population growing rapidly, the estimated population by 2050 will be 9 billion, therefore, there is a need to increase fruit production (The Royal Society, 2009; Hakeem *et al.,* 2012 and Wargent and Jordan, 2013). Further, not only just the production but in order to provide the nutrient demand of population, varieties with diverse characters should be developed. Characters like sweeter taste, good aroma, flavour and attractive colour are the top priority

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of the consumer. On the grower's point of view, fruit crop varieties which are tolerant to biotic and abiotic stresses are preferred.

With the change in the climatic scenario, like onset of early monsoon, sudden hailstorm at the time of flowering and fruiting, rise in temperature and fluctuations in daily temperature hinders the quality and appearance of fruits. These climatic disturbances interferes in the flowering and results in the poor fruit setting, poor fruit development with reduced yield and quality which ultimately fetches lower price in the market. Along with this, the unfavourable environment for the fruit growth makes favourable environment for several pests and thus reducing the yield of the fruit crops. Developing varieties which overcome these can be a big task by using breeding methods. Mostly conventional breeding methods like clonal selection, hybridization, back crossing etc., are based on the phenotypic characters and also a tedious process particularly in fruit crops. Due to the presence of long juvenile period in fruit crops, the conventional breeding methods make the process more time taking. Furthermore, the conventional breeding method carries the threat of being environmental stress susceptible with loss of genetic diversity (Basey *et al.,* 2015). Adoption of mutation breeding has the potential to narrow down the juvenile period with the induction of variability in the existing population which otherwise not available.

Among various physical mutagens like X-rays, gamma rays, alpha particles, beta particles, fast moving neutrons etc., gamma rays are the highly preferred physical mutagen which gained its popularity in the field of crop science after the World War II, when the concept of gamma garden was first introduced. Aiming to utilize the atomic energy in the favour of the mankind gamma gardens were setup in various countries like Europe, India, United States, Japan and Russia. According to MVD (Mutant Variety Database) 2022, there are more than 1,500 varieties have been developed by using gamma rays. However, its potential has not been utilized in India as only one variety i.e. Pusa Nanha had been developed using gamma rays of 150 Gy. With huge potential, now-a-days gamma rays along with biotechnological tools are being exploited in inducing variability among the fruit crops. Marker assisted breeding is one such tool which is now being utilized for assessing the desirable trait in the early stages of breeding. This chapter will touch certain aspects of mutation, brief about various mutagens, and effectiveness of gamma rays in improvement of fruit crops along with its role in inducing variability in fruit crops.

Mutation and its types

Hugo De Vries coined the term 'Mutation' as the sudden and the heritable change(s) in the genetic material either DNA or RNA of a living organism which is not a resultant of recombination or segregation. Mutations have played significant part in evolution as the modification in genetic material (DNA or RNA) inherited by the organisms lead to phenotypic transformations (Wagner, 2012).

Based on origin, the mutations are classified as:

(i) Spontaneous mutation : When mutation occurs in nature i.e. without any human interference then it is known as spontaneous mutation. The frequency of spontaneous mutation is very low i.e. 1 in 10^5 to 10^8 and thus leads to random population variation (Torii *et al.,* 2003). The spontaneous mutations may result due to the certain transposable elements present in genome called transposons. Transposons or jumping genes are the genetic elements, movement of which in the genome lead to change in DNA. Although certain environmental factors such as sunlight (UV rays), radiation and cigarette smoke may result in mutation. In simple words, these are arisen due to error in DNA replication. Simultaneously, not every spontaneous change in the DNA eventually results in everlasting changes of the DNA. Despite these substitution would be permanent; they might not everytime result in visible or distinguishable effects (Ranel, 1989). For instance, the survival of African nightshade might be due to latent adaptable mutation, but the reasons are unknown so far. Apart from this, spontaneous mutations rely on chance and made breeding programmes markedly slow.

(ii) Induced mutation : Induced mutagenesis has been extensively used in plant breeding since its discovery in the 1920s (Mba *et al.,* 2010). On the other hand, induced mutation is the resultant of mutagenic agents either physical or chemical. Induced mutagenesis has over thrown the restrictions of variability in plants and induces specific improvement without disturbing their better attributes (Roychowdhury and Tah, 2013). Induced mutation can be targeted or non-targeted. Non-targeted mutagenesis also known as random mutagenesis is considered as the time consuming process as the mutants develop contain unspecific results. Whereas targeted

Table-1 : Varieties developed by gamma irradiation in fruit crops (Source: Mutant Variety Database, 2022).

S. No.	Variety released	Doses	Parentage	Country	Breeder / Institute	Improved characters
1.	**Apple**					
a.	Mori-hou-fu 3A	30Gy	Fuji	Japan (1963)	Institute of Radiation Breeding	Resistant to diseases
b.	Lysgolden	50 Gy	Golden Delicious	France (1970)		Fruit free of russeting and improved fruit quality
c.	Blackjoin BA 2 520	50 Gy	Jonathan Blackjoin	France (1970)		Improved and more regular red colored fruit
d.	Courtagold		Golden Spur	France (1972)		Drastic reduction in tree size, mainly due to shorter internodes, used as pot plant and in gardens
e.	Courtavel		Starking Delicious	France (1972)		Drastic reduction in tree size, shorter internodes, used as pot plant and gardens
f.	Donghenghongpingguo	250 Gy	Jingguan	China (1987)		Plant structure
g.	James Grieve Double Red	62 Gy	James Grieve	Czech Republic (1995)	Vyzkumny a Slechtitelsky Ustav Ovocnarsky	Good well-balanced taste, altered acids to sugars ratio and high yield
2.	**Plum**					
a.	Spurdente-Ferco		Ente	France (1988)		Early maturity, self-compatible, better branching and fruit setting
3.	**Loquat**					
a.	Shiro-mogi	200 Gy	Mogi	Japan (1981)		Large fruit size and good taste
4.	**Olive**					
a.	Briscola	40 Gy	Ascolana Tenera	Italy (1981)		Reduced plant height by 50 %, easy harvest and male sterility
5.	**Banana**					
a.	AL-BEELY			Sudan (2007)	Dr. Mohamed Ahmed Ali	High yield (30%).
b.	Priama 1	0.03	Ambon Kuning	Indonesia (2019)	Azri Kusuma Dewi	Tolerant fusarium wilt disease (TR 4), high vitamin-C content
6.	**Pineapple**					
a.	Natsu-hime		A. ananasoids	Japan (2005)	Okinawa Prefectural Agriculture Experiment Station	Altered leaf color
7.	**Papaya**					
a.	Pusa Nanha	150 Gy		India (1987)	IARI Regional Research Station, Pusa, Bihar	Reduced plant height, higher production (50% higher), reduced girth of trunk and length of leaf
8.	**Peach**					
a.	Shimizu Hakutou RS		Shimizu Hakutou	Japan (2004)	Okayama Prefectural Agriculture Experimental	Resistant to black spot disease
b.	Plovdiv 6	10 Gy	Dupnishka	Bulgaria (1981)		High yield, large fruits, good quality and middle early maturity
9.	**Pear**					
a.	Chaofu 1	2.5 Gy	Chaoxiany angli	China (1989)	Mongolia Academy Institute of Horticulture	Improved plant structure and good cooking quality.

Table-1 : Contd...

S. No.	Variety released	Doses	Parentage	Country	Breeder / Institute	Improved characters
b.	Chaofu 10	2.5 Gy	Chaoxianyangli	China (1989)	Mongolia Academy Institute of Horticulture	Improved agronomic features and good cooking quality
c.	Gold Nijisseiki (Japanese pear)	0.12-0.15 Gy/day	Nijisseiki	Japan (1990)	Sanada et al.,	Resistant to black spot disease
10.	**Citrus**					
a.	Xuegan 9-12-1 (Orange)	100 Gy	Xuegan	China (1983)		Almost seedless, high yield and parthenogenesis
b.	Hongju 418 (Orange)	100 Gy	Dahongpao hongju	China (1983)		Almost seedless, high yield and sweet taste
c.	Zhongyu 7			China (1985)		Improved seed production traits and good cooking quality
d.	IAC 2014	40 Gy	Pera IAC sweet orange	Brazil (2016)	Neto et al.,	Seedlessness, more resistant to citrus canker disease
e.	PAU Kinnow1	30 Gy	Kinnow	India (2017)	H.S. Dhaliwal, Gurupkar Singh Singh, P.S. Aulakh Aulakh	Seedless, higher yield
f.	NIAB Kinnow	20 Gy	Kinnow	Pakistan (2017)	Ehsan Ullah Khan	High yielder, high resistance to Citrus canker, scab and wither- tip diseases
11.	**Cherry**					
a.	Polukarlik Orlovskoi Ranne (Sour cherry)		Orlovskoi Rannei	Russian Federation (1979)		Semi-dwarfing
b.	Polukarlik Turgenevki		Turgenevka	Russian Federation (1979)		Semi-dwarfing
c.	Nero II C1 (Sweet cherry)		Durone Nero II	Italy (1983)		Compact growth habit
d.	Burlat C1		Bigarreau Burlat	Italy (1983)		Compact growth habit
e.	Sumste Samba (Sweet cherry)		Stella 35A	Canada (2000)	Kappel et al.,	Medium maturity
f.	Burak (sweet cherry)	50 Gy	0900 Ziraat	Turkey (2014)	Burak Kunter	Improved fruit quality, yield and increased fruit size
g.	Aldamla	25 Gy	0900 Ziraat	Turkey (2014)	Burak Kunter	Compact growth habit (70-80%), improved fruit quality and long petiole.
12.	**Grapes**					
a.	Fikreti	50 Gy, colchicine (0.1%)	Marandi (seeds)	Russian Federation (1986)		Early maturity and high yield
13.	**Pomegranate**					
a.	Karabakh	50-70 Gy		Russian Federation (1979)		
b.	Khyrda	50-70 Gy		Russian Federation (1979)		Dwarfness
14.	**Fig**					
a.	Bol (Abundant)	50-70 Gy		Russian Federation (1979)		

Table-2 : Gamma-sensitivity of various fruit crops.

Variety/ Cultivar	Irradiated tissue	Gamma-sensitivity	Reference
Japanese Plum cv. Shiro	Microcuttings	30 Gy	Predieri and Gatti, 2000
Strawberry cv. Tioga	Explant culture	80 Gy	Phadvibulya *et al.,* 2003
Grapes cv. Pusa Seedless	Microcuttings	10 Gy	Khawale *et al.,* 2006
Lemon cv. Kutdiken	Budsticks	5 Kr	Gulsen *et al.,* 2007
Citrus sinensis	Seeds	27 Gy	Ling *et al.,* 2008
Fig cv. Roxo de Valinhos	Plantlets	50 Gy	Ferreira *et al.,* 2009
Rough lemon	Calli	20 Gy	Kumar *et al.,* 2010
Lemon (*Citrus limon* L. Burm.f.)	Protoplast	20 Kr	Helaly and Hosieny, 2011
Strawberry cv. Akihime, DNKW001	In vitro Buds	177 Gy	Murti *et al*., 2013
Rough lemon	Epicotyl segments	35 Gy	Kaur, 2015
C. macrophylla sour orange	Nodal segments Seeds	29.2 Gy 155.6 Gy	Tallón *et al.,* 2015
Grapes cv. Pusa Navrang, Pearl of Csaba, Hybrid 76-1 and Julesky Muscat	Nodal segments	10 Gy	Dev *et al.,* 2016
Strawberry cv. Arnavutköy	Axillary bud shoots	40 Gy	Kepenek, 2016
Kiwifruit cv. Hort16A	Callus	30 Gy	Pathirana *et al.,* 2016
Vitis vinifera cv. Red globe Muscat	Hardwood cuttings	18.49 Gy 17.02 Gy	Surakshitha *et al.,* 2017
Cape gooseberry (Physalis peruviana L.)	Dry seeds	2 Kr	Gupta *et al.,* 2018
Mandarin, Llimau Madu	Nucllus segment	10-60 Gy	Dita *et al*., 2018
Banana cv. Tanduk	Shoots	33 Gy	Abdulhafiz *et al.,* 2018
Guava cv. Shweta	Budwoods	30 Gy	Singh *et al.,* 2018
Mango cv. Peach and Bappakai	Scion Seeds	19.95 Gy, 21.37 Gy 27.54 Gy, 23.44 Gy	Kumar *et al.,* 2018
Papaya cv. Ranchi local, Pusa Surya	Pre-soaked seeds Seeds immersed in water	28.35 Gy, 33.13 Gy 24.05 Gy, 23.78 Gy	Sahu *et al*., 2019
C. limetta, C. grandis	Pollen grains	500 Gy	Kundu *et al.,* 2020
Sour orange Alemow	Seeds Seeds	156 Gy 127 Gy	Jiménez *et al.,* 2020
Musa acuminata cv. Berangan	Plantlets	37 Gy	Hasim *et al.,* 2021
Mango cv. Tommy Atkins	Cuttings	10 Gy	Franco *et al.,* 2021

mutagenesis are more specific and result oriented due to the fact that it produces desirable results. Targeted mutagenesis involves use of biotechnological approaches for development of new varieties. The utilization of genomics in targeted mutagenesis brings down the extent of breeding methods significantly, which is a paramount impediment of traditional plant breeding methods (Wilde *et al.,* 2012). Use of TILLING (Targeting Induced Local Lesions in Genomes) took the mutation breeding at another level. This technology facilitates the breeders to recognize the mutated genes without phenotypic screening. These novel technologies are safe to use and somewhat cost effective.

Mutagens and their classification

Mutagens are the agents that bring about changes in an organism when exposed to it. They are broadly classified under two categories i.e. physical and chemical mutagens. Different planting materials have been exploited to induce mutations as *in vitro* cell culture, propagating materials like seeds, rhizome, bulbs, tubers, runners, cuttings, seedlings and whole plant. Out of these, seeds are the most common and

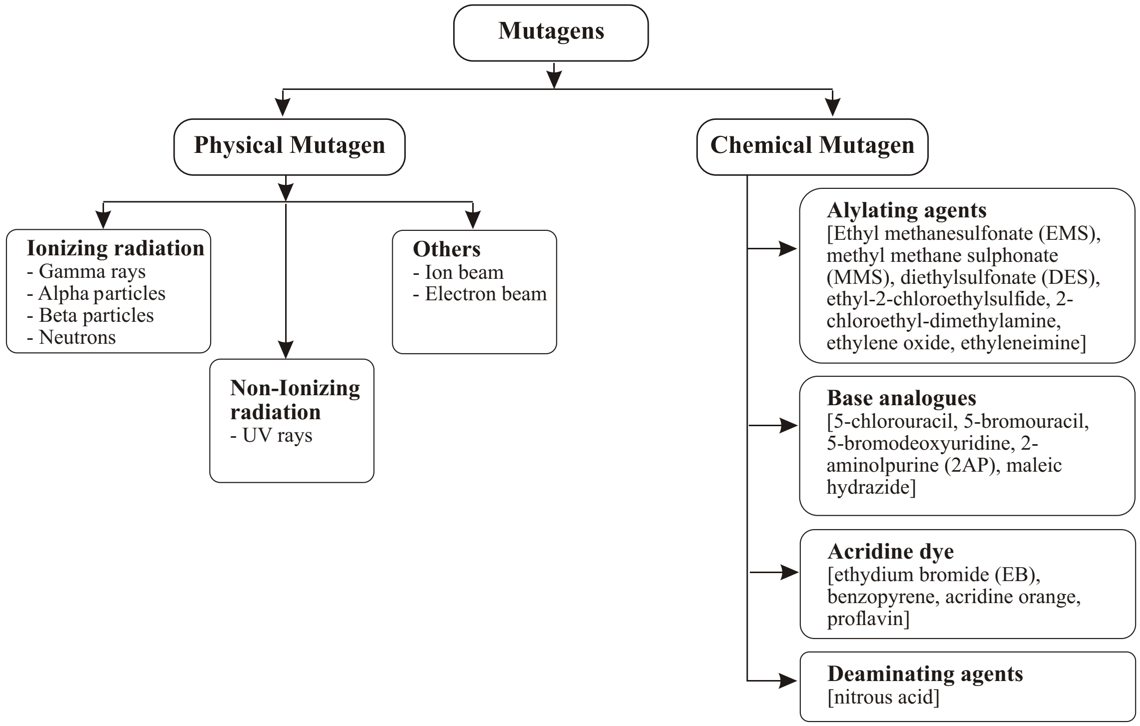

Figure-1 : Schematic classification of mutagens used for inducing variability among crop plants.

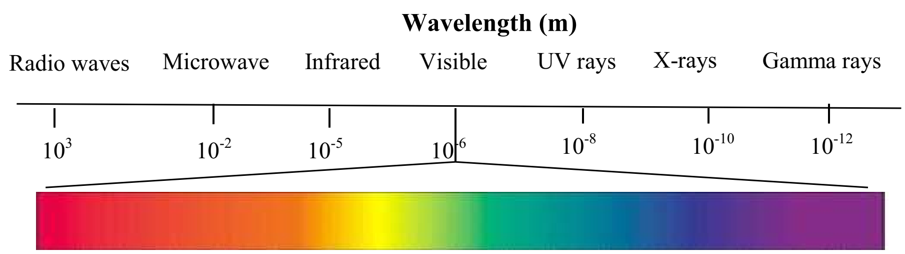

Figure-2 : Electromagnetic spectrum of different ionizing and non-ionizing radiation.

widely preferred propagating material for inducing mutation. Figure1 shows the detailed classification of mutagens.

Physical mutagens

Physical mutagens like gamma rays, X-rays, alpha particles, beta particles, fast moving neutrons etc., are used to induce mutations. When radiation passes through the tissues, causes physical and chemical changes in the organism. In physical changes, ionization as well as excitation of molecules take place which leads to the alterations in DNA, lipids, enzymes, membrane etc. Chemical changes include formation of free radicals i.e. OH^- and H^+ (Van Harten, 1998). In the presence of oxygen, these free radicals react with oxygen and form peroxyradicals. In case of low linear energy transfer, as in case of gamma rays, formation of peroxyradicals occurs. Whereas in high linear energy transfer, as in case of fast moving neutrons, formation of hydrogen peroxide takes place resulting in change due to the recombination of free radicals. Reaction of these, (hydrogen peroxide and free radicals) interact with the biological molecules and hinder the DNA repair mechanism and thus brings change in the genotype of organism.

Gamma rays : Gamma rays fall under the category of ionizing radiation as these consist of high level of energy photons i.e. 10 kilo electron volts (keV) to several hundred keV that perforate the cell and causes ionization (Kovacs and Keresztes, 2002). Gamma radiation has the smallest wavelength and immensely penetrating ability due to which it interferes with the DNA repair mechanism and ultimately results in an altered DNA and causes various types of mutation. Gamma rays on reacting with the planting material which is mostly consists of water, on radiolysis produce reactive oxygen species i.e. O_2^- and OH^- (Kovacs and Keresztes, 2002). These reactive

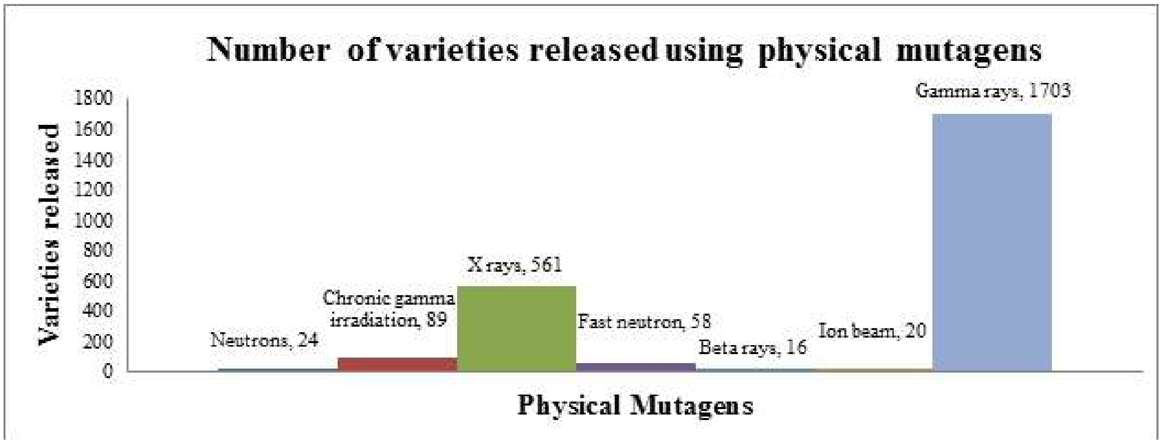

Figure-3 : Dominance of various physical mutagens worldwide (Source: Mutation Variety Database, 2022).

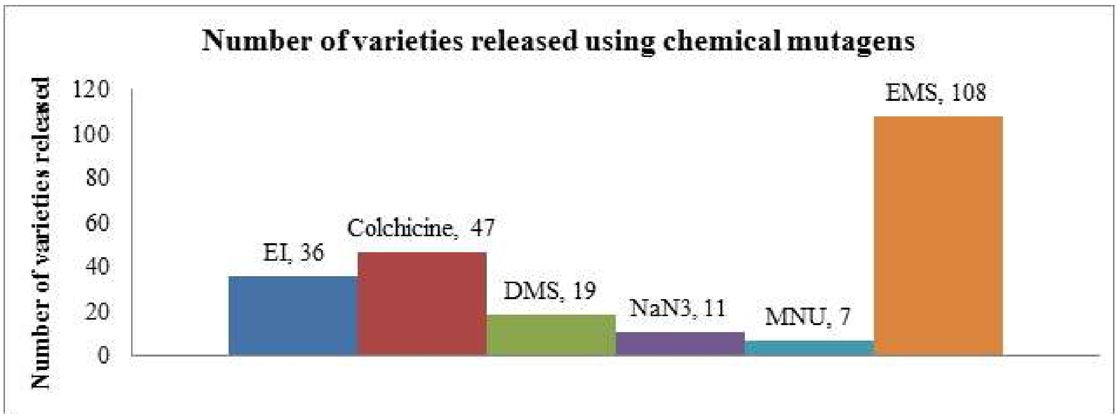

Figure-4 : Dominance of different chemical mutagens worldwide (Source: Mutation Variety Database, 2022).

oxygen species further causes change in cellular activities and can potentially change expression of a gene. Moreover, gamma radiation also affects the physiology of plants by inflating the thylakoid membrane, changes in phenolic compounds, reconversion of metabolites etc. (Gunckel and Sparrow, 1961). When the radiations are applied in high doses, these reactive oxygen species may result in serious damage to the DNA and sometimes causes the death of the plant part.

X-rays : Wilhelm Conrad Roentgen in 1895 first discovered X-rays. X-ray is a packet of electromagnetic energy (photon) that originates from the electron cloud of an atom. X-rays originate from electrons that are electrically accelerated in a high vacuum and then lead to the target. Due to its higher penetration ability, lower doses of X-rays are preferred for crop improvement (Spencer-Lopes *et al.,* 2018). They are just like gamma rays, electromagnetic, ionizing radiations and a photon of energy (EPA, 2021).

Ultravoilet (UV) rays : UV rays fall under the category of non-ionizing radiations which was discovered by Alterberg in 1934. Sunlight is the biggest source of UV rays and in electromagnetic spectrum UV radiation ranges between the X-ray and the visible light. The wavelength of UV rays is shorter as compared to visible light whereas larger than that of X-rays. Exposure to UV radiation does not always cause mutation due to its limited tissue penetration ability. UV radiation is sub-divided into three categories i.e. UV-A, UV-B and UV-C. Out of these three only UV-A forms free radicals and oxidizes DNA bases (Udage, 2021).

Beta particles : Beta particles have mass and originate from the radioactive isotopes of sulphur-35 and phosphorus-32, as these two sources are able to create mutagenesis in plants. Beta particles have restricted use in mutation breeding due to the limited penetration ability.

Ion beams : Iron beams are nothing but the accelerated charged particles. Heavy ion beams are highly accepted powerful mutagen which is able to create wide spectrum of phenotypes without damaging the plants when applied with high frequency at low rate (Abe *et al.,* 2000). Heavy ion beams have high linear

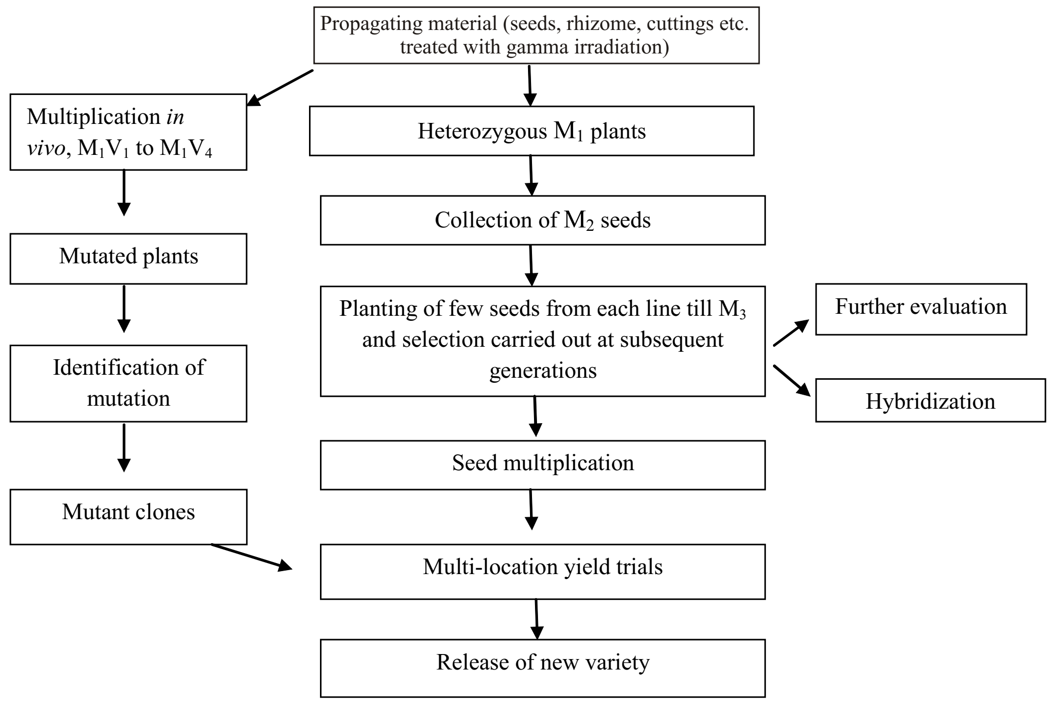

Figure-5 : Summarized flow chart showing steps involved in the development and evaluation of mutant population derived from the sexual and asexually treated plants with gamma irradiation (Oladosu *et al.*, 2016; Suprasanna *et al.*, 2012).

energy transfer and also give rise to double strand breaks. This causes heavy amount of either deletion or frame shift mutations resulting in wide range of mutations.

Fast moving neutrons : Fast moving neutrons are generated in nuclear reactors and these are neutral particles containing high kinetic energy. These are the proportionately less explored technique in inducing mutagenesis. It is reported to cause large deleterious effects as sometimes more than 1 Mb might get damaged which results in chromosomal rearrangement (Gilchrist and Haughn, 2010). The fast moving neutrons mutagenesis is carried out either by irradiation or by particle bombardment. These are reported to cause large number of non-restoration double lesions along with delay in DNA repair mechanism as compared to the propagules treated with X-rays or gamma rays (Hendry, 1991). The prevalence of double strand break is high in fast moving neutrons as compared to gamma rays. This is also one of the reasons for the preference of gamma rays over fast moving neutrons.

Chemical Mutagens

When mutagenesis is carried out using chemicals, it is known as chemical mutagenesis. Chemicals depicted in figure 1 can potentially be utilized for the crop improvement. Out of these EMS is widely exploited chemical mutagen for crop mutagenesis as depicted in figure 4. Chemical mutagens are broadly recognized into four categories i.e. alkylating agents, base analogue, acradine dyes and deaminating agents. EMS comes under the category of alkylating agents i.e. it induces mutation by adding alkyl group to the nitrogenous base. EMS is a mono-functional ethylating agent which on reaction with guanine or thymine makes DNA machinery to recognize the altered base as adenine or cytosine, respectively.

Base analogue mutagens are analogue to the nitrogenous bases of DNA. These chemicals integrate themselves during the time of DNA replication which results in faulty pairing of bases and thus cause mutation.

Acridine dyes like generally result in frameshift mutation by interpolating themselves into the DNA. In simple words, these chemicals stumble in between adjoining bases on the opposite stand, whereas deaminating agents carryout mutation by removing amide group from cytosine or adenine and further during cell replication, the pairing of deaminated bases takes place with other nitrogenous bases and causes mutation.

Mutation created using chemicals is easy and can be done in laboratory by using basic equipments. But the handling of these chemicals should be done very carefully as they are highly carcinogenic and prone to cause serious damage when came in contact with human body. Due to this reason proper handling of these chemicals should be done with wearing rubber gloves, laboratory goggles and mask in a Biohazard flow-hood.

Mutation Breeding

Freisleben and Lein (1944) first introduced the term "mutation breeding". It is the deliberate induction of mutation in plant breeding. It is an essential segment of genetic advancement of crop plants and also an essential component of worldwide food security as well as nutrition. In fruit crops, the demand of superior quality and willingness of customer to pay higher prices made plant breeding to develop elite varieties with superior qualities. About more than nine decades ago in 1927, crop improvement work had been carried after X-ray was proved as a potential mutagen on Drosophila by Muller (Udage, 2020).

In order to carryout mutation breeding experiments in crop plants, the very first step is treating the propagule with the selected mutagen (Suprasanna *et al.,* 2015). In the next step, propagules from mutated population (M_1) were collected and used to plant next generation i.e. M_2. These M_2 plants were then further screened for the desirable characters and elimination of chimeras. The schematic procedure for the use of gamma rays as mutagen in crop improvement is given in Figure-5.

According to MVD (Mutant Variety Database, 2022), the numbers of mutant varieties released by various countries were 3,377 till date. China is leading with 835 mutant varieties, which is followed by Japan with 490 registered mutant varieties and India with 348 registered mutant varieties. The Russia with 218 and USA with 118 mutant varieties placed at 4th and 5th, respectively. In case of fruit crops, a total of 64 varieties have been developed by using various chemical and physical mutagens. More than half of these developed varieties (35 out of 64) were originated through gamma irradiation which depicted its importance in fruit crop improvement. The list of these 35 varieties has been given hereunder as Table 1.

Treatment method of gamma rays

Before the induction of gamma-rays, it is pertinent to decide the kind of planting material to be treated and according to that the doses of radiation will be decided. Seeds with low moisture content needed to be soaked first in order to increase the efficiency of the radiation by forming the free radicals and also the doses of radiation are slightly higher for seeds as compared to the vegetative planting material. In order to carry out successful mutagenesis through gamma rays, selection of the effective and coherent dose is essential. Induction of gamma rays is carried out in gamma chambers and gamma rays radio nuclides Co-60 and Cs137 are used in food irradiation (Kovács and Keresztes, 2002). It is advised to take three to four doses or more in order to find out the gamma sensitivity of the particular genotype. The sensitivity of irradiation is detected by LD_{50} dose i.e. dose at which 50 per cent mortality is observed. LD_{50} helps in evaluating the effectiveness of the dose. In case of gamma rays, dose that limits the survival at 50 per cent is considered as good treatment.

Effect of gamma rays on fruit improvement

In fruit crop improvement, various methods have been employed and mutation breeding is one of them. Induced mutagenesis through gamma rays tends to alter the genetic constitution as well as physico-chemical activities in fruit crops.

Effect of gamma-rays on cytology of plants

When ionizing radiation is absorbed in biological materials, there is a possibility that it may act directly upon critical targets on cells (Kovács and Keresztes, 2002). It tends to cause genetic variation by deleting, inserting and translocation of base pairs. Ionizing radiation also affects the cell cytology as in case of mangosteen, where applying gamma radiation resulted in variability of stomata size as well as density (Widiastuti *et al.,* 2010). Whereas in case of papaya, gamma irradiation treatment resulted in decrease of total chlorophyll content as well as stomata (Mahadevamma *et al.,* 2012) along with abnormalities in sex (Ramesh *et al.,* 2019). In the similar results with guava, there was a decrease in mean length of stomata in leaves of cv. Shweta when treated with gamma rays of 30 Gy (Singh *et al.,* 2018). Increase in leaf chlorophyll content of in grape cv. Doukkali with 20 Gy has been observed (Oualkadi *et al.,* 2018). Reduction in stomatal count by 40.16 and 32.73 per cent has been reported when buds of kinnow were treated with 20 and 15 Gy, respectively (Mallick *et al.,* 2016). Gamma irradiation sometimes lead to the generation of haploid plants which was observed in loquat (Blasco *et al.,* 2016) and citrus (Kundu *et al.,* 2017). In another study carried out by Baiq *et al.,* 2018, where gamma irradiated bud woods of Pamelo Nambangan resulted in low pollen viability (7.73%) with 20 kGy as compared to control (96.51%), however, pollen size was bigger as compared to control. Furthermore, a decrease in photosynthetic rate i.e. G_{12} (4.92, 5.20 and 4.92 µmol m^{-2} s^{-1}) and G_{13} (4.98, 5.04 and 4.96 µmol m^{-2} s^{-1}) on Kinnow with a treatment of 25 Gy was observed (Kumar *et al.,* 2020).

Effect of gamma-rays on phenotypic expression

Gamma rays are known to influence plant growth and development by inducing cytological, genetical, biochemical, physiological and morphogenetic changes in cells and tissues (Jan *et al.,* 2010). Depending upon the intensity of irradiation i.e. low or high, germination of seed, seedling growth and other biological activities show marked changes (Wi *et al.,* 2005). Outcome of radiation doses at plant level can be potentially evaluated at morphological, biochemical and physiological levels, where immensity of the resulted change depends highly on the intensity of dose (Ahuja *et al.,* 2014). A mutation study conducted on apple rootstocks, resulted in four mutants and apple varieties grafted on these mutated rootstocks gave high yield and better fruit quality (Przybyla *et al.,* 2003). In another study, after irradiating papaya seeds, the resultant mutants were dwarf in stature, showed delay in germination and early flowering with improved fruit quality as compared to the parent (Nahat and Chau 2008; Mahadevamma *et al.,* 2012; Pujar *et al.,* 2019). Increase in plant height and shoot number has been noticed in three grape cultivars viz. Desi, Sundar Khani and Chinese grapes up to 5 Gy dose. However, it was also observed that with an increase in radiation dose above 5 Gy a decrease in plant height with all the three grape varieties was detected (Munir *et al.,* 2015). Motallebi-Azar *et al.,* 2005 obtain vigorous and wide angles branches when shoots of almond cv. A200 treated with 36µC gamma rays for 150 min. Low doses of irradiation could also cause significant changes in the plants which was observed when seeds of avocado were exposed to 15 Gy resulted in multiple shoot induction with zero decrease in germination as well as dwarfing effect (Valter *et al.,* 2011). On the other hand, there is an increase in germination percentage of 87.5% when seeds of mango cv. Dusehri irradiated with gamma rays of 2.5 Kr and minimum i.e. 21.7% of germination is recorded with 15.0 Kr (Hafiz *et al.* 2005). On irradiating apple scions of Amasya cultivar at 29.01 Gy, nearly 70 per cent produced significantly lower plant height than standard 'Amasya'. Similarly, nearly 80 per cent of the mutants had lower TCSA than 'Amasya' (Atay *et al.,* 2018).

Effect of gamma-rays on physicochemical properties of fruits

Gamma irradiation is a non-thermic technique that has lately attained considerable recognition. This method has high ability for the prevention of microorganisms and sustaining quality attributes. According to earlier reports, gamma radiation did not have unfavorable effects on vitamin C content of most of the vegetables up to 1 kGy (Fan and Sokorai, 2008). High potency of gamma rays influenced the peculiarity of reducing sugar and starch proportion (Sosedov and Vaka *et al.,* 1963). It was reported that gamma irradiation increased the TSS content of loquat cv. Jiefangzhong, TSS > 16% was obtained at a frequency of 0.48 and 0.47 per cent at 1500R and 2500R, respectively (Jiang *et al.,* 2007). Also gamma irradiation showed a positive influence on peroxidase, total soluble protein, catalase, glutathione reductase, ascorbate peroxidase and super oxide dismutase activity in Citrus (Ling *et al.,* 2008; Helaly and Hosieny, 2011). Similarly, in a span of two years (2012-2014), an increase in fruit quality in terms of fruit weight (1463.40 gm and 1669.78 gm), fruit length (23.14 cm and 24.60 cm), minimum central cavity (10.61 cm and 10.46 cm), TSS (12.98 °brix and 13.12 °brix), carotene (40.02 µg/100gm and 41.98 µg/100 gm), fat (0.17% and 0.18%), protein (0.64% and 0.66%), ash (0.75% and 0.77%), sugar (10.92% and 11.18%), carbohydrate (10.94% and 11.13%) and minimum moisture content (87.53% and 87.36%) of papaya when seeds were treated with 10 Kr gamma rays (Kumar *et al.,* 2017). On the other hand, Islam *et al.* (2018) reported increase in oil content in fruits of avocado cultivar Hass and Fuerte, when gamma radiated (0-50 Gy) bud sticks were grafted on duck seedling.

Conclusions

Induced mutation through gamma radiation can potentially increase the variability among fruit plants for inducing new traits. It provides new amalgamation of genes which leads to the development of high yielding varieties with good quality. When interacted with the plant tissues it brings out desirable as well as undesirable changes. Therefore, careful selection of the irradiation dose can significantly contribute in fruit breeding. In order to make the breeding process less time consuming, new biotechnological approaches like TILLING can be used for precise and efficient results. In order to meet the demand of growing population mutation breeding can be considered as new approach for altering the already existing superior varieties. Now-a-days the increasing interest of people in eating healthy and superior quality demands varieties with novel characters, which can potentially be done by using gamma irradiation.

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Chapter 2

Mutagenetic Studies in Soybean [*Glycine max* (L.) Merrill]

S.P. Singh[1], Netrapal Malik[1], P.B. Singh[2], Harish Pal Bhati[3], Rohit Rana[4], Y.K. Singh[1] and Manoj Mishra[1]
[1]*Chandra Shekhar Azad University of Agriculture and Technology Kanpur, Uttar Pradesh*
[2]*Department of Genetics and Plant Breeding, RCA, MPUAT, Udaipur, Rajasthan*
[3]*Department of Life Science, Swami Vivekanand Subharti University, Meerut, Uttar Pradesh*
[4]*Rashtriya Kisan Post Graduate College, Shamli, Uttar Pradesh*
Email : dr.sp.singh24@gmail.com

Abstract

The literature of mutations with early results in soybean has been well documented in the literature available. In this paper, efforts have been made to review the literature on induced mutations in soybean. The different mutagenic agents used for inducing mutations, effects of different mutagenic agents on yield, quality contributing characters and resistance to different diseases have been described. The choice of mutagenic agents will depend mainly on local conditions; therefore, this work should be intensified.

Key words : *Soybean, X-rays, physical and chemical induced mutagenesis, review, mutation.*

Introduction

Soybean [*Glycine max* (L.) Merrill] has become the miracle crop of the 21st century. It is a triple beneficiary crop, which contains about 40% proteins, possessing high level of essential amino acids except methionine and cystine, 20% oil rich in poly unsaturated fatty acids specially omega-6 and omega-3 fatty acids, 6-7% total minerals, 5-6% crude fibre and 17-19% carbohydrates (Chauhan *et al.,* 1988). Besides, it has good amount of iron, vitamin B-complex and isoflavones such as daidzein, genistein of glycitin. Presence of calcium and iron makes it highly suitable for women who suffer from osteoporosis and anemia. The isoflavones of soybean have been found to possess health benefits, as they exhibited properties like cancer preventing, combating menopausal problem and helping to recover from diabetics (Chauhan *et al.,* 2002).The history of mutations with early results in soybean has been well documented (Brock, 1965; Scossiroli, 1965). They discussed prospects of mutation breeding in altering the quantitative characters. Furthermore, Koo (1972) reviewed utilization of induced mutations in soybean. Mutants from diploid cell cultures were also reported (Weber and Lark, 1979). Some useful early ripening mutants become obvious from the fact that some of them have been developed into released commercial varieties (Kawai, 1967). Varieties developed by X-ray irradiation viz., Vikrarn-T-61, high oil with larger seed and Colorado irradiado, high oil with high yard have been released in India and Argentina, respectively (Sigurbjornsson and Mick, 1974). In the present paper, efforts have been made to review up-to-date literature on induced mutations in soybean.

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Physical mutagens

Physical mutagens include various types of radiations viz., X-rays, gamma rays, alpha particles, beta particles, fast and thermal neutrons and ultra violet rays. A brief description of these mutagens is presented below. The wavelengths of X-rays vary from 10^{-11} to 10^{-7}. They are sparsely ionizing and highly penetrating and are generated in X-rays machines. X-rays can break chromosomes and produce all types of mutations in nucleotides, viz, addition, deletion, inversion, transposition, transitions and transversions. These changes are brought out by adding oxygen to deoxyribose, removing amino or hydroxyl group and forming peroxides. Gamma rays are identical to X-rays in most of the physical properties and biological effects, but gamma rays have shorter wave length than X-rays and are more penetrating than X-rays. They are generated from radioactive decay of some elements like ^{14}C, ^{60}Co, radium etc. Of these, cobalt 60 is commonly used for the production of Gamma rays. They cause chromosomal and gene mutations like X-rays by ejecting electrons from the atoms of tissues through which they pass. Alpha rays are composed of alpha particles. They are made of two protons and two neutrons and thus have double positive charge. They are densely ionizing, but lesser penetrating than beta rays and neutrons. . Alpha particles have positive charge and hence they are slowed down by negative charge of tissues resulting in low penetrating power. Alpha particles lead to both ionization and excitation resulting in chromosomal mutations. Beta rays are composed of beta particles. They are sparsely ionizing but more penetrating than alpha rays. Beta particles are generated from radioactive decay of heavier elements such as ^{3}H, $^{32}P$and ^{35}S etc. They are negatively charged, therefore, their action is reduced by positive charge of tissues. These are densely ionizing and highly penetrating particles. Since they are electrically neutral particles, their action is not slowed down by charged (negative or positive) particles of tissues. They are generated from radioactive decay of heavier elements in atomic reactors or cyclotrons. Fast and thermal neutrons result in both chromosomal breakage and gene mutation. These neutrons are effectively used for induction of mutations especially in asexually reproducing crops. UV rays are non ionizing radiations, which are produced from mercury vapour lamps or tubes. They are also present in solar radiation UV rays can penetrate one or two cell layers. Because of low penetrating capacity, they are commonly used for radiation of micro-organisms like bacteria and viruses. UV rays can also break chromosomes.

Chemical Mutagens

The chemical mutagens can be divided into four groups, viz., (I) alkylating agents, (2) base analogues, (3) acridine dyes, and (4) others. A brief description of some commonly used chemicals of these groups is presented below-

Alkylating agents : This is the most powerful group of mutagens. They induce mutations especially transitions and transversions by adding an alkyl group (either ethyl or methyl) at various positions in DNA. Alkylation produces mutation by changing hydrogen bonding in various ways. The alkylating agents include ethyl methane sulphonate (EMS), methyl methane sulphonate (MMS), ethylene imines (El), sulphur mustard, nitrogen mustard, etc. Out of these, the first three are in common use. Since the effect of alkylating agents resembles those of ionizing radiations, they are also known as radiomimetic chemicals. Alkylating agents can cause various large and small deformations of base structure resulting in base pair transitions and transversions.

Base Analogues : Base analogues refer to chemical compounds which are very similar to DNA bases. Such chemicals sometimes are incorporated in DNA in place of normal base during replication. Thus they can cause mutation by wrong base pairing. An incorrect base pairing results in transitions or transversions after DNA replication. The most commonly used base analogues are 5 bromouracil (5BU) and 2 amino purine (2AP).

Acridine dyes : Acridine dyes are very effective mutagens. Acridine dyes include proflavin, acridine orange, acridine yellow, acriflavin and ethidium bromide. Out of these, proflavin and acriflavin are in common use for induction of mutation. Acridine dyes get inserted between two base pairs of DNA and lead to addition or defection of single of few base pairs when DNA replicates. Thus they cause frameshift mutations and for this reason acridine dyes are also known as frameshift mutagens. Proflavin is generally used for induction of mutation in bacteriophages and acriflavin in bacteria and higher organisms.

Other mutagens : Other important chemical mutagens are nitrous acid and hydroxylamine. Their role in induction of mutation is briefly discussed here. Nitrous acid is a powerful mutagen which reacts with

C_6 amino groups of cytosine and adenine. It replaces the amino groups with oxygen (+H to - H bond). As a result, cytosine acts like thymine and adenine like guanine. Thus transversions from GC- AT and AT - GC are induced. Hydroxylamine is a very useful mutagen because it appears to be very specific and produces only one kind of change namely, GC AT transition. All the chemical mutagens except base analogues are known as DNA modifiers.

Effect of mutagenic agents

Meiosis : Ahmad *et al.* (1977) reported paracentric inversions in the hybrids between the two species of soybean as the dose was increased. Qing *et al.* (1997) reported that after irradiation of soybean seeds for 3 days with 500 rad gamma rays, the number of mitochondria per cell decreased, while the number of vacuoles increased and cell structure changed dramatically with some organelles having disintegrated Ping *et al.* (1998) studied cytomorphology of a male sterile mutant NJ89-1 in soybean and reported that the observations on anther and pollen development showed that NJ89-1 differed from msl-ms6 mutant in many aspects such as abortion stage, meiosis, tetrad formation, pollen wall and anther wall, etc. NJ89-1 displayed similar meiotic abnormalities of asynapsis or desynapsis to those of st2-st5 mutants by differed from st2-st5 mutants in female fertility with females of st2-st5 mutants being strongly impaired.

Bione *et al.* (2002) observed many univalent a few bivalents in diakinesis of a mutant line BR97-13774H. Telophase II exhibited a varied number of different sized nuclei; pollen sterility was estimated at 93.12 per cent. Bione *et al.* (2002b) reported that many univalent, few or total absence of bivalents were found in diakinesis of BR97-12986H, soybean mutant. Bivalents presented in or two terminal chiasmata, while univalents retained the sister chromated cohesion. Bivalents and most univalents congregated at the equatorial plates, although univalents frequently migrated to the poles prematurely. Laggards resulting from delay in chiasmata terminalization were also recorded. Pollen sterility was estimated at 91.2% segregation ratio for sterility in this line and its progenies reached 3:1.Vinita *et al.* (2004) reported that the highest frequency of PMC's showing univalent formation were observed in the combination treatment (gamma rays and EMS), Multivalent were also observed in the form trivalents, tetravalents a chain of bivalents in the treated population, however the maximum frequency was observed at higher doses i.e. 40 Kr of gamma rays. Foti *et al.* (2004) reported that reduction in pollen production; germination and tube growth were observed in all the genotypes with increasing UV-B radiation. They also reported that the number of columellae heads of the exine was also reduced with increasing UV-B radiation.

Seed germination : Hassan *et al.* (1985) irradiated seeds of Bragg, Hodgson and Lee-74 containing 1113% moisture content with 100-500 Gy gamma rays and 5-30 Gy fast neutrons and reported that growth inhibition increased with increasing doses and germination was inhibited only at the higher doses. Lee-74 was the most sensitive variety to gamma radiation and Bragg the most sensitive to fast neutron doses above 20 Gy, as revealed by differences in epicotyl length. Bhatnagar *et al.* (1989) treated seeds of soybean cv. Bragg with EMS (ethyl methanesulfonate) and gamma rays, with or without additional exposure to UV light for 2 h at 260 rim and reported that mutation frequency in the M_2 ranged from 2.24 to 22.85%. Among the mutants obtained T-214 was from the 25 kR gamma radiation + UV treatment. It exceeded the parent in germinability by 15% and was 5 days earlier in maturity. Padmavathi *et al.* (1992) noticed that the chemical mutagens (EMS) affected the germination percentage than the physical mutagens (gamma rays). YongMing *et al.* (1998) reported that in the M, seed germination potential decreased with increase in irradiation dose, while no significant differences were observed between the various treatments and the control in germination percentage. Pavadai and Dhanaval (2005) reported that germination percentage showed the decreasing trend with the increase in dose of gamma rays.

Seedling survival : Klobe *et al.* (1973) reported that seeds of D68 X 127 were treated with gamma rays, fast neutrons, diethyl sulphate (DES) and ethyl methane-sulphonate (EMS). M_2 seedling survival decreased (in comparison with untreated control) following radiation and chemical treatment. Zakri and Jalani (1986) treated two cultivars (Palmetto and Acadian) of soybean with ethyl methanesulfonate and gamma rays and reported that the cultivar Palmetto showed higher survival percentages following either treatment. Li (1988) reported that when dry seeds of several soybean varieties were treated with electrons at various doses, marked effects were observed in the M, on seedling height and survival percentage. Wang *et al.* (1989) treated seeds of the soybean line LF81-837 with 0.001, 0.002 and 0.005 M NaN_3 at pH 3 and reported that plant survival was reduced by 49.9% in the M, generation when seeds were treated with 0.005 M sodium azide solution. Li *et al.* (1994) irradiated dried seeds of soybean cv. Changnong 5 with gamma rays (120-200 Gy, 2.28 Gy/min) or an electron beam (180-450 Gy) and reported that dressing treated seeds with benzamide resulted in a lower survival rate and fertility, but a higher chromosomal aberration rate compared with those treated with gamma rays or the electron beam alone.

Chlorophyll mutations : Constantin *et al.* (1974) reported that fast neutrons and EMS were the most effective inducers of chlorophyll deficiencies and morphological mutants. Fujii and Tano (1987) reported that the somatic M, mutations induced by EMS (ethyl methanesulfonate) and segregation of chlorophyll deficient mutants in the M_2 were studied in the strain T-219. The results indicated that in the M_2 generation, chlorophyll mutation frequencies were estimated as 0.14, 0.61 and 0.41 % per µg EMS at treatments with 0.5, 0.1 and 0.2% EMS, respectively. Harb (1990) treated the two cultivars of soybean with gamma rays and reported that there was large reduction in the chlorophyll and carotenoid contents of mutants. Patel *et al.* (1998) reported that the chlorophyll content of the cultivars increased until flowering and then declined, while biomass accumulation in all genotypes increased till harvest. Leaf chlorophyll content dry matter accumulation was highest in CV JS 75-76. Geetha and Vaidyanathan (2000) reported that gamma rays were found to be more effective to induce chlorophyll mutations than ethedium bromide in M_2 and M_3 generations of soybean. Qing *et al.* (2004) studied the effect of low level radio frequency electromagnetic field on chlorophyll fluorescence dynamics process in photosynthesis cell of soybean and reported that low level of radiofrequency electromagnetic field leads to the decrease of potential activity of photosystem II (PSII) reaction centre, the increase of relative content of PS II inactive centre and the damage of electron store of PSII.

Leaf mutants : Badaya and Mehrotra (1974) reported that treatment of presoaked Clark-63 seed with ethyl methanesulphonate, ethyleneimine, and gamma rays resulted in a mutation spectrum for leaf shape and size, leaflet number, and testa colour. Kiang and Halloran (1975) reported that the frequency of mutations induced by ethyl methane-sulphonate in the M_1, and M_2 generations for leaflet number were in the range 1-5% over all characters. Fujii *et al.* (1983) reported that when soybean seeds were treated with caffeine solutions, the number of mutant spots per leaf on the resulting plants ranged from 3.7 at 0.01% to 24.8 at 0.05% caffeine. However, when the seeds were treated with 12-O- tetradecanoyl-phorbol-l3-acetate (TPA) plus caffeine the number of leaf spots decreased, significantly so in the case of 0.03% caffeine. TPA alone at concentrations of 1-20 µg/ml did not induce any mutations. Fu (1986) reported that SF7910-3, with 2 opposite trifoliate leaves per node, oval leaflets and white flowers, and SF7919-61, with 4-7 leaflets/leaf (instead of 3) and white flowers, were obtained from [unnamed] varieties treated with 15 krad gamma rays and were subjected to selection until the M_5. Guo (1986) reported that dry seeds of Tie 6817 were irradiated with 16 krad gamma rays. The multi-leaflet trait appeared in the M_3 and was selected for until the M_6 when 2 lines showed frequencies of 100 and 95.5%, respectively, for the trait. Multi-leaflet mutant Mufu 81-6009 has white flowers, vigorous, indeterminate growth, yellow, round seeds, 4-7 leaflets/leaf (in common with other named multi-leaflet mutants), late maturity, increased branching, a 1000-seed weight of 150-170g, a protein content of 42.15% and a larger leaf area than Mufeng 5.

Xue *et al.* (2000) while studying the mutagenic effect of 60 Co gamma irradiation on soybean observed that the M_2 seedling were with one or three primary leaves and joined or wrinkled cotyledons.

Altered stem structure

Plant height : Nicolae and Nicolae (1977) treated the seeds of the soybean line B-89/J I with gamma rays and thermal neutrons and observed that most of the mutant lines in M_2-M4 were taller than the control line of B-89/11. Fahmy *et al.* (1997) reported that the increasing doses of gamma-rays were negatively associated with plant height. Kundi *et al.* (1997) reported that after irradiation of three varieties of soybean viz PK 416, SL96 and PB Soybean No.1 with three doses of gamma rays viz 10 kR, 20 kR and 30 kR, there was marginal increase in mean values for plant height.

Growth type : Wang and Yu (1988) reported that three genotypes were exposed to 8 doses of gamma radiation at 2 developmental stages. Following radiation at the VE-V1 stage, growth of the

M_1, generation was reduced more when the same dose was administered at a lower rate. Reductions in growth rate and number of morphological abnormalities were greater at doses of 50 Gy and above.

3.6.3 Short stemmed : Khvostova (1967) reported gamma induced short stemmed and lodging mutants.

3.6.4 Reduced internodal length : Mutations for internodal length in XZ generation were recorded by Humphery (1951).

Stem thickness : Mutations for stem size were recorded in M_2 generations of X-ray irradiated soybean varieties (Humphery, 1951).

Branching : More densely branched mutants were recorded by Zacharias (1956) in X-ray irradiated material.

Lodging : Weber and Fehr (1967) studied maturity period in both irradiated and segregating populations and observed any difference for lodging.

Alteration of ripening time

Maturity : Szyrmer and Boros (1986) studied the maturation period of soybean lines and reported that the maturation period of the mutant was not significantly shorter than in the control varieties. Bhatnagar *et al.* (1989) treated seeds of soybean cv. Bragg with EMS (ethyl methane-sulfonate) and reported that the mutants were 5 days earlier in maturity. Tulmann and Peixoto (1990) observed some very early mutants with the same level of productivity as in the parent cultivar (Parana) when seeds were treated with 22 kR gamma rays. Mehta *et al.* (1994) treated a local cultivar of soybean (Kalitur) with gamma rays and EMS. They reported that two mutants namely 7 and 13 were isolated in M_2 and the maturity period of these mutants were superior as compared to the control treatment of Kalitur. Khudhair *et al.* (2002) irradiated the seeds of soybean with 0, 100, 200, 300 kR of gamma rays and selected two mutants which were superior in their yield components and earliness in maturity compared with the variant H226 and other control cultivars.

Yield contributing characters

Number of pods per plant : Zakri and Jalani (1986) treated two cultivars (Palmetto and Acadian) of soybean with ethyl methane sulfonate and gamma rays and reported that the mutant P630-2 had 86 pods/plant compared with 22 for the control.

Pod set : Birnberg *et al.* (1987) reported that when leaves of soybean cultivars Evans and Lincoln were treated with gibberellic acid (GA_3) about 3 days before anthesis, the fraction of flowers on the associated node that set pods was reduced by 28-76%.

Yield : Skorupska (1984) treated seeds of 14 soybean varieties with 10 kR of gamma rays administered alone or in conjunction with $NaNO_3$ solution, and reported that morphological abnormalities were frequent in all the treatments in M_2 while, in M_3, the traits showing the greatest variation for seed yield/plant. Krausse (1989) developed 6 mutant lines, out of which Dorado was the best mutant line having higher yields (1320-1560 kg/ha as compared to control line 1205 kg/ha).

Bhatnagar *et al.* (1990) reported that seeds of black-seeded soybean cv. Bhat were treated with gamma rays (15-25 kR), with or without additional exposure to UV radiation (2 h at 260 nm). The results indicated that among the useful mutants identified, T154 from the 20 kR + UV treatment surpassed the parent and local standards for yield. Bhatnagar *et al.* (1992) irradiated seeds of the soybean cultivars Punjab-1, Gaurav and NRC-I with 15 and 20 kR gamma-rays and observed that in the M_3 generation, Li *et al.* (1995) reported that methanol application of soybean significantly increased seed yield. Seed yield was highest with a single application of 25% (v/v) methanol. Kumar and Lal (2001) reported that the highest magnitude of variation in grain yield was induced by 30 kR gamma rays.

Seeds per plant : Increase in average seeds/plant in X_2 was reported by Sebok *et al.* (1963). According to Georgiev and Topcieva (1970), the average number of seeds/plant failed to increase with increase in dose but in the variety Adams dose 4 and 8 kR increased the seeds/plant over the un-irradiated control. Rajput (1987) reported depressive effect of gamma rays on the mean value for seeds/plant which could have been due to poly-genornic mutations. These observations were based on M_2 of 10, 15, 20 and 25 kR doses kR gamma treated varieties viz., Loppa, T-I S and Columbus.

Plant Vigour : Seven plants showing marked increase in vigour in X_2 generation over normal plants were observed by Humphrey (1951). Further in subsequent generation, Humphrey (1954) confirmed the same.

Alteration of seed storage substances

Protein content and oil content : Dahiya (1973) reported that with radiation treatment (gamma rays) the quality of proteins changed. Some of the M_2 progenies showed a greater range of variation in the content of methionine and tryptophan. Hiraiwa *et al.* (1975) reported that treatment of the varieties Mutsumejiro, Raiden and Miyagishirome with 8 and 16 kR gamma rays, the mean protein contents of the selected M_4 populations of first two varieties, treated with 8 and 16 kR gamma rays, and of the last variety, treated with 8 kR gamma rays, were significantly greater than those of the untreated controls. In the M_5 generation mean protein contents of selected populations of Mutsumejiro and Raiden were significantly higher than those of the controls. Qiu and Gao (1988) reported higher frequencies of mutants with high protein and oil contents using EMS as compared with fast neutrons and these were more highly heritable in M_2 and M_3 lines. Nilegaonkar and Agte (1989) reported that when Kalitur, a black seeded soybean cultivar was exposed to physical and chemical mutagens and subsequently studied for changes in electrophoretic and solubility behaviour of proteins, trypsin inhibitor activity and proximate analysis. Mutation induced changes in protein structure and lowered fat percentage. The mutant cv. MACS 107 had a trypsin inhibitor activity significantly lower, by 15%, than Kalitur.

Wang *et al.* (1989) treated seeds of the soybean line LF81-837 with 0.2 or 0.4% solutions of ethyl methane-sulfonate (EMS) at pH 7 and reported that treatment of the seeds with 0.4% EMS followed by selection in the early generations is recommended for improving protein content. Eskins *et al.* (1991) grow normal green (Clark Ll) and mutant yellow (Clark y9y9) mutants in full-spectrum solar irradiation and reported that response of the mutant to light quality indicated that blue light slightly enhanced expression of the mutation at higher irradiances. Rubisco (ribulose-bisphosphate carboxylase) proteins and rubisco activity (leaf area basis) were directly related to irradiance level but were enhanced in blue light over equal irradiance red light. This enhancement was not shown in the presence of far-red light. Qing *et al.* (1996) reported that gamma rays increased the plant peroxides activity at higher doses. Protein content also increased with increasing doses of irradiation.

Resistance to Diseases : Tsai *et al.* (1974) reported that seed of six varieties of soybean were treated with 1530 kR gamma rays or 1% ethyl methane-sulphonate solution, and about 5000 M_3 to M_6 lines, derived from apparently resistant plants, tested for *Phakopsora pachyrhizi* resistance under natural conditions, followed by repeated selection, five lines showed appreciable resistance, two of which, CHI-41 and CH3-77, were finally selected for production. Smutkupt *et al.* (1974) reported that seeds of Sansai and SJ2 were treated with 5-30 kR gamma rays and seven lines originating from the M_2 of both varieties were selected in the M_4 on the basis of lodging resistance. Nicolae (1979) reported that Cerag I was selected in Algeria from a collection of induced mutants from Romania. Compared with its parent B107/l0 (T) is more resistant to cold and drought. Oh (1983) reported that from 430 M_3 soybean lines, five were selected as highly resistant and 20 as moderately resistant. Kwon and Oh (1983) reported that seeds of the soybean varieties Kwangkyo and Kangrim were irradiated with 15 and 20 kR gamma rays. In the M_3, 18 mutants from Kwangkyo were selected which showed moderately resistance against soybean mosaic virus. Wang *et al.* (1986) reported that a cultivar Heinong 26 derived from Dongnong- 4 following gamma irradiation was tolerant to drought and of low temperatures during the seedling stage.

Tulmann *et al.* (1988) treated three soybean cultivars with gamma irradiation or treated with ethyl methane-sulfonate in order to induce resistance to tobacco ring spot *nepovirus* (causal agent of bud blight) and *Phakopsora pachyrhizi* and reported that resistant mutants were selected in the M_2 and M_3 generation. Oh *et al.* (1988) reported that seeds of soybean were gamma-irradiated with 15 and 25 kR and mutants were screened for resistance to soybean mosaic *potyvirus.* Five lines were subsequently selected which showed highly resistance.

Smutkupt *et al.* (1988) treated seeds of I1 cultivars with gamma-irradiation at 15 and 30 kR and reported that M_3 bulk and single populations and M_2 bulk populations were screened for resistance to *Phakopsora pachyrhizi* at 2 locations. After further selection, 16 lines were selected as *P. pachyrhizi* tolerant mutants. Nazim *et al.* (1988) reported that seeds of the cultivars Calland, Columbus and Williams were gamma-irradiated with 20 kR. M_2 plants were screened against *Drechslera australiensis* and *Alternaria alternata.* Their reactions suggested that the induced resistances were polygenically inherited. In the M_3, 30 and 25 mutants were true breeding for resistance to C. *australiensis* and *A. alternata,* respectively.

Resistance to chemicals : Hendratno (1988) reported that seeds of cv. Orba were treated with fast neutrons, gamma-rays, ethyl methanesulfonate and sodium azideand observed one mutant which showed high tolerance of Al toxicity and exceeding Orba in yield by 17%. Sebastian (1989) reported that seed mutagenesis (using N-nitroso-N-methylurea [N-methyl-N-nitrosourea] and ethyl methanesulfonate) followed by selection for resistance to chlorsulfuron yielded a soybean mutant with a high degree of resistance to both post- and pre-emergence applications of a variety of sulfonylurea (SU) herbicides.

Inheritance of quantitative characters

Heritability : Singh *et al.* (1980) reported that when ten varieties were irradiated with 10-20 kR gamma rays, the estimates of heritability (broad sense) ranged from 0-51% for days to flowering, 0-58% for days to maturity, 0-80% for plant height, 0-49% for primary branches, 0-81 % for pods per plant, 0-92% for seed per pod and 0-80% for yield per plant. Geetha and Vaidynathan (1998) reported an increase was noticed in heritability and genetic advance for some economic traits like seed yield per plant and 100-seed weight in M_2 generations. Kumar and Lal (2001) reported that the phenotypic and genetic coefficient of variation and the estimates of heritability in the broad sense significantly increased in the mutagenic populations.

Genetic divergence : Mehetre *et al.* (1996) studied the gamma induced genetic divergence in M_2 generation of soybean and reported that the genetic diversity was independent of varieties and doses of gamma rays. Mehetre *et al.* (1996) opened that the genetic diversity was independent of varieties and doses of gamma rays. They further observed the sufficient amount of variability due to induced mutations for different polygenic characters over the parent variety in M_2 families.

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Chapter 3

Status of Nutrients in Soils under Rice Cultivation

B. Aparna, Gladis R., Biju Joseph, Rani B. and Sreelakhmi M.M.
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani-695522
Email : aparna.b@kau.in

Abstract

Rice (*Oryza sativa* L.) is one of the most important sources of food for the world population. Around 3 billion people or about 50% of human population uses rice as food and nutrients source. China is the major producer of rice in the world. Total rice production have to be increased to feed an increasing world population. Rice is produced under both upland and lowland ecosystems with about 76% of the global rice produced from irrigated-lowland rice systems (Wu *et al.,* 2021).

Key words : *Nutrients, soil, cultivation, toxicity, rice.*

The demand for rice in India is projected at 128 million tonnes for the year 2012 and will require a production level of 3,000 kg/ha significantly greater than the present average yield of 1,930 kg/ ha. This low level of productivity has to be increased substantially with the help of varieties/hybrids, judicious use of fertilisers and environment friendly good agricultural practices. Yield plateauing in irrigated areas has necessitated turning the focus to rainfed rice ecology. Improved rice production and productivity in rainfed areas may not only help the resource-poor farmers, but also substantially increase food production. Globally, paddy soils comprise the largest anthropogenic wetlands and are a critical resource for global food production

A wide range of naturally occurring biotic and abiotic constraints, including poor soils, water scarcity, crop pests/diseases/weeds, and unsuitable temperatures, are well-known to reduce the productivity of food crops especially rice, leading to low efficiencies of input use, suppressed crop output, and ultimately reduced food security. The task of producing the additional rice to meet the expected demands of the year 2025 poses a major challenge. The danger is that stability in rice production is linked to social and political stability of the countries in the Asia-Pacific Region (Evenson *et al*, 1996). The scope of area expansion in some countries is offset by the reduction in rice lands in major rice producing countries. So far irrigated rice which occupies about 57 percent of the area and produces 76 percent of total rice has helped double the rice production. It will be easier to produce the necessary increases in productivity under irrigated conditions than under rainfed or other ecosystems.

Soil degradation and quality deterioration limit crop yields in many intensively cultivated farms. Changes in organic matter and soil nutrient supplying capacity, nutrient imbalance and multi-nutrient deficiency, waterlogging and iron toxicity, soil salinity and alkalinity, and development of hard pans at shallow depths are some of the major indicators of deteriorating soil quality. A lot of yield gaps can be attributed to knowledge gaps. Techniques which can be used to handle the soil degradation, include the chlorophyll meter (SPAD) and leaf colour chart (LCC), N placement methods, use of modified coated urea materials, phyto-availability soil tests, nutrient-

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efficient rice varieties, periodic deep tillage to exploit the subsoil N reserve, catch crops to tap pre-rice accumulated soil nitrate, and use of biofertilizers (Balasubramanian and Karthickumar, 2017).

While moving towards the modern rice production and management technologies, at most care should be taken to sustain soil health and rice productivity. With this in mind we shall think of the nutrient management strategies to be adopted for rice production and how best the inherent available nutrients in soil and the added nutrients can boost up rice production. A very good understanding on the nutrient status of the soil, the nutrient requirement of rice varieties and nutrient use efficiency under different systems of production will help to address most of the problems associated with rice production. This will also open up the avenues for newer areas of rice research. A brief discussion in this connection is presented below.

Nutrient Management Strategies

Soil fertility is an integral part of soil quality that focuses more on the productivity of the soil, which is a measure of the soil's ability to produce a particular crop under a specific management system. Nutrient Management Fertilizer responsive, high yielding rice varieties developed in the 1960s made it possible to produce 7.5 to 10 t of plant biomass per hectare per year. Initially, this level of production was sustained by nitrogen (N) fertilizer additions with soil and manure being the other nutrient sources. Within a few years, applying only N gradually exhausted nutrient reserves in many soils, making it impossible to produce high yields. There is now a large mass of experimental data (onfarm as well as on-station) showing that application of N, phosphorus (P), and potassium (K) fertilizers produce higher yields than either the application of N or N and P. The contribution of P and K to yield is substantial and proves that India's soils generally suffer from multi-nutrient deficiencies. Productivity, therefore, can only be sustained by planned applications of nutrients that the soil cannot provide. The anaerobic soil environment created by flood-irrigation of lowland rice creates a unique and challenging environment for the efficient management of soil and fertilizer nutrients. Supplying essential nutrients in adequate rates, sources, application methods, and application times are important factors that influence the productivity and sustainability of rice (Fageria *et al.,* 2003).

Intensive rice cropping with short-duration high-yielding varieties along with increased use of mineral fertilisers and improved irrigation facilities have resulted in spectacular increases in crop productivity. This has, however, led to gradual replacement of organic manures as sources of plant nutrients. Seventeen elements are considered essential for plant growth and these are divided into two groups, macro (carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium and sulphur) and micro-nutrients (zinc, iron, manganese, copper, molybdenum, boron, chlorine, and cobalt) (Fageria *et al.,* 2011).

Fate of Major Nutrients

A decline in rice yields has been associated with intensification of rice production. In continuously irrigated systems this has been attributed to a decline in soil N supply. Nutrient mineralisation and immobilisation is constrained by the quantity and nature of the organic substrates and the physico-chemical environment of the soil system itself. In Asia, rice production has increased an average 2.7% annually-due to greater fertilizer use and crop intensification together with varietal improvement and investment in irrigation facilities. Nitrogen efficiency in tropical rice is low.15N recovery rarely exceeds 30–40% in wetland rice production systems. Ammonia (NH_3) volatilization and denitrification are recognized as major nitrogen loss mechanisms in such systems. The greatest losses of N are reported to occur when the fertilizer treatment leads to a high concentration of ammoniacal N in the floodwater. Studies using micrometereological technique suggest that ammonia volatilization may be the most important loss process in wetland rice ecosystems. Directly measuring denitrification in the field proved more difficult than measuring NH_3 volatilization due to difficulty in distinguishing the main end product of denitrification (N_2) against a large background of atmospheric N_2. Nitrogen is typically the main limiting nutrient in the production of lowland rice, and use of N fertilizer is vital for the sustained production of sufficient rice to meet demand. About 20% of the global production of fertilizer N is used in rice production systems that experience soil submergence (Runge, 1983). Yet the use efficiency of this fertilizer N by the crop is typically low, due at least in part to losses of the applied fertilizer N arising from unique features of submerged soils as compared with aerated soils. The main N transformation processes in submerged soils—as in aerated soils—are mineralization, immobilization, nitrification, denitrification, ammonia (NH_3) volatilization, and biological N_2 fixation. Soil submergence modifies these processes, and a unique feature of submerged soils is the simultaneous formation and loss of NO_3-, occurring within the adjoining aerobic and anaerobic soil zones. Submerged soils as compared with aerated soils are favorable environments for loss of N by nitrification–denitrification, NH_3 volatilization, and for addition of N via biological N_2 fixation (BNF). Mineralization and Immobilization Mineralization, or more specifically ammonification—the conversion of soil organic N to ammonium—supplies plant-available N in submerged agricultural soils. Even with high-yielding rice crops receiving high rates of fertilizer N, >50% of the total N assimilated by the crop typically originates from the breakdown of soil organic N compounds (Mikkelsen, 1987). This breakdown of organic N in submerged soils is characterized by anaerobic decomposition, which involves different microorganisms and end products than aerobic decomposition. Ammonium accumulates in anaerobic decomposition due to the absence of O_2, which is required for conversion of NH_4 to NO_3 .

Nitrogen transformations in submerged microbial decomposition of organic matter in aerated soil is accomplished by a wide range of microorganisms including fungi, heterotrophic bacteria, and actinomycetes. Respiration by these organisms is associated with high energy release, and the decomposition of substrates progresses rapidly with evolution of CO_2. As cell synthesis proceeds, there is a heavy demand for mineral nutrients, particularly N. Decomposition in the bulk volume of a submerged soil, on the other hand, depends on a relatively restricted bacterial microflora. These anaerobes operate at a lower energy level and are less efficient than aerobes as a consequence of incomplete decomposition of carbohydrates and synthesis of fewer microbial cells per unit of organic C degraded. The processes of both decomposition and cell synthesis are consequently slower under anaerobic than aerobic conditions. The main end products of anaerobic decomposition are CO_2, CH_4 , organic acids, NH_4 , H_2 S, and resistant residues .On the other hand, nitrogen di oxide are also generated in rice fields, since nitrogen is an essential nutrient for rice.The emission of nitrogen di oxide has risen and this accelerated release of nitrogen di oxide is due to agricultural production (Lovley and Coates, 2000).

Green manure incorporation in wetland rice fields reduced N losses from mineral N source due to resulting lower floodwater pH and lower partial pressure of NH_3 (pNH_3) than that of urea applied alone. At present, the integrated use of green manure and mineral N is receiving much attention in the hope of meeting farmers' desire to reduce cost of production as well as ecological considerations such as increased methane production which contribute to global climate change. Other promising alternative practices for increasing fertilizer N efficiency include improved timing and application methods, particularly through better incorporation of basal N fertilizer without standing water, deep placement, and use of coated fertilizers. In wetland rice ecosystem N-application in three equal splits at transplanting, tillering and panicle initiation growth stages has been found to be more efficient in increasing rice yield than single or two split applications.

Phosphorus is an essential element required for energy storage and transfer within the plant. At maturity, a high-yielding rice crop contains 60 to 80 lbs P_2O_5/acre, with about 70 percent of the P contained in the rice panicles. An understanding of the long-term controls on paddy soil P speciation and distribution in the profile may provide insights for optimizing P fertilizer use for sustainable food production. Many studies have shown that P fertilizer additions can significantly alter P speciation and the rates of total P accumulation in surface paddy soils over decadal time scales (Beck and Sanchez, 1994) Flooding leads to an initial increase in P availability as Fe III–oxide sorbents binding P are reductively dissolved so that the soil pH becomes more neutral; further, the higher water content allows faster P diffusion to the rhizosphere. Subsequent soil drainage and drying decreases P availability as precipitating Fe III–oxides sequesters soluble P through co-precipitation and surface adsorption. It is also well established that P speciation in lowland and upland paddy soils are solubilised by different mechanisms as the lowland paddy soils are affected by the seasonal fluctuations of groundwater. Adsorption and dissolution are some of the abiotic factors controlling nutrient transfer between non-living pools and soluble forms, whereas biotic factors, including microbial activity, change organic P into inorganic P, and vice versa. Most studies have been focused on the transformation of organic P fractions into inorganic P fractions through the process of mineralization.

Potassium is involved in large number of physiological processes like osmoregulation, cation-anion balance, protein synthesis and activation of enzymes. Being a major inorganic solute, it plays a key role in the water balance of plants. It also reduces lodging, imparts disease resistance and improves the quality and shelf life of crop produce. Considering its role in rice production potassium is regarded as major element. The soil, K originates from slowly weathering minerals. In the soil solution, K is present as K ion (K^+), the form used by plants. In rice plants, K participates in many enzymatic and physiological processes; notably in the opening and closing of stomata (leaf openings responsible for gas exchange). In general, K increases tillering, grain size and weight, and disease resistance. In rice plants about 75% of plant K remains in leaves and stems, and the rest is translocated to grains. Nutrient K is less mobile in soils because of the strong affinity with some exchange sites of clays. Large rates of K uptake can be attributed to its high mobility due to the large permeability of cell membranes to K-ions, which arise from the occurrence of a range of highly K selective, low and high affinity ion channels and transporters. The large K uptake rates achieved by roots result in a steep depletion of solution K in the rhizosphere. It has been well established that a significant proportion of plant needs of K is met from non-exchangeble fraction of soil K (Srinivasarao *et al*., 2010).

Secondary Nutrients

Calcium and Magnesium

Calcium (Ca) and magnesium (Mg) deficiencies are r are in lowland rice. Rice is highly tolerant to soil acidity. Optimum soil pH for lowland rice grown on Brazilian Inceptisol was reported to be 4.9 (Fageria and Baligar 1999). In highly acidic soils, dolomitic lime can be added to supply Ca and Mg. Only a small amount of these elements are removed in the grain, and unless the straw is removed from the field, the total removal is small.

Changes in Ca and Mg concentrations are minimum in flooded soil. The convergence of pH to near neutral also affects the availability of plant nutrients mostly in a favourable manner. However, soil reduction, following flooding of soils that are rich in reducible iron, accumulates excessive concentrations of iron in the soil solution that could be toxic to wetland rice. Also, production of reduction products in submerged soils, such as sulphide and organic acids in flooded soils, may cause toxicity and retardation of rice plant growth, especially in soils that are high in easily decomposable organic matter or if high amounts of organic materials are added to the soils . Salient changes in the availability of plant nutrients and organic matter accumulation as a result of flooding of soils,

At low redox potentials as noticed in wet land paddy soils, sulfur is reduced and H_2S, hydrogen sulfide, is released. Because the concentration of sulfates is higher in wetlands, sulfide emission is also higher, and toxicity greater. Toxicity can occur as the result of contact with roots, or with reduced availability of sulfur to plants because it precipitates with trace metals. Zinc and copper can also be limiting because they precipitate with sulfur. If ferrous iron is present, it will precipitate with sulfides. Ferrous sulfide (FeS) give many wetland soils their black color, and is the source of sulfur commonly found in coal deposits.

Micronutrients

Micronutrient deficiencies are widespread. 50% of world cereal soils are deficient in zinc and 30% of cultivated soils globally are deficient in iron. Steady growth of crop yields during recent decades (in particular through the green revolution) compounded the problem by progressively depleting soil micronutrient pools. In general, farmers only apply micronutrients when crops show deficiency symptoms, while micronutrient deficiencies decrease yields before symptoms appear. Some common farming practices (such as liming acid soils) contribute to widespread occurrence of micronutrient deficiencies in rice crops by decreasing the availability of the micronutrients present in the soil. Major problems in alleviating micronutrient deficiencies include difficulty in the identification of field crop symptoms, variation in soil micronutrient status, soil pH, and intensity, and seasonal fluctuations in the levels and temperature regimes in the region, inadequate facilities and field tests to validate soil and plant micronutrients in the region (Broadley *et al.,* 2012).

Zinc deficiencies mainly occur when soil pH is, high organic matter in soil, calcareous soils with high bicarbonate content, intensively cropped soils. Paddy soil under prolonged submerged condition exhibit zinc deficiency. Symptoms are common on younger or middle aged leaves with brown to dusty brown spots on younger leaves (2-4 weeks after transplanting) in red soils, yellowing of leaves/midrib bleaching. Symptoms are prolonged during early growth stages due to immobilization of zinc. Symptoms of zinc deficiency sometimes resemble Fe/Mn deficiencies. Zinc deficiency in rice soil is commonly known as khaira. The main symptom of khaira in rice is usually in nursery; chlorotic/yellow patches at leaf base on both sides of the midrib; restricted root growth and usually main roots turn brown. Zinc deficiency has also been associated with high bicarbonate content, a Mg : Ca ratio in soils >1, the use of high level of fertilizers, intensive cropping, use of high yielding cultivars, and irrigation with alkaline water. But curative measure for correcting are application of 20-25 kg/ha $ZnSO_4$ in acid soil, 22 kg Zn/ha initially followed by 5-10 kg Zn in the later years or 50% gypsum + 10 t GM + 22 kg Zn once in 2-3 years in sodic/acidic soils, 1.0-1.5 kg/ha Zn as foliar spray at tillering stage and 2 times latter is very helpful for rectifying this deficiency.

The iron content in wet land paddy soil generally varies from 1% to 20%, averaging 3.2%, but its normal concentration in plants is only 0.005%. Iron deficiency is common in upland, high pH and aerobic soil and toxicity is one of the major constraints to lowland rice production which disrupts the rice plant physiology in several respects. The main reason for iron deficiency are low concentration of iron in upland soil, coarse textured soil, low land soil with very low organic matter content, increased rhizosphere pH etc. Though it is the most difficult and costly micronutrient deficiency to correct it can be controlled by application of $FeSO_4$ 25 kg/ha in between rows, application of iron containing fertilizers or foliar spary of $FeSO_4$ 1% - 3% solution (Sahrawat, 2005). The toxicity of iron is associated with reduced soil condition of submerged or flooded paddy soils, which increases concentration and uptake of iron (Fe^{2+}). Higher concentration of Fe^{2+} in the rhizosphere also has antagonistic effects on the uptake of many essential nutrients and consequently yields reduction. In addition to reduced condition, increase in concentration of Fe^{2+} in submerged soils of lowland rice is associated with iron content of parent material, oxidation-reduction potential, soil pH, ionic concentration, fertility level, and lowland rice genotypes. Oxidation-reduction potential of highly reduced soil is in the range of –100 to –300 mV. Iron toxicity has been observed in flooded soils with a pH below 5.8 when aerobic and pH below 6.5 when anaerobic. Visual toxicity symptoms on plants, soil and plant tissue test are major diagnostic techniques for identifying iron toxicity. Appropriate management practices like liming acid soils, improving soil fertility, soil drainage at certain growth stage of crop, use of manganese as antagonistic element in the uptake of Fe^{2+} and planting Fe^{2+} resistant rice cultivars can reduce problem of iron toxicity.

Boron is concerned with precipitating excess cations, buffer action, regulatory effect on other nutrient elements etc., development of new cells in meristematic tissue, translocation of sugars, starches, phosphorus etc., essential for cell wall formation. Boron (B) deficiency is spreading in most of rice growing soils. Although considered tolerant, rice suffers with B deficiency resulting in substantial yield loss (Givi *et al*., 2010). Several factors including drought, low soil pH, calcareous nature of soil, and B leaching and fixation have been considered as the possible reasons of B deficiency. Boron deficiency occurs under moister stress and dry condition which cause reduced plant height. Plants fail to produce panicles if they are affected by B deficiency at the panicle formation stage. The tips of emerging leaves are white and rolled Soil application of B (1-2 kg/ha) is superior to foliar sprays. For hidden deficienct, spary 0.2% boric acid or borax at pre flowering or flower head formation stages.

The role of manganese is regarded as being closely associated with that of iron. Manganese also supports the movement of iron in the plant. It influences auxin levels in plants and high concentrations of Mn favour the breakdown of Indole Acetic Acid (IAA), takes part in electron transport in photosystem II . Application of organic matter brought about an increase in the content of water soluble plus exchangeable manganese in all the soils excepting the lateritic one irrespective of moisture regimes will not cause any change in the content of iron and manganese in insoluble complex Manganese deficiency is very common in upland rice, degraded paddy soil high in Fe content, accumulation of H_2S, acid sandy or acid sulphate soil, excessive liming in acid soil etc. manganese deficiency can be corrected by application of farmyard manure, acid forming fertilizer, $MnSO_4$ or MnO at 2-5 kg/ha as multiple application . Chelates should be avoided as Fe and Cu displaces Mn under wetland situations.

Silicon is considered a plant nutrient “anomaly” because it is presumably not essential for plant growth and development. The beneficial effects of silicon have been attributed to correction of soil toxicities arising from high levels of available Mn, Fe^{2+} and active aluminium. Rice is considered to be a Si accumulator plant and tends to actively accumulate Si to tissue concentrations of 5% or higher. Recently Si has been regarded as quasiessential element (Epstein, 2002). Silicon also provides greater stalk strength and resistance to lodging, increased availability of phosphorus, reduced transpiration etc. Silicon tends to maintain erectness of rice leaves, increases photosynthesis because of better light interception (Ma *et al.,* 2006). Si deficiency is not very common in irrigated rice and thus to date tends to be of little economic significance. Nonetheless, the damage caused by Silicon deficiency is important throughout the growth cycle of the rice crop. In the long term, Si deficiency is prevented by not removing the straw from the field following harvest, and recycling rice straw (5-6% Si) and rice husks (10% Si). Si deficiency can be mananged by the application of substantial input of Si from irrigation water, rice hulls or rice hull ash are recycled to replenish Si in soil. Avoid applying excessive amounts of Nitrogen fertilizer, application of calcium silicate slags regularly to degraded paddy soils or peat soils at a rate of 1-3 t ha^{-1}.

Copper in general helps in the utilization of iron during chlorophyll synthesis. Lack of copper causes iron to accumulate in the nodes of plants. It has an unique involvement in enzyme systems of plants like oxidase enzymes, terminal oxidation by cytochrome oxidase, photosynthetic electron transport mediated by plastocyanin etc. It also acts as "electron carrier" in enzymes which bring about oxidation-reduction reactions in plants Excessive liming in acid soil sometimes causes Cu deficiency in wetland rice soils can be controlled by seeding root dipping in 1% $CuSO_4$ suspension, apply Cu at 5-10 kg/ha once in 5 years in the form of CuO or $CuSO_4$. Foliar application can be done during tillering to panicle initiation stage. Soil application can also be done with $CuSO_4$ as broadcasting or band placement. Boron and molybdenum are generally fixed in wetland rice soil. In case of boron main reaction occurs when acid soils are limed. Lime is able to replace Al^{3+} by Ca^{2+} and produce insoluble precipitation of aluminium hydroxide/iron hydroxide. This precipitate adsorbs large quantities of boron. Soil high in organic matter also has high Boron. Molybdenum adsorbed strongly by iron/aluminium oxides. Soils high in non crystalline iron on clay surfaces, tend to be low in available molybdenum due to fixation.

Status of Organic Carbon Status In Wetland Rice Soils

Wet land rice soils are a large terrestrial carbon pool and play an important role in global carbon cycles as natural carbon sinks. Accumulation of organic matter in wetland soils depends on the ratio between inputs (organic matter produced in situ and ex situ) and outputs (decomposition under waterlogged conditions and erosion by hydrology. Decomposition is a more complicated process as it involves aerobic and anaerobic processes. Organic matter decomposition is often incomplete under anaerobic conditions and thus, the lack of oxygen is the main factor determining plant detritus turnover. Consequently, plant remains coming from the inflow, from the wetland biomass, or from the vegetation growing along the margins, accumulate in wetlands at different decomposition stages creating a net retention of organic matter and plant detritus. Decomposition rates in wetland rice soils are also a function of climate (temperature and moisture enhanced microbial activity) and the quality (chemical composition) of the organic matter entering the system. Hence, wetland rice soils characteristics lead to the accumulation of high amounts of organic matter in the soil, serving as carbon sinks and making them one of the most effective ecosystems accumulating soil carbon.

Rice crop present a different behaviour compared to other crops. Rice can grow in soil without oxygen at root level. Organic matter is oxidised to carbon di oxide through aerobic pathway whereas anaerobic pathway is not that prevalent. The decomposition of soil or added organic matter is relatively fast under aerobic conditions where oxygen is the electron acceptor. However, under submerged conditions in rice soils ,the supply of free oxygen is low or absent and the decomposition of organic matter depends on the availability of electron acceptors such as ferric iron or sulphate.

Enhancement of Soil Acidity

In acid, red laterite and lateritic soils, the following problems are encountered in wetland paddy soils :

Moderate to high acidity

Deficiency of nutrients, because of there soils are low in C, N and available nutrients.

Toxicity due to iron and in some soils due to aluminum and manganese.

P-deficiency and high P-fixing capacity which necessitate higher rates of application of P-fertilizers

Impeded drainage in certain areas.

As a result of flooding, the pH of acidic soils increases and that of alkaline soils decreases and the chemical reaction of submerged soils generally stabilizes in the neutral range 8,13. This is the benefit of flooding of soils to rice crop. The following reasons may be attributed to the extreme acidity in wetland paddy soils-release of hydrogen atoms under natural chemical processes in the soil,reaction of atmospheric carbon dioxide with water to form carbonic acid, reaction of organic molecules with water and cause acid dissociation, oxidation of ammonium nitrogen, sulfur, and iron,accumulation of organic matter and subsequent release of fulvic and humic acid, products of decomposition.reaction of aluminum cations with water (a process known as hydrolysis).

Salinity and Degraded Sodic Soils

Saline and alkaline soils cover millions of hectares in several South and South-East Asian countries. Saline soils represent a group of soils in which percentages of soluble salts, usually chlorides and sulphates of the alkali bases are very high.

(i) Saline or solonchak or white alkali soils : In these, salinity is caused by soluble salts other than alkali salts. They have high soluble salts and low exchangeable sodium.

(ii) Alkali or sodic or solonetz or black alkali soils : These are formed by accumulation of alkalies, such as Na, K etc. in excess. Such soils have low salt content but high exchangeable sodium.

(iii) Saline-alkali soils : In these, alkali and other soluble salts have combined effects. They are also called saline sodic as they have high salt content and high exchangeable sodium.

Electrochemical Changes in Rice Soils

The main electrochemical changes that influence the chemistry and fertility of submerged soils and growing of crops such as wetland rice include :

A decrease in redox potential (redox potential, Eh) or reduction of the soil.

An increase in pH of acid soils and a decrease in pH of alkali soils, and changes in the floodwater pH.

An increase in specific conductance and ionic strength of soil solution. Ionic equilibria influence sorption–desorption reactions and the availability of major and micronutrients.

Submerging aerobic soils in water decreases its Eh that drops and stabilizes at a fairly stable range of +200 mV to –300 mV depending on the soil, especially the content of organic matter and reducible species (nitrate, sulphate and ferric iron), particularly iron. Wetland rice soils have free water at the surface for at least the major part of the crop growing season. Water may be retained by levelling and building levees or dikes. Flooding drastically reduces the diffusion of atmospheric oxygen into the soil, and facultative and anaerobic microorganisms sequentially reduce soil substrates. The redox potential is a quantitative indicator measuring the tendencies of different oxidations and reductions (net flow of electrons) to occur. Redox potential, measured as electric potential in volts, characterizes the processes that bring about a given chemical and biochemical milieu in a soil. The higher the value of the redox potential, the greater the presence of strong oxidizing agents in a soil.

Fe toxicity in Several Acid Soils Fe Deposition on Roots

Iron toxicity symptoms vary with rice cultivars which are characterized by a reddish brown, yellow, or purple-bronzing or orange discoloration of the lower leaves of the rice plants. Typically, iron toxicity symptoms are manifested as tiny brown spots starting from the upper tips and spreading toward the bases of the lower leaves. With progress in iron toxicity, the brown spots coalesce on the interveins of the leaves. With increased iron toxicity stress, the entire affected leaves look purplish brown, followed by drying of the leaves, which gives the rice plant a scorched appearance. Equally important, the roots of rice plants affected by iron toxicity become scanty, coarse, short and blunted, and dark brown in color; with the alleviation of the stress, the roots may slowly recover to the usual white color. Iron toxicity symptoms on rice leaves and changes in root color and morphology are useful for diagnosis of the stress. Toxicity symptoms commonly develop at the maximum tillering and heading growth stage, but may be observed at any growth stage of the rice crop.

Aluminium Toxicity

Aluminium is present in soils in a variety of forms and bound to the soil constituents, particularly clay particles and organic matter. When soil pH drops as in rice soil, aluminium becomes soluble and the amount of aluminium in the soil solution increases. As a rule of thumb, soil aluminium concentration of 2–5 parts per million (ppm) is toxic to the roots of rice plant, and above 5 ppm is toxic to tolerant species. In most rice soils, aluminium will reach toxic levels when subsurface pH_{Ca} falls below 4.8. Generally, there is sufficient organic matter in topsoil so that aluminium can remain bound and does not become toxic to plant roots even though it is extractable in a laboratory analysis.

Toxic levels of aluminium in the soil solution affect root cell division and the ability of the root to elongate. The root tips are deformed and brittle and root growth and branching is reduced . Poor crop and pasture growth, crop yield reduction and smaller grain size occur as a result of inadequate water and nutrition. The effects of aluminium toxicity are most noticeable in seasons with a dry finish. Roots are unable to effectively grow through acidic subsurface soil, which forms a barrier and restricts access to stored subsoil water for grain filling.

H_2S Toxicity Wetlands are capable of reducing sulfate to sulfide. Sulfide is released to the atmosphere as hydrogen, methyl, and dimethyl sulfides or is bound in insoluble complexes with phosphate and metal ions in wetland sediments (Mitsch and Gosselink 1993). Dimethyl sulfide released from wetlands may act as a seed for cloud formation (Hader *et al.* 1991). Sulfate may exist in soils or may enter wetlands through tidal flow or atmospheric deposition. Healthy rice plants release sufficient quantities of oxygen to inactivate the accumulated sulphide in the rhizosphere. Sulfide toxicity is not very common in rice. It is, however, associated with low-Iron (Fe) soils. It can occur in well-drained sandy soils, degraded paddy soils, poorly drained organic soils, and acid sulfate soils. Sulfide toxicity reduces nutrient uptake of plants by reducing root respiration. It has an adverse effect on metabolism, particularly when an excessive amount is taken up by the rice plant.

Development of Hard Plough Pan

The physical properties of soil are affected by paddy upland rotation. As soil organic matter decomposes in paddy-upland rotation, soil density increases with decreasing soil porosity. Cultivation of paddy in wetland results in the development of hardpan. A tillage-induced compaction layer is sometimes referred to as a “hardpan,” or “plow pan” and occurs in the layer of soil just below the depth of tillage. It occurs when soils are cultivated repeatedly at the same depth. The weight of the tillage equipment, such as discs or cultivator shovels, can cause compression of the soil and smearing at the base of contact between the soil and tillage implement. For any upland frequency tested, the application of organic materials decreased the solid phase ratio and increased the gaseous phase ratio. The application of organic materials could thus alleviate the densification of paddy soil in paddy-upland rotation.

Problems from Added Fertilisers

Nitrate contamination of groundwater from heavy nitrogen applications is already a problem in some Asian countries, where water in some wells contains nitrate levels that exceed permissible limits. Rice cultivation often uses large amounts of chemical fertilizer. Nitrification is rather an easy process under reduction conditions. If paddy soil is submerged more than ten days, it is unlikely that any nitrate will be released from rice fields into the groundwater. Direct or dry seeding of rice is becoming increasingly common now a days , because of its lower labour cost. The use of nitrogen, the main nutrient element in crop growth, tends to be inefficient. A great deal of applied nitrogen is lost by leaching, volatilization and other natural processes. This is not only wasteful, but burdens the natural environment with excessive nitrogen. The problem is particularly marked in paddy fields, since nitrogen losses are high under flooded conditions.

Leaching of Nutrients

Generally, N fertilizers are completely water soluble and a significant portion is lost through leaching in wetland rice soils. In well-drained sandy soils, much of the nitrate can be lost by leaching as water moves nitrate down through the soil profile. Application of N fertilizers at higher doses cause higher leaching loss. Soils having low organic matter status cause more leaching loss of nitrogen than soils rich with organic matter. Phosphorus is less mobile in soil and leaching loss is lower as compared to other nutrients. Besides, phosphate is extremely reactive and binds strongly with aluminum, iron, manganese, calcium, and other elements present in soils. Phosphorus losses vary from one event to another depending upon amount, intensity, and duration of rainfall.

Loss due to Volatalization

When urea, the major source of fertilizer N for rice is broadcast on the surface of flooded soils, it undergoes rapid hydrolysis and induces high ammoniacal N concentrations and pH in the floodwater, with subsequent ammonia volatilization losses. The technological approach to increase the efficiency of the use of urea fertilizer in flooded soils which consists of the inhibition of the urease activity for minimizing the loss has received considerable attention in recent years and it is observed that urease inhibitor, phenyl phosphorodiamidate (PPD) effectively inhibited the urease activity, delayed urea hydrolysis, and reduced the buildup of ammoniacal N in floodwater.

The reduction of soils upon flooding proceeds stepwise in a thermodynamic sequence. Free oxygen is reduced first, followed, in order, by nitrate, manganese compounds, ferric iron compounds, sulfate, and, last, carbon dioxide. Consequently, the redox potential falls sharply and the partial pressure of carbon dioxide increases considerably. As a result, the pH of acid as well as of alkaline soils stabilizes at about neutral, and availability of most nutrients increases.

The anaerobic fermentation of organic matter produces and accumulates an array of substances, many of them transitory and not found in well aerated soils. These substances include various gases, hydrocarbons, alcohols, carbonyls, volatile and non volatile fatty acids, phenolic acids, and volatile sulfur compounds. The degree of humification (polymerization of organic compounds to humic substances) is low, but the decomposition of organic matter can be as rapid as in upland soils. The magnitude of reduction is determined by the amount of easily degradable organic matter, the rate of decomposition, the formation of toxins to microorganisms, and the amounts and kinds of reducible nitrates, manganese and iron oxides, sulfates, and organic compounds. The most important redox buffer system in wetland soils is comprised of iron and organic compounds. Carbon dioxide and methane are the end products of organic matter decomposition in wetland rice soils.

Mitigation of Methane

At between 50 and 100 million tonnes of methane a year, rice agriculture is a big source of atmospheric methane, possibly the biggest of man-made methane sources. The warm, waterlogged soil of rice paddies provides ideal conditions for methanogenesis, and though some of the methane produced is usually oxidized by methanotrophs in the shallow overlying water, the vast majority is released into the atmosphere.

Rice is grown very widely and rates of methane emission may vary greatly between different areas. Differences in average temperature, water depth and the length of time that the rice paddy soil is waterlogged can all result in big regional variations. However, methane emission from worldwide rice agriculture has been well studied in recent years and fairly reliable estimates of global emissions now exist. Emissions from rice paddies can vary hugely during the course of a year.

Methane (CH_4) is the primary GHG from irrigated rice farming systems, so understanding methane production is important for understanding the overall GHG burden of rice production. The total methane emissions from a paddy field are determined by methane production, oxidation and transport (Frenzel *et al.* 1999). These in turn are affected by the physical, chemical and biological properties of the soil, quantity of organic residues, temperature, plant physiology, and water regime (Minami 1995) .Atmospheric methane (CH_4) is recognized as one of the most important greenhouse gases and may account for 20 percent of anticipated global warming. Flooded rice fields are a significant source of atmospheric CH_4. The emission is the net result of opposing bacterial processes, production in anaerobic microenvironments, and consumption and oxidation in aerobic microenvironments, both of which can be found side by side in flooded rice soils. Methane is produced strictly in anaerobic environment where the redox potential is less than -200 mV essential condition to methanogenic bacteria starting their activities. It can be seen that agricultural production of methane is almost the same of energy production. On the other hand, considering only agricultural activity, rice cultivation is responsible for about 35.6% of methane generation. The atmosphere concentration of methane has more than doubled from the pre-industrial era to nowadays values, varying from around 700 ppb to 1800 ppb. It shows an effect on greenhouse 25 times superior to carbon dioxide.

Pollution of Adjacent Fields

The fertilizers and other chemicals added to the wetland rice soils results in the pollution of the ground water and as well contaminants the adjacent fields. When the flooded water is letout, for carrying out the tillage operations, the water enters the adjacent fields and channels and thus pollutes. This is one of the major concern with respect to rice cultivation.

Health Issues in Human Beings

The pesticide residues encountered in wetland rice soils can lead to cardio pulmonary disorders, neurological and haematological symptoms and skin diseases in human beings. The group of farmers exposed to these pesticides (organo phosphates, organo chlorides, organotins) used in paddy cultivation faced significantly higher acute and chronic health effects .Multiple health impairments due to these pesticides have been reported among various groups of farmers. Treatment costs including medication and fees plus the opportunity cost of farmer 's time lost in recuperation formed a measure of health cost per farmer.

Methodology to Attain Above Objectives

By the year 2020, the estimated annual demand for rice will exceed 760 million tons as world population swells to 8 billion persons, more than half of whom will be rice consumers. Therfore maintaining the sustainability of rice producing environments in the face of increasing demands will require new concepts and agricultural practises and a management that should satisfy changing human needs and maintain production over time in the face of ecological difficulties and socio economic pressure , maintain or enhance the quality of the environment, conserve or enhance the natural resource

Integrated Fertilizer Use and Balanced Use of Fertilizers

In addition to chemical fertilizer, there are avenues to augment it through the addition of organic manures, exploitation of microbes and the adoption of Integrated Plant Nutrition Systems (IPNS). Intensive rice cropping with short-duration high-yielding varieties along with increased use of mineral fertilisers and improved irrigation facilities have resulted in spectacular increases in crop productivity. This has, however, led to gradual replacement of organic manures as sources of plant nutrients. There has been a sharp increase in the prices of P and K fertilisers following withdrawal of subsidy, which has led to their decreased consumption by the farmers. The low purchasing power of the farming community and the issue of soil health have again renewed interest in organic recycling. Organic sources available for use in rice production include the bulky organic manures like FYM, quick growing leguminous shrubs grown in the cropping sequence, leguminous trees grown in alley formations and using their loppings as mulch materials, forage or food legumes properly inoculated with Rhizobia and grown in the sequence, blue green algae and Azolla. Yield potential of both the crops in rice-based cropping systems can be realized by organic manuring of Kharif rice with the available sources along with mineral fertilization of both the crops in the acid lateritic soilSoil Test based nutrient application caters the need of the soil taking into consideration the health of the soil.

Genetic Manupulation

Recent efforts of IRRI in transferring the nodulating genes to rice roots is an innovative approach which may help rice plant fix atmospheric nitrogen for its own and future use. While this is recognized as a breakthrough using biotechnological tools, future research should be based on the current gains to create a nodulation rice plant in the near future. Until that is accomplished, the addition of a legume crop either in rice-wheat rotation or in a rice-rice system would be imperative

Integrated Crop Management (Prescription Farming)

Based on the extensive and critical testing of rice varieties and the crop management technology, it is possible to develop a "prescription rice farming" for individual farmers and each situation. The concept was tested on a limited scale in Indonesia during 1996-1997.

Potential for Controlling Methane Emission

With an increasing world population, reductions in rice agriculture remain largely untenable as on methane emission reduction strategy. However, through a more integrated approach to rice paddy irrigation and fertilizer application substantial reductions remain possible. Many rice varieties can be grown under much drier conditions than those traditionally employed, with big reductions on methane emission without any loss in yield. Additionally, there is the great potential for improved varieties of rice, able to produce a much larger crop per area of rice paddy and so allow for a cut in the area of rice paddies, without a cut in rice production. Finally, the addition of compounds such as ammonium sulphate, which favour activity of other microbial groups over that of the methanogens, has proved successful under some conditions. Strategies to reduce methane emissions from rice cultivation include changes in water management, fertilizer application, and chemical additions. Water management strategies include midseason drainage and intermittent irrigation . Chemical additions (*e.g.,* sulfate or iron) decrease the activity of methanogens by providing alternative electron acceptors and restricting the availability of substrates in submerged soils. Other chemical amendments have included nitrate (reduced emissions 23 percent), thiourea, and calcium carbide. Other options for reducing methane emissions include changes in tillage and selection of rice cultivars that are associated with lower methane emissions.

Conclusions

The continuous cropping of rice, either singly or in combination has brought about a decline in soil health through nutrient deficiencies, nutrient toxicity, salinity and overall physical deterioration of the soil (Cassman *et al.* 2003). Also upland rice cultivation has promoted soil erosion in the fields and clogged irrigation and drainage canals downstream. The over use or improper use of irrigation without drainage encouraged waterlogging, resulting in salinity build-up and other mineral toxicities. Proper technology backed by policy support and political will is needed for addressing these issues. Soil fertility and nutrient supplying capacity of wet land soil can be maintained on a long-term basis only by replenishing, by addition through external inputs, nutrients removed by cropping and those lost through physical, chemical and biological processes. Wetland rice culture favours fertility maintenance and build-up of organic matter in soils, and is the backbone of long-term sustainability of the wetland rice systems..Strong extension network for effective transfer of latest technologies, improvement of credit and market facilities and crop insurance are required for rained lowland ecology.Sustainability from both ecological and economic point of view is important aspects for increasing rice productivity in different eco-systems.

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Chapter 4

Nutrient Cycling in Agroforetsry Systems

Sharmistha Pal*, Pempa Lamu Bhutia and O.P.S. Khola
ICAR-Indian Institute of Soil and Water Conservation, Research Centre, Chandigarh-160 019
Email : sharmistha.ars@gmail.com

Abstract

Agroforestry system is well recognized for its role in recover, recycle and utilize the soil nutrients. The nutrients addition in agroforestry system takes place by number of mechanism such as biological nitrogen fixation by nitrogen fixing trees, leaf litter into soil, input from chemical fertilizers added to the soil and animal manures. Agroforestry practices increases organic matter accumulation in soil, which favours activity of beneficial microbes in soil. The added organic matter serves as substrate for microbes and promotes nutrient cycling in soil. A substantial amount of nitrogen is added by nitrogen fixing trees under to agroforestry systems through biological nitrogen fixation. There exist a number of ways, by which nutrients are lost from the system. These are crop harvest, erosion of soil, runoff, leaching, volatilization *etc.* To maintain a positive nutrient balance, the nutrient losses from the system are to be minimized. The balance between net nutrient inflow and outflow of a system determines net nutrient build up. A more efficient nutrient cycling under agroforestry system, favours soil fertility build up. The effectiveness of nutrient recycling under different agroforestry systems may be improved better soil water and nutrient management practices and suitable tree crop combination.

Key words : *Nutrient cycling, nitrogen, soil organic matter, agrofoirestry systems.*

Introduction

India occupies only 2.4% of the world's geographical area, 1.5% forest and pasture lands, 4.2% water resources. There is tremendous pressure on our natural resource base as India supports about 18% human and 15% livestock population of the globe. Land use diversification with agroforestry can help to address some of these major challenges. Agroforestry provides a number of ecosystem services, such as provisioning (food, fuelwood, fodder, timber *etc*.), regulatory (hydrological benefits, micro-climatic modifications, *etc*.), supporting services (nutrient cycling, biodiversity conservation, *etc*.), and cultural services (recreation, aesthetics, *etc*.) (CAFRI Vision, 2015). Under agroforestry landuse systems, biomass productivity, soil fertility build up, soil conservation, nutrient cycling, microclimate modification, and carbon sequestration potential are generally greater than that of an annual system (Calfapietra *et al.,* 2010).

Nutrient cycling is the process of transfer of nutrients from one component of the system to another. The movement of essential nutrients from soil environment to plant system to animals and again back is a basic ecological function to sustain the environment. The nitrogen present in fertilizer and organic matter is released in available form and thereafter taken up by the plants to meet their nutrient requirement.

The basic principal of maintaining a sustainable ecosystem is to replenish the soil with nutrients that

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has been removed by crop harvest, runoff, leaching and other soil plant pathways. The agroforestry system is growing of trees with crop plants on same piece of land, which therefore promotes a highly efficient cycling of nutrients compared to agriculture. Trees can have significant effect on soil fertility; however, the extent of effect varies based on several factors, especially on the competition between different components for light, water and nutrients, within a system. The two distinctive features that make agroforestry different from other systems are competition and complexity.

In simultaneous agroforestry system, tree and crop grow on same land unit, at same time, which allows competition for light, water or nutrients. Such type of system include alley cropping, contour hedges and silvipastoral systems. The proportion and spatial arrangement of different components may vary widely in such system. The competition of nutrients and light is maximized in simultaneous agroforestry systems.

In case of sequential agroforestry systems, maximum growth of different components takes place occur at different times, even though they are in close proximity. Such type of agroforestry system include shifting cultivation, taungya and some multistrata systems, competition for resources is reduced in sequential agroforestry because of differential temporal demands for light, water and nutrients.

Nutrient inputs in agroforestry system

The nutrients are added into the system by a number of means such as biological nitrogen fixation by nitrogen fixing trees, leaf litter into soil, input from chemical fertilizers added to the soil and animal manures.

Nutrient outputs in agroforestry system

There exist a number of ways, by which nutrients are lost from the system. These are crop harvest, erosion of soil, runoff, leaching, volatilization *etc.* To maintain a positive nutrient balance, the nutrient losses from the system are to be minimized. The balance between net nutrient inflow and outflow of a system determines net nutrient build up. In steady state the inflow and outflow are equal. A more efficient nutrient cycling under agroforestry system, favours soil fertility build up.

Nutrient cycling in Agroforestry systems

Forest ecosystems are closed and efficient nutrient cycling systems because of their high rates of turnover and lower losses. On contrary, the other hand common agricultural systems are often open, with relatively low turnover high losses. Nutrient cycling in Agroforestry systems falls between two extremes. The deep root system trees helps to absorb nutrient from lower soil layers. Agroforestry and other land use systems promotes turnover of nutrients from one component to another.

Nitrogen fixing trees in Agroforestry

Nitrogen fixing trees can substantially increase nitrogen inputs to soil.

Selection of suitable plant genotypes, and Rhizobium inoculation can enhance biological nitrogen fixation.

Nitrogen transfer from nitrogen fixing trees also facilitated by decomposition of litter pruning and root residues.

Role of legume tree in nutrient cycling

The improved nutrient cycling in agroforestry system is perhaps due to the presence of leguminoceae species either woody or non-woody. Several leguminoceae trees such as *leucaena leucocephala, Acacia sp., Dalbergia sissoo, Gliricidia sp Sesbania sp etc*. and other non-legumes, eg Casuarina equisetfolia, Alnus spp etc are capable of fixing about 50 to 500 kg of nitrogen per ha (Raj *et al.,* 2017).

Increased nutrient uptake in Agroforestry systems

Trees can contribute to soil fertility buildup by nutrient uptake from lower soil layers. Nitrogen fixing trees increase nitrogen inputs to Agroforestry systems through biological nitrogen fixation. Biological nitrogen fixation takes place by non symbiotic and symbiotic pathways. Non symbiotic fixation is carried out by soil organisms not dependent on plants, but the quantity of nitrogen fixed are lesser in relation to the greater requirements of agro ecosystems. Symbiotic fixation occurs through associations of plant roots with nitrogen fixing bacteria. The symbioses are between leguminous species and Rhizobium of Bradythizobium forming nodules on roots. This may also be between a small number of non-leguminous and Frankia. A number of tree and shrub species selected for Agroforestry are legumes and are fast growing nitrogen fixing trees. Such species are *Erythrina, Gliridia* and *Sesbania*. Other nitrogen fixing legumes include Albizia, lnga, Prosopis and the numerous Acacia species together with *Faidherbia albida*.

Reactive Nitrogen in Agroforestry Systems of India

Agroforestry is highly promising meeting the basic essential needs through enhanced production and providing environmental benefits with increase in present area from 17.45 m ha (mha) (Rizvi *et al*., 2014) to 53.0 m ha in next 35 years (Dhyani *et al*., 2013). United Nations Convention to Combat Desertification acknowledges the potential of agroforestry to control desertification and rehabilitation.

Nitrogen is the most limiting nutrient among all essential nutrients in Indian agriculture production in India. Nitrogen loss through soil erosion and runoff water further aggravate the problem of nitrogen deficiency in soil (Lehmann, 1999). Unscientific use of chemical fertilizers causes N cascade in the form of eutrophication, depletion of tropospheric ozone, increased nitrate level in drinking water, loss of biodiversity, and extinction of several species (Rosenstock *et al.,* 2014). Integration of leguminous trees into agroforestry system increases the reactive N supply in rooting zone through biological nitrogen fixation (BNF), retrieval of nitrogen from the sub soil layer, and decreases N loss through leaching and erosion.

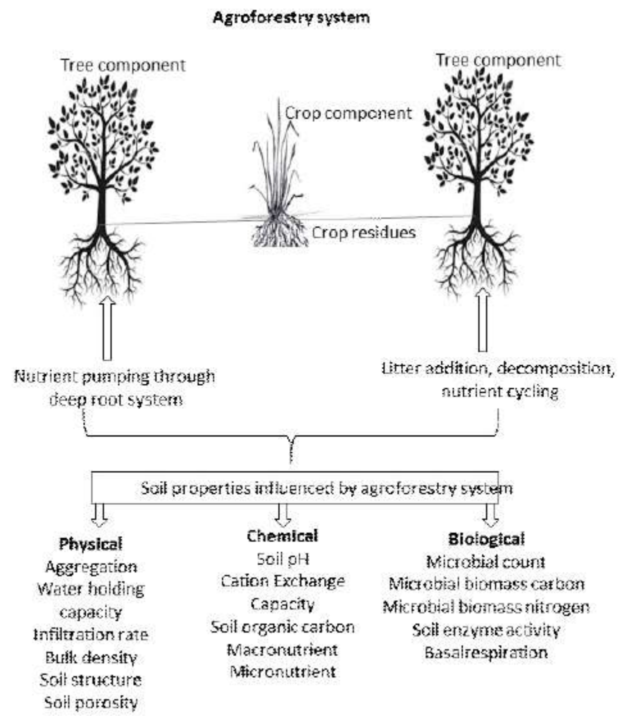
Large quantity of foliage and litterfall in agroforestry system (AFS) also release N upon decomposition and thus reduces the requirement of nitrogenous besides increasing overall productivity. Agroforestry also plays important role as a sink for reactive nitrogen (Nr) in N-cycling by reducing the N-erosion through litter cover.

Several studies have reported that agroforestry retains greater ecosystem functions, higher biodiversity and N retention (Tscharntke *et al.,* 2011). Tree species, plantation age and climatic conditions are the major governing factors for nitrogen cycling under AFS.

The added organic matter input in agroforestry system has nitrogen in the organic form, so it is not going to emit easily as is case of inorganic fertilizers. Gregory and Nortcliff (2013), stated that the discrepancy between slow and quick release litters could be utilized for maximizing the synchrony between crop N demand and release.

Processes increase nutrient input to the soil

A number of processes are involved in nutrient deposition to the soil. Atmospheric nutrient deposition involve wet (dissolved in rainfall) and dry deposition (carried in dust). Tree cover on land surface reduce wind speed, decrease runoff and increase water penetration. The processes that reduces losses from the soil under agroforestry systems are nutrient retrieval by reducing leaching, reduced evapo-transpiration, and iimproved soil moisture storage. Soil physical conditions improves under agroforestry system are by ppenetration of compact soil layers by roots and mmoderation of soil temperature. Soil biological



processes are favoured under agroforestry systems by iimproved soil fauna, better soil nitrogen mineralization and exudation of growth promoting substances by rhizosphere (Figure-1).

Agroforestry and Soil Organic matter

Agroforestry systems can maintain soil organic matter and biological activity through a number of ways :

(i) increasing the plant residues

(ii) reducing the rate of soil organic matter decomposition by shade effect and mulching decreasing loss of humus in eroded soil.

In an agroforestry system, tress contributes nitrogen build up by two mechanisms, *viz.* Biological nitrogen fixation and deep nutrient capture. The reported rate of nitrogen fixation varies from 20 to 300

Table-1 : A comparison of carbon sink value of different agroforestry systems across the world.

Agroforestry models in different countries	Soil carbon sink value (US ton/ha)*	Reference
Gmelina tree based Agri-silviculture models in Central Indian sub-continent	30.20	Swamy and Puri (2005)
Populus deltoides based Agri-silviculture model in Punjab, India	10.4	Chauhan *et al.,* (2010)
Acacia nilotica (babul) based Silvopastoral model in Haryana, India	3.09	Kaur *et al.*, (2002)
Homegardens of Kerala, India	1.76	Saha *et al.*, (2009)
Casuarina equisetifolia based Agri-silviculture model in Tamilnadu, India	1.73	Viswanath *et al.*, (2004)
Silvopastoral model with combination of *Pinus elliottii* and *Paspalum notatum* (common grass species) in U.S.A.	7.60 to 26.7	Haile *et al.*, (2008)
Douglas fir (*Pseudotsuga menziesii*) + *Trifolium subterraneum* based Agri-silviculture model in USA	105.8	Sharrow and Ismail (2004)
Leucaena leucocephala (N_2 fixing leguminous tree) based Alley-cropping system in Africa	14.9	Lal (2005)
Homegarden based agroforestry system in Africa	220.5	Nair (2012)
Populus deltoids based Alley-cropping system in Canada	62.83	Bambrick *et al.*, (2010)
Populus deltoids (poplar tree) + *Hordeum vulgare* (barley) based Agri-silviculture model in Canada	86.5	Peichl *et al.*, (2006)
Poplar (*Populus deltoides*) and Soybean + maize + wheat based hedgerow intercropping system in Canada	1.38	Oelbermann *et al.*, (2006)
Cork oak (*Quercus suber*) based Silvopastoral model in Spain	29.21 to 55.3	Howlett (2009)
Betula pendula based Silvopastoral model in Spain	146.6 to 165.3	Howlett *et al.*, (2011)
Eucalyptus + *Brachiaria* (grass species) based Silvopastoral model in Brazil	389.1	Tonucci *et al.*, (2011)
Acacia mangium + *Arachis pintoi* (fodder species) based Silvopastoral model in Costa Rica	190.7	Amezquita *et al.*, (2005)
The practices of fodder/protein bank system comprising the combination of Pterocarpus marsupium + Gliricidia sepium species in Mali	36.81	Takimoto *et al.* (2008)

*https://www.ars.usda.gov/is/np/agbyproducts/agbyappendix.pdf
1 Mg = 1.10 U.S. tons

kg N ha^{-1} yr^{-1} . Research evidences showed that non nitrogen fixing trees like cherry and mandarin can accumulate nitrogen, which is comparable or more than nitrogen fixing trees, due to their greater root volume and nutrient capture from sub surface soil (Anudha, 2017).

In agroforestry systems, trees contribute to nitrogen build up by namely biological nitrogen fixation and deep nutrient capture. The degree of BNF in agroforestry system varies, although average annual estimate is approximately 150 kg N per hectare (Giller and Wilson, 1991). Studies have shown that the presence of activenodules of leguminous Papilionaceae and Mimosaceae families, which indicate that BNF can supply considerable nitrogen inputs to crops via litter fall. There are reports that non-fixing trees, such as selected species of *Cassia* (recentlyrenamed *Senna*), accumulate nitrogen in their leaves more than nitrogen-fixing legumes, which is attributed to their greater root volume and high nutrient capture ability (Garrity and Mercado, 1994).

Deep nutrient capture is the process of nutrient uptake by tree roots from the depths beyond the reach of crop roots. This process significantly contributes to additional nutrient build up in agroforestry system as otherwise such nutrients would have been lost from the system by leaching. In a study conducted in western Kenya, Hartemink *et al.* (1996) detected nitrate levels in the order of 120 kg N per hectare at subsoil depths of 50 to 200 cm. The source of this nitrate pool is attributed to the mineralization of topsoil organic nitrogen, which was relatively high in these soils, followed by the nitrate leaching from topsoil layers. The nitrate anions are then held in the subsoil by positively charged clay surfaces.

Replenishing nitrogen capital

The recovery of leaf nitrogen incorporated into the (10 to 30 percent) is generally lower than the recovery from fertilizers (20 to 50 percent) **(**Sanchez and Palm, 1996**)**. In soil, microorganisms utilize

Table-2 : Carbon sequestration potential (CSP) of trees in India.

Region	Agroforestry system	Tree species	CSP (Mg C/ha/yr)	References
Himalaya	Block plantation	*Cedrus deodara*	2.47	Wani *et al.* (2014)
		Acacia/Dalbergia/Prosopis	1.13-3.08	Kaur *et al.* (2002)
	Agrihortipasture	*Malus domestica,*	1.15	AICRPAF (2006)
	Agrisilviculture	*Dendrocalamus hamiltonii*	15.91	Kaushal *et al.* (2014)
		Populus deltoides	12.02	Singh and Lodhiyal (2009)
	Grove	*Bambusa spp.*	19.14	Nath and Das (2012)
	Silvipasture	*Grewia optiva, Morus alba etc.*	2.17	AICRPAF (2006)
Indo-Gangetic	Agrisilviculture	*Leucaena leucocephala*	10.48	Mittal and Singh (1989)
	Block plantation	*Acacia nilotica*	2.81	Kaur *et al*. (2002)
Humid and sub-humid	Agrisilviculture	*Gmelina arborea*	3.23	Swamy and Puri (2005)
	Forest plantation	*Eucalyptus spp.*	2.18	Bala *et al*. (2012)
	Block plantation	*Gmelina arborea*	4.01-5.01	Swamy *et al.* (2003)
Arid and	Block plantation	*Albizia procera*	1.79	Rai *et al.* (2000)
		Leucaena leucocephala	10.32	Rao *et al*. (2000)
		Eucalyptus tereticornis	13.86	Pragason and Karthik (2013)
	Agrisilviculture	*Albizia procera*	3.70	Newaj and Dhyani (2008)
		Acacia pendula	0.43	Rai *et al*. (2002)
		Casuarina equisetifolia	1.57	Viswanath *et al*. (2004)
		Delbergia sissoo	1.47	NRCAF (2007)
		Emblica officinalis	1.58-1.62	Swamy *et al*. (2003)
Tropical	Home garden	*Mixed tree species*	1.60	Saha *et al*. (2009)
	Block plantation	*Eucalyptus spp.*	3.71	Ajit *et al.* (2014)

carbon substrate for growth and also utilize the nitrogen from organic inputs.

Phosphorus cycling in agroforestry system

Phosphorus is very often critical nutrient in low input agroforestry systems and should be applied to the soil as and when its depleted. Judicious application of phosphorus from combined sources may result in better nutrient use efficiency. Phosphorus accumulation in agroforestry systems takes place through tree biomass and litter decomposition, as a part of routine nutrient cycling. The phosphorus cycle is an important determining factor of biological activity, as the photosynthesis and microbial decomposition of tree litter needs adequate levels of phosphorus in specific biochemical forms.

Agroforestry, solely however, may not meet crop phosphorus requirement. It has been reported that the leguminous mulches and green manures (@4 tonnes per hectare) provide 8 to 12 kg P per hectare (Sanchez and Palm, 1996)). In case, soil is deficient in phosphoorus, the external fertilizer phosphorus must be supplied to agroforestry systems. Combinations of organic and inorganic sources of phosphorus may result in a more efficient nutrient utilization. The two main nutrient pathways responsible for phosphorus loss are removal by crop harvest and soil erosion. Loss of phosphorus enriched topsoil through soil erosion may lead to eutrofication of surface waters.

Replenishing phosphorus capital

Agroforestry cannot be expected to provide additional phosphorus, especially in soils with a high phosphorus-fixation capacity. Applications of rock phosphates orsome other phosphorus fertilizers could replenish the soils phosphorus pool, over a duration of time. This is being considered as modern approach namely investing in natural resource capital.

Soil organic matter, nutrient cycling and biological dinitrogen-fixation in agroforestry systems

Microbial biomass plays a key role in decomposition of organic materials and soil nutrient cycling. It is also used as an indicator of changes in soil quality resulting from soil management under different agroecosystems (Ndaw *et al.* 2009). Nutrient cycling, availability and productivity of agroecosystems mainly depend on the size and activity of microbial biomass (Moore *et al.* 2000). A comparison of carbon sink value and carbon sequestration potential is shown in table-1 and table-2.

Nutrient Pumping

Nutrient pumping in agroforestry systems is regulated by the growth and spread of root system of multipurpose trees. The deep root system act as 'safety net' and absorb leached nutrients, and pumped it to the aboveground growing part of the tree (Kumar, 2011). In further process such as leaf litter addition, decomposition *etc* leads to release and return of nutrients to the soil system.

Toky and Bisht (1992) reported length (cm) and basal diameter (cm) of main and lateral roots of some important agroforestry multipurpose tree species. They reported *Prosopis cineraria* with highest main root length (288 cm) followed by *Acacia nilotica* (215 cm) and *Eucalyptus tereticornis* (179 cm); whereas *Populus deltoides* with highest lateral root (271 cm) system.

Schroth (1999) and Gowda and Kumar (2008) reported that the rooting depth of trees determines their nutrients uptake capacity from subsoil and subsequently makes the sub soil nutrients available to soil surface, thereby increasing increases nutrient availability for associated plants with shallower root systems through the mechanism of nutrient pumping. The closer associated tree components in coconut + dicot tree system had high subsoil root activity and recorded greater nutrient capturing potential from the lower leaching nutrients (Gowda and Kumar 2008).

Montagnini and Nair (2004) reported grevillea may utilize (capture/pump) nutrients from deeper soil layers and made available to the maize crop which capture nutrients from surface soil layer in grevillea and maize intercropping system.

Conclusions

Agroforestry is considered as one of the most sustainable land use system for increasing production and natural resource management. Agroforestry system is capable to recover, recycle and utilize the soil nutrients. Agroforestry system maintains nitrogen through nitrogen fixing trees, deep nitrate capture and nitrogen cycling. Carbon is another most important nutrient efficiently recycled in Agroforestry system. Phosphorus accumulation in agroforestry systems can be increased by adding through external addition from fertilizer.

The effectiveness of nutrient recycling under agroforestry systems can be further enhanced by incorporation of nitrogen fixing trees, reducing leaching, runoff and erosion losses from the system. Nutrient cycling under different land use systems depends not only on the type of land use also the type of trees and field crops and their combinations. Leguminoceae trees are best component and partners of the field crops because it increases the efficiency of nutrient cycling with large input of nutrients (maximum turnover) and less output (loss of nutrients). Therefore Agroforestry system can increase the nutrient uptake and their utilization that may lead to improved organic matter status of the soil, improved nutrient cycling and productivity. For long-term sustainable production, agroforestry systems must include soil addition of phosphorus and, in certain cases, nitrogen fertilizers as well in order to reverse nutrient depletion and ensure the efficient nutrient utilization.

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Chapter 5

Integrated Management Strategies for Cluster Bean Wilt caused by *Fusarium solani*

Poonam Yadav[1], Poonam Kumari[2], Parvesh Kumar[2] and Pinki Devi Yadav[3]
[1]*Department of Plant Pathology, Rajasthan College of Agriculture, MPUAT, Udaipur-313001, Rajasthan*
[2]*Department of Plant Pathology, Chaudhary Charan Singh Haryana, Agricultural University, Hisar-125004, Haryana*
[3]*Division of Plant Pathology, S.K.N. Agriculture University, Jobner, Jaipur-303329, Rajasthan*
Corresponding Author Email : py1745013@gmail.com

Abstract

Fusarium wilt is an important disease of cluster bean caused by *Fusarium solani.*. The crop suffers from many diseases among this cluster bean wilt disease caused by *Fusarium solani,* has become a serious problem in recent years & affecting quantitative and qualitative reduction in seed quality and quantity. The disease is initiated in the yellowing of leaves and finally dark brown discolorations in vascular bundle. Under severer condition whole plant dry and die.

Key words : *Integrated management, wilt, pathogen, cluster bean.*

Introduction

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.], commonly known as guar is a member of Leguminosae (Fabaceae) family and derives its name from a Sanskrit word Gauaahar which means cow fodder or otherwise fodder of the livestock. It is an important legume crop and mainly grown under rainfed condition of India during kharif and Zaid seasons. Cluster bean can be grown for different purposes viz. vegetables, green fodder, green manuring, grain and gum. Total area under production of guar in India is about 2.56 million ha with the production of 0.72 million tons of guar seed. Rajasthan alone contributes around 70 percent production of India. Besides Rajasthan, it is also cultivated in Haryana, Gujarat, Punjab, Uttar Pradesh and Madhya Pradesh (Pandey and Roy, 2011). In Rajasthan, cluster bean is cultivated throughout the state. The area, production and productivity are 35.30 million ha, 14.04 million tons and 398 Kg/ha, respectively. The main guar growing districts are Bikaner, Jaisalmer, Barmer, Hanumangarh, Sriganganagar, Jodhpur, Churu, Sikar, Nagour, Jalore and Jaipur. (Anonymous, 2016-17). It can fix 37-196 N kg/ha/year. The crop is known to suffer from number of fungal diseases.There is no other legume crop so hardy and drought tolerant as cluster bean. Its endosperm is rich source of high-quality protein and galactomannan which is very important for the industry (Punia et al 2009, Rai *et al*., 2012). This galactomannan is commonly known as guar gum and forms about 35 per cent of the dry weight of the seed. Pure guar gum contains about 80 - 90 per cent of the galactomannan. (Sharma and Sharma 2013) A review of literature revealed that very limited information is available on ecofriendly management of this disease. There is no single control measure is effective. The use of fungicides can cause hazards to human health and known to increase environmental pollution. To overcome this negative impact, alternative eco-friendly approaches for management of

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Fusarium wilt of cluster bean are needed. Hence various approaches have been practiced to minimize the losses due to wilt pathogens. Host-plant resistance offers the most feasible.

Symptomatology

A brief account of literature concerning with symptomology, survey, collection of samples, isolation, purification, identification, pathogenicity and its management through bio agents, fungicides and plant extract were presented in this chapter. However, the literature on particular aspect of *Fusarium solani* on cluster bean was scanty, it was fully supplemented with and supported by other pathogens and crops. *Fusarium solani* is serious pathogen in guar seeds causes wilt disease which is responsible to reduce the quality and yield of the crop. It causes severe economic losses. The pathogen is seed borne both extra and intra embryonal showed white discolouration with irregular shape or covered with white mycelium crust causing wilt disease (Pareek and Verma 2015). The major symptoms produced by Fusarium oxysporum f.sp. ciceris in chickpea are yellowing and drying of leaves from base upward, drooping of petioles and rachis, improper branching of vascular bundles and finally wilting of plants (Nene and Haware 1980).

Disease causing pathogen

According to White (2000), the most commonly reported *Fusarium* spp. isolated from corn roots were *F. oxysporum* Schlectend and *F. solani* Sacc. Other associated species were *F. graminearum* Schwabe, F. acuminatum Ellis and Everh.and *F. equisetai* (Corda) Sacc. *F. moniliforme* J. Sheld., F. proliferatum (Matsushima) Nirenberg, and F. subglutinans (Wollenweb and Reinking) tend to be associated with root rots in young plants. The symptoms range from slight reddish brown to dark black discoloration of completely rotted roots. Roots infected by F. graminearum are often red or pink in colour. *Fusarium* spp. can also be isolated from symptomless root. Singh and Shrivastava (1988) observed typical symptoms of root rot as sudden death of mothbean seedlings. The leaves first started withering and drying and the root rot was followed by killing the whole plant. The diseased roots showed brown to black lesions.

Distribution and impact of wilt on clusterbean

Mathur and Sinha (1970) reported from Uttar Pradesh that root rot of guar, an important disease, was caused by *Sclerotinia rolfsii* Sacc., The occurrence of *Fusarium solani* on guar (*Cyamopsis tetragonaloba*) causing root rot/wilt was reported from Rajasthan by Mathur and Shekhawat (1988). Singh and Kang (1991) reported Neocosmospora vasinfecta var. vasinfectum as the cause of wilt of guar. The pathogen causing wilt of guar in Gujarat was identified as *F. vasinfectum* and when later producing perithecia in 8–10 days old culture as *Neocosmospora vasinfecta* (Patel *et al.,* 1998). Lodha (1993) recorded that dry root rot of cluster bean might occur at any stage of the crop from pre- emergence to maturity. Seedling blight occurs primarily on cotyledons as elongated black cankers on growing seedlings. Infected seedlings show bronzing and drooping of upper tender and parts can be easily uprooted. Patil *et al.,* (2007) reported that colonies of *F. moniliforme* are rosy buff to rosy pink in colour with purple pigmentation having profuse to scanty growth of mycelium. Vir and Grewal (1973) observed in their continuous study from 1971 to 1973 that wilt of guar (*F. solani* f. sp. caeruleum) was a serious problem and causes heavy losses to summer sown crop (April to June) under Delhi conditions. An association of *Fusarium equisetii* and *Macrophomina phaseolina* with black stem rot of cluster bean was also noticed by Satyaprasad *et al.,* (1983). Rael Karimi and James Otieno Owuoche (2012) – Fusarium wilt (*Fusarium udum* Butler) is an important soil borne disease of pigeonpea [*Cajanus cajan* (L.) Millsp], which causes significant yield losses in susceptible cultivars throughout the pigeonpea growing areas.

Epidemiological study

Hussein and Juber (2014) reported *Fusarium solani* f. sp. Cucurbitae, the causal agent of the crown and root rot disease of watermelon. They reported that twelve fungal species were associated with diseased plants, *Fusarium solani* f. sp. Cucurbitae was predominant and appeared in all samples with frequency ranged between 27.50 - 80.00%. Shanmugam *et al.,* (2016) reported that *Fusarium solani* is a soil borne pathogen. It was first reported in polyhouse cucumberat IARI, New Delhi in India. The symptoms including water soaked on roots that turned reddish brown to get decayed, leaves displayed yellowing and the plants exhibited wilting have been also report due to *Fusarium solani* causes seedling blight of cucumber. Singh and Shrivastava (1988) observed typical symptoms of root rot as sudden death of mothbean seedlings. The leaves first started withering and drying and the root rot was followed by killing the whole plant. The diseased roots showed brown to black lesions. *Rhizoctonia bataticola* is a soil borne pathogen but it is also associated with seeds of cluster bean (Singh and Chohan, 1973 and Bhatia *et al.,* 1998). Rael Karimi and James Otieno Owuoche (2012) reported that soil borne fungus enters the host vascular system at root tips through wounds leading to progressive chlorosis of leaves, branches, wilting and collapse of the root system. Temperature, soil type, water retentive nature of the soil and nutrient availability has been shown to affect *Fusarium* population.

Pathogenicity testing

Gupta and Srivastava, (1976) tested pathogenicity of the *F. solani* on fennel was tested by two differrent methods In one experiment, they inoculated one month old plants grown in pots filled with sterilized soil. The inoculation was done by exposing roots and putting on them, the fungus inoculum grown on sand maize medium. The roots were then covered with the soil. In second method, one month old healthy plants were transplanted by them in the pots containing sterile soil inoculated with fungus. Suitable controls were also maintained. All the inoculated plants showed typical symptoms of the disease after 25-30 days by both the methods of inoculation. Sinha and Prasad (1989) found that several fungi were associated with fenugreek and other seed spices including *Fusarium* spp. and their pathogenicity was tested by seed inoculation with rolled towel paper method.

Efficacy of fungicides on wilt of cluster bean

Satisfactory chemical control of soil borne Fusarium is difficult to achieve. Various chemicals have been reported of different workers to reduce the incidence of disease and increase the yield. To eliminate the seed-borne infection of Fusarium spp. several fungicides have been reported to be effective. Chavan *et al.,* (2009) observed that carbendazim and carbendazim+mancozeb gave 100 per centinhibition of mycelial growth of *F. solani* at 0.2 and 0.3 per cent concentration. Iqbal *et al,.* (2010) evaluated eight fungicides against mango malformation caused by *F. mangiferae* and found that benlate and carbendazim proved to be the best fungicides giving no growth of fungus even after 3, 8 and 16 days of inoculation. Madhavi and Bhattiprolu (2011) were tested six fungicides against *Fusarium solani* by Poisoned Food Technique showed that a combination of carbendazim+mancozeb was effective in inhibiting mycelial growth (93.6%), followed by Carbendazim alone (92.4%). According to Choudhari *et al.,* (2012) reported that the growth of *F. solani* (root rot of mulberry) inhibited completely by carbendazim at 100 ppm followed by thiophanate methyl (96.6%) and thiram (70.0%). Bhaliya and Iadeia (2014) were evaluated different contact, systemic and combination of fungicide in vitro against *Fusarium solani*. Amongst contact (non-systemic) fungicides evaluated maximum inhibition in mycelial growth was observed in mancozeb (100%) and zineb (100%) followed by chlorothalonil (72.52%). Yadav *et al.,* (2014) studied the effect of combinations of fungicides and organic amendments against basal rot of onion caused by *Fusarium oxysporum* in pot conditions. Benlate+neem cake was found most effective with minimum (13.00%) disease incidence followed by bavistin+neem cake (16.00%) and benlate+mustered cake (19.00%). Jat *et al.,* (2017) tested five different fungicides against *Fusarium oxysporum* causing coriander wilt. Complete inhibition of the fungal growth i.e., 100 per cent was recorded with bavistin (carbendazim) at 200 and 500 ppm followed by companion (carbendazim + mancozeb), topsin-M (thiophanate methyl) and vitavax (carboxin + thiram) at 500 ppm and also reported minimum 10.39 per cent wilt incidence with seed treatment by carbendazim. Jat and Ahir (2017) tested five different fungicides against *Fusarium oxysporum* causing coriander wilt. Complete inhibition of the fungal growth i. e.100 per cent was recorded with bavistin (carbendazim) at 200 and 500 ppm followed by companion (carbendazim + mancozeb), topsin-M (thiophanate methyl) and vitavax (carboxin + thiram) at 500 ppm Lodha (1993) reported carbendazim, benomyl, thiram, thiophanate methyl were most effective in controlling the dry root rot of mungbean, cowpea, clusterbean and mustard caused by *M. phaseolina.* Gupta *et al.* (1983) evaluated the efficacy of seven fungicides against *Fusarium oxysporum* f. sp. cepae incitent of basal rot of onion. All the fungicides significantly inhibited growth of the pathogen in vitro. Benlate (Benomyl) performed best (250 ppm), followed by Bavistin (carbendazium), thirum and vitavax (carboxin) (2000 ppm). Soni (2004) reported that Bavistin (carbendazium) was effective followed by Topsin-M and Captan against wilt of cucumber caused by *Fusarium oxysporum* f. sp. cucumerinum both in in vitro and in vivo. Khan *et al.* (2012) evoluted eight fungicides under laboratory condition against dry root rot of chickpea caused by *Rhizoctonia bataticola* and found that indofil M-45, Bavistin, companion, copperoxycloride and Benelate were completely inhibited the growth of the fungus on potato dextrose agar medium as compare to check. Kaushal (2008) reported that seed treatment with thiram and carbendazim at 2 g/kg was effective in control of chickpea dry root rot.

Efficacy of Bioagents on wilt of cluster bean

Use of biocontrol agents is an alternative eco-friendly approach for the management of plant diseases. First of all, Weindling (1934) described the mycoparasitic action of Trichoderma fungus on Rhizoctonia and Sclerotinia and its beneficial effects for plant disease control. Studies revealed that Trichoderma harzianum is one of the most important antagonists against many soils borne pathogens (Papavizas and Lumsden, 1980). Seed treatment with the antagonists reported to be the cheapest method and delivery of antagonists to the rhizosphere of crop plants thatare to be protected from seed and soil borne disease (Ahmed and Grainge 1982). Vasudeva *et al.,* (1952) reported a strain of *Bacillus subtilis* which produced antibiotic bulbiformin against *Fusarium solani*, the fungus causing wilt of pigeon pea. In another study, Majumdar *et al.,* (1996) reported maximum growth inhibition by *Trichoderma harzianum* in laboratory studies. Okhovvat and Karampour (1996) studied the effect of biological control agents like *Trichoderma harzianum* (T_1 and T_2), and *Trichoderma viride* (T_3 and T_4), *Trichoderma koeinngii* (T_5) and *Gliocladium virens* (G_1 and G_2) to control chickpea root-rot caused by Fusarium solani and found that the antagonists in order of efficacy were $T_3>T_5>T_2>T_4>T_1>G_1>G_2$. Ghasolia and Jain (2003) observed that seed treatment with bio- control agents i.e., *Trichoderma harzianum* and *Trichoderma viride* were found effective against Fusarium wilt of cumin under in vitro conditions. Ahmed *et al.,* (2012) was observed three fungicides i.e., benlate, ridomil and dithane M-45 and two bio-agents *Trichoderma harzianum* and *T. viride* as antagonists for management of Fusarium root rot in okra. Maximum colony diameter of the pathogen (6.9 cm) was recorded in control treatment. *T. viride* was less effective when used alone or with any fungicide, while *T. harzianum* reduced the colony diameter by 43.5 per cent under in vitro. Jat *et al.,* (2017) studied on biocontrol agent's i.e.*Trichoderma harzianum, T. viride, Bacillus subtalis* and *Pseudomonas fluorescens* against *Fusarium oxysporum* f. Sp. coriandri. *Trichoderma harzianum* (83.69%) was found most effective to inhibit the mycelial growth of fungus followed by *Trichoderma viride* (81.1).

Efficacy of Plant extract on wilt of cluster bean

Bianchi *et al.,* (1997) investigated the effect of garlic on the mycelial growth of *Fusarium solani* and found that mycelial growth was strongly inhibited at the maximum. Philip and Sharma (1997) tested the fungitoxic effect of leaf and oil cake extracts of neem (*Azadirachta indica*) on the mycelial growth, spore production and spore germination of *Fusarium solani* causing root-rot disease and found that extracts had inhibited germination and growth of both pathogens. The neem extracts were the most effective against both fungi. The efficacy of leaf extract of *Azadirachta indica* was tested by Bansal and Gupta (2000) they reported that complete inhibition of mycelial growth and spore germination was achieved with 100 per cent leaf extract concentration. Rai (2002) evaluated the plant extracts to manage the wilt of pigeonpea caused by *Fusarium udum*. Leaves of *Azadirachta indica.* All were shown their toxicogenic property against *Fusarium udum* inhibiting the growth of organism. Verma and Dohroo (2003) showed that garlic cloves extract resulted total inhibition of growth of *Fusarium oxysporum* f. sp pisi. Sharma and Gaur (2003) tested tulsi and jatropha plant extract against wilt pathogen of chickpea completely checked mycelial growth of *Fusarium oxysporum.* Rai and Pradeep (2007) while using leaf extract of various plants noted that the incidence of *F. monilifrmae* was markedly reduced in wheat, cowpea, coriander and Beta vulgaris. The extract also protected the seedlings against wilt, seedling rot, blight, yellowing, leaf spots and damping off. Lakhran and Ahir (2018) evaluated efficacy of different plant extracts aak, datura, garlic, neem, kheep and tumba against dry root rot of chickpea caused by *Macrophomina phaseolina.* Among these plant extracts garlic extract was found most effective in reducing root rot incidence followed by neem leaf extract.

Host plant resistance

Choudhary *et al.,* (2011) screened twenty-five germplasms of mungbean against dry root rot caused by *Macrophomina phaseolina* under field conditions. Three genotypes namely MSJ-118, KM-4-44 and KM-4-59 were found resistant to dry rot. Bajwa *et al.*, (2000) found that out of thirty-two genotypes evaluated against Fusarium wilt only one line was resistant and four lines were tolerant. The results are in agreement with Patel *et al.*, (2002) They also evaluated genotypes of Cluster bean Genotypes GAUG 998, GAUG 9112, GAUG 605and GAUG 9010 showed moderate resistance to wilt (*Neocosmospora vasinfecta*) Fourteen chickpea lines were identified to be resistant to wilt at seedling stage by Iqbal *et al.,* (2005) but no line was found to be resistant at reproductive stage. Resistance levels of 25 sesame genotypes were evaluated by Silme and Cagirgan (2010) for their reaction to *Fusarium oxysporium* f.sp. sesame and classified Birkan, Camdibi, WS 143, WS 313 as resistant while WS 131 was categorized as moderately susceptible. Seven popular guar cultivars namely Krishna 51, B 53, Pusa Nav Bahar, Swati 55, Neelam 51, BM 83 and Amul 51 (local collection as well as from two different seed companies) were evaluated by Bohr *et al.,* (2011) for reaction to guar root rot pathogens F. solani and *Rhizoctonia solani*. Based on root rot incidence under inoculated (20g inoculum kg-1soil) conditions, Swati 55, Neelam 51, Amul 51, Krishna 51, B 53, BM 53 and Pusa Nav Bahar were considered susceptible. This study shows that most of the available Cluster bean cultivars were susceptible to root rot pathogen and there is need to develop resistant cultivars for its suppression. Different methods have been used for screening common beans for resistance to this disease (Tu and Park 1993, Chaudhary *et al.,* 2006).

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Chapter 6

Genetics and Cytogenetics of Chickpea

S.C. Gaur[1] and S.P. Singh[2*]
Department of Genetics and Plant Breeding, B.R.D. (PG) College, Deoria, U.P.
CSAUAT-Agriculture Research Station, Kalai, Aligarh, U.P.
Corresponding Author Email : dr.sp.singh24@gmail.com

Introduction

Chickpea *(Cicer arietinum* L.*)* is a self- pollinated crop belonging to the leguminosae family of the Tribe *Cicereae.* It is diploid species with 2n=2x=16 chromosomes. It is important pulse crop and ranks second in area and third in production among the pulses in the world. It is cultivated from Mediterranean region to the Indian Sub-continent, the west Asian and North African (WANA) region and Eastern African highland. However, it is in the Indian sub-continent, that the crop holds the prime position because bulk of population sustains chiefly on Vegetarian diet. Chickpea is a rich source of protein, having crude protein that range between 12.6 and 30.5% (Singh 1985). The daily per *capita* availability of 14g chickpea is a source of approximately 2.3% (56 kal) energy and 4.7% (2.7 g) protein to Indian population besides being a major source of Caleium and Iron (10-12%). in addition to being an important item of human food and animal feed, Chickpea also plays important role in sustaining soil productivity by fixing up to 141 kg nitrogen per hectare (Repela 1987).

Genetic variability is immensely valuable to chickpea breeders for its improvement. Owing to rapid agro ecological changes taking place all over the world, many species, old and primitive cultivars, land races and their wild relatives, endowed with superior gene complexes are being rapidly eroded. It is feared that many these diverse froms may become exinct in due course if corrective steps and not token immediately.

Taxonomy and Geographic Centres of Diversity

The name *Cicer* is Latin origin. The genus *Cicer* belong to family *Leguminosae* , subfamily *Papilionoideae* and tribe, the *Cicereae* Alef. (Kulpicha 1977). Earlier, *Cicer* was considered to belong to tribe, *Viceae* Alef. (Van der Maesen 1987) delt with this genus has 43 species that included 34 wild perennial, eight wild annual and one cultivated annual species, *Cicer arietinum*. (Van der Maesen 1972), Ladizinsky and Adler (1976 a) and Witcombe and Erskine (1984) carried out detailed taxonomic studies of genus *Cicer.* Ladizinsky and Adler (1976 b) studied biosystematics relationship between cultigens and its 6 annual wild relatives and assigned them into three cross ablitity gronps. Group I consisted of *C. arietinum*, *C. reticulatum* and *C. Echinospermum*, Group II consisted of *C. judaicum, C. pinnatifidum and C. bijugum* and Group III Consisted of only one species *C. zunetaum.* The chromosome number of all these species was 2n=2x=16. Within the groups, hybridization is possible with variable fertility. However, it was not successful between the members of different groups. This study suggested that there is no apparent barrier to gene flow between *C. arietinum* and *C. reticulatum* of Group I while it is much more difficult to produce hybrids with *C. echninospermum*. As per the genepool (GP) scheme of Harlan and de Wet (1971), the GP_1 comprises *C. arietinum* and *C reticultum* (wild); GP_2 apparently consists of *C. echinospermum*, while the remaining species can be assigned to the GP_3. Morphological, physiological and

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genetics of *C. reticulatum* are good approximation of *C. arietinum* and such from may be regarded as the progenitor of *C. arietinum* (Smartt 1990).

Cytogenetics of Chickpea

Information on cytogenetics has been useful to manipulate sets of chromosomes, individual chromosomes or chromosomal segments to solve a particular problem in a number of agricultural crops. This knowledge has assumed a greater significance in recent years in chickpea after the discovery of useful genes for resistance to biotic and abiotic stresses in wild species. While three is a large number of information available in chickpea, it mainly deals with chromosome number and somatic karyotypes.

Chromosome Number

Chickpea genome has eight pairs of somatic chromosomest (Iyengar 1939, Ramanujan and Joshi 1971). However, very rarely in some genotypes, the somatic chromosome number was found to be 14 (Dombrovsky Sludsky, 1927, van der Maesen 1927, Dixit 1932) and survival of such plants in nature remains doubtful. Dixit (1932) described as *desi* type 2 pusa no. 22 having 2n=14 which gave rise to a mutant called *C. gigas* with 2n=16. Majority of wild species *viz*., *C. reticulatum, C. echinospermum, C. bijugum, C. judaicum, C. chrossanicum, C. cuneatum and C. incisum* have been reported to have 2n=16 chromosoms (Van der Maesen 1972, Sharma 1983, Galasso *et al* 1996). However, these reports that deviation from the standard chromosome number. For example, van der Maeson (1972) separated 16 as well as 24 chromosomes in *C. montbrettic* diploid chromosome number was reported to be 14 in *C. songaricum* (Mercy *et al* 1974), *C. anatolicum* and *C. pungens* (Van der maesen 1972). Pundir *et al* (1993) contradicted earlier report of 2n=24 in *C. canariense* and confirmed 2n=16.

Karyomorphology

Identification of chromosomes in *Cicer* species present difficulty due to their small size which affects clear discrimation of the arm ratios and the total chromosome length. Dombraovasky- sludsky (1927) was the first to study somatic mitotic in *Cicer arietinum*. Characteristic features of its karyotype include a pair of very long submetacentric and satellite chromosomes, a pair of very short metacentric chromosomes and six pairs of metacentric to submetacentric chromosomes (Phadnis 1970, Ahmad 1988). The presence of maker chromosomes, which are comparatively langer and always with secondary constriction, is invariability reported with overall morphological homogeneity. Vonera *et al* (1991) were the first to use automated karyotyping in chickpea by image analysis system, which did not difler significantly from the traditional karyotypes. Ahmad (1988) determined *C. reticulatum* as the wild species with the higher nmber of metacentric primary constrictions and *C. cuneatum* with only one metacentric primary constriction. Ocampo *et al* (1992) found that *C. reticulatum* prossessed maximum number of metacentric chromosomes and *C. cuneatum* had minimum while only *C. judaicum* had submetacentric chromosomes. All *kabuli* genotype had three submetacentric and five metacentric pairs with the exception of genotype IL 482 which had four submetacentric and four metacentric pairs (Venora *et al* 1995). Differences in number of statellites, chromosome size and shape are more prominent in *desi* than *Kabuli* genotypes. Pericentric inversion could be the reason for genotypic differences with regard to located of the centromere on chromosomes. Karyotype asymmentry analysis showed low evolution of the annual species of the genus *Cicer. Cicer bijugum* and *C. cuneatum* were included in the lowest group of asymmentry and therefore less evolved (Ocampo *et al* 1992).

Inter specific Hybridization

Many interspecific crosses have been attempted between cultivated and wild species. So far, only a few combinations have been successful. Cross between *C. arietinum and C. reticulatum* has fertile. Successful cross between *C. arietinum* and *C. echinospermum* has also been reported (Pundir *et al* 1992). Pundis and van der Maesen (1983 a) succeeded to achieve some rare hybrids like *C. Judaicum .x C. pinnatifidum, C. judaicum x C. bijugum, C. pinntifidum x C. bijugum and C. judaicum C. cuneatum.* However most of these hybrids were sterile. Advances in tissue culture technique have enabled to over come post fertilization barriers in chickpea. Even though interspecific hybrids are reported in chickpea, not many rare practically useful in crop improvement programmes Hybrids between C. *arietinum* and *C. reticulatum* show normal fertility. However, many undesirable traits are also transferred from *C. reticulatum*. To overcome this problem, use of *C. reticulatum* as male parent is suggested. Rare hybrids between secondary and tertiary gene pouls do not draw much interest of breeders as they suffer from medium to high sterility and undesirable traits that get incorporated along with desired traits.

Genetic Studies of Chickpea

Genetics of both qualitative and quantitavie traits have been subject of investigation in chickpea. Since the discovery of Mendelian principles and more than 60 Mendelian genes controlling morphological characteristics have been reported with a few instances of linkage, comprehensive linkage map is yet be prepared.

Genetics of Qualitative Traits

Leaf morphology : Leaves in chickpea are compound and generally imparipinnate having 11-13 leaflets. Kidambi *et al* (1988) reported that lanceolate leafled shape is monogenecally dominat over obvate and segregates independently of purple while flower colour. However Ghatge suggested monogenetically dominance of ovate (*Ovlt*) over lanceolate leaflet and found leaflet size as controlled by three gens, two of which were supplementary in action and gave large leaflets, while third one was inhibitory gene. Gene *Ovlt* was common with one of the genes far leaf size.

Growth habit genetic studies of chickpea : Chickpea plant can be erect, semi-erect, semi-spreading and prostrate depending on the angle of branches from the vertical axis. Prostrate habit is reported to be under the control of a single recessive gene (Patil, 1959, Argikar and D'Cruz 1963, Rao *et al* 1980). Inheritance studies showed that the umbrella type of branching is controlled by a single recessive gene br (Ayyar and Balsubramanian 1937, Bhat and *Argikar* 1951, Argikar and D'cruz 1963). Sandhu *et al* (1990) reported a mutant with compact dwarf plant type that showed monogeric inheritance. A single recessive gene *pt* with pleiotropic action was ascribed to this mutant.

Flower colour : Inheritance studies indicated one, two and three gene systems for flower colour in chickpea. Khan and Akhtar (1934) reported two genes, B and P for blue flower whereas p Is for pink flower, Ayyar and Balasubramanian (1936) added a third factor, C, to the inheritance of flower colour, which is complementary to B. thus, the homologous dominant condition of all the three genes results in pink flower; blue flower results white P is recessive and White when B or C is recessive.

Seed coat colour : Inheritance of seed coat colour has been subject of rather extensive studies and different views have been expressed. Seed coats of *desi* type are thicker than Kabuli types. Thick coat is governed by a single dominant gene, which is linked with flower colour at 19 cM distance (Gill and Cubero 1993). Texture of seed surface is governed by a single pair of gene (R/r) with rough surface showing dominance over smooth surface (Balasubramanyam 1937, Pawar and Patil 1983). Sichkar and Bushulayan (1998), found three pairs of genes in controlling seed coat colour. Black seeds are formed by epistatic action while brown seeds by complementary gene action.

Foliage colour : Anthocyanin pigments impart a purplish colour to different parts of the plant resulting into light green, green, purple light green, purple and bronze colours. Rao *Et al* (1980) reported that purple and light green foliage colour and governed by a single recessive gene and both are recessive to normal green colour. Digenic inheritance with dominance and recessive epistasis has been suggested for the foliage colour by sandhu *et al.,* (1993).

Double poddedness : A single recessive gene,is responsible for double pods per peducle. Kumar *et al* (2000b) studied the inheritance of 5 gene using F_{10} derived RILs from a cross of ICCV2 x JG62 and confirmed monogenic recessive inheritance. The triple podded trait has also been reported to be monogenic and controlled by a recessive gene, *trp* (Singh and Chaturvedi 1998)

Flowering time : flowering time is an important trait for crop adaptation and productivity especially when grown under environmental conditions of terminal droght and high temperatures. Gumber and Singh (1996) reported two duplicate genes (Ele1 and Ele2) for flowering in Punjab. The presence of dominant allele at either of the loci produced late flowering plants. Both genes in homozygous recessive state cause early flowering.

Non-nodulation : Non nodulating mutants in chickpea were first reported by Davis *et al* (1985). Genetic studies on non nodulation indicated that recessive alleles at three different loci, designated at rn_1, rn_2 and rn_3 were responsible for nun-nodulation in PM 233, PM 665 and PM 679 mutants, respectively. (Davis *et al* 1986)

Genetics of Quantitative Traits

Crop duration : Crop duration is a quantitative character with linkages to different phonological traits *viz*. days to flowering, days to podding, days to maturity, reproductive period, pod eastablishment period and pod filling period. Useful heritable variation, for these traits have been reported to exist in chickpea (Kumar *et al* 1999).

Plant height : Genetic analysis of agronomic characters in chickpea in 28 dialled traits over 8 year and two locations revealed that plant height is predominantly under the additive control and thus highly predictable (Singh *et al* 1992). Additive and non-additive genetic variances were important for plant height.

Seed size : Seed size is not only a component of seed yield but also an important criterion for consumer preference. Inheritance of seed size is reported to be monogenic (Argikar 1956), oligogenic (Patil and D'cruz 1964) and polygenic (Athwal and sandha 1967). Small seed size is reported to be dominant over large seed size (Athwal and Sandha 1967). Ghatge (1993) identified two additive genes *Bsd* and *Smsd*, for seed size in chickpea in which medium seed size was dominant over bold and small seed size.

Yield components : A large number of studies has been made using dialled, linex tester, generation mean and triple test cross analysis to draw inferences regarding inheritance of different yield components chickpea. There are reports suggesting preponderance of additive, non-additive and both the components in their inheritance. Genetic analysis of yield components using 28 dialled trials over 8 years and two locations revealed that both additive and non-additive genetic components are important for seed yield, number of branches, pods per plant and seeds per pod (Singh *et al* 1992.)

Information on interrelationship among yield components is vital for breeders to decide upon the selection strategy for desired improvement. The genetic reasons for correlate response include pleiotropig and linkage. A survey of various reports on correclation reveals strong positive correlation between number of pods per plant and seed yield in almost all the studies. Similar is the case with number of seeds per plant, number of branches per plant and biological yield which show positive association with seed yield. The importance of pods and branches per plant as major yield contributing traits in chickpea has been confirmed in a large number of reports.

Prospects

Chickpea cyogenetics legs behind that of maize barley, wheat, rice and tomato. A few linkage relationship between morphological markers have been reported in chickpea and a linkage map involving morphological biochemical and molecular markers is being developed. He independence of various linkage group has not yet been tested and none of the linkage groups has been associated with the respective chromosomes. No cytogenic stocks other than tetraploids are available in chickpea. Sharma (1983) attempted to produce trisomics through triploids in chickpea following hybridization between tetraploids and diplois. But only one triploid plant coluld be obtain inspite of repeated pollination. A set of primary trisomics or translocation involving all the chromosomes is need to associate linkage groups with respective chromosomes. Development of techniques, which exploit differential condensation patterns of individual chromosome and fluorescence in *situ* hybridization (FISH) marker for genetic identification of individual chromosomes. The FISH method is quite efficient in physical mapping of large DNA clones. This would be helpful in establishing relationship between physical and genetical maps. The availability of the pachytene karyotype may be used to compare chromosomes with those of the related annual and perennial species in the genus *cicer* in order to get a further insight to the phylogency of the genus.

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Chapter 7

Applications of Direct Freshness Indicators in Fresh Fruits Packaging

Aarzoo Jangra[1] and Jyoti[2]
[1]Department of Life Science PDM Bahadurghad, Delhi, India
[2]Department of Foods and Nutrition CCSHAU Hisar, Haryana, India
Email : aarzoo.jangra00@gmail.com

Abstract

Food safety is a major concern for every food manufacturing unit. So, to provide the safe food to the consumers different researches carried out one of them is; development of such kind of indicators which can be used in food sectors. By these indicator, people can monitor the food commodity and it also provides the information about the condition of food, or its surrounding environment. At this time these kind of indicators not widely spread but having potential. This article describes application of direct freshness indicators in fresh fruits packaging. It is possible that with the help of this technology we can maintaits quality of food throughout the supply chain.

Key words : *Direct freshness indicators, fruit packaging, radio frequency indication.*

Introduction

Nowadays major concern for Food Scientist and Technologist is Safety of Food and Environmental issues. To determine various levels of different issues like toxins, food borne pathogens, pesticides residues and water borne pathogens, there is very strong need of the hour to develop certain technologies. Bioindicators provide very definite and quick results with techniques used detection and indication of undesirable changes occurred in processed packaged foods. In India for monitoring Food Safety and Quality in Bioprocess and Food industries, there are very wide future prospects and scopes for applications of bioindicators for processed foods (Thakur and Ragavan, 2013).

Major role of Food packaging material is to preserve and protect various foods (Robertson, 2013). With the help of indicators or sensors, information about quality and freshness of food, temperature indication, traceability and safety of food may be displayed. In smart packaging, a sensor may be used which is defined as a "tool or device to determine, detect or quantify matter or energy and give a response or signal for the determination or measurement of a chemical or physical characteristic" (Kerry *et al*., 2006). Basically, sensor consists of two elements: a transducer, a receptor and their output commonly give signals. Indicators are commonly defined as medium or substance that shows the presence, concentration or absence of different material as a marker which shows reaction between two substances by their physic-chemical changes like color, texture, weight and energy. Sensors and indicators are used many times interchangeably but many times indicators are preferred to be used as bio and chemical sensors (Hogan and Kerry, 2008).

(Turner *et al*., 1987) studied and defined that Chemical indicators are indicators that convert chemical components into useful analytical signals that range from absorption of specific elements to total component analysis. Moreover bioindicators are those

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chemical indicators in which for utilization of bio –chemical mechanism, there is a recognition system which interface the optical electronic system. Whereas (Nic *et al*., 2006) "A device that uses specific biochemical reactions mediated by isolated enzymes, immunosystems, tissues, organelles or whole cells to detect chemical compounds usually by electrical, thermal or optical signals."

Advantage of using freshness indicators is to Constant quality monitoring, Spoilage monitoring,

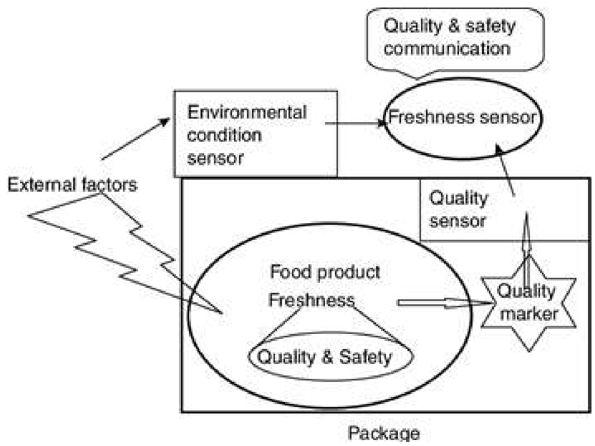

Fig-1 : Principle of Freshness Indicators.

microbial quality, for effective packaging to reduce environmental decay to get Preservatives free fresh fruits.

1. Principle of bio indicators for Food Packaging

Bioindicators consists of receptors, transducer they help in explaining the biophysical and biochemical properties of any product. Moreover Bioindicators helps in maintaining physical and biochemical properties of any medium. These have specific element i.e. organic or biological present in them which help in recognition of different molecules. Bio indicators are a associative and resourceful technique that intrigues researches from all fields to advance research in different fields like medical and for future application by collective efforts of various fields like biology, chemistry, biotechnology, engineering, and physics and so on. In bio indicators there is no requirement of already prepared sample therefore it provides broad range of quick analysis and also they are economical asorganisedanalytical measurement application. Bioindicators are partial for bioterrorism, food analysis; human health and environmental monitoring e.g. sweat bioindicators. Wide use of bioindicators is mainly in scientific researches this is due to their impressive results in all fields (Kuswandi *et al., 2011*).

2. Mode of Action of Freshness Indicators

Interaction between fruits and indicator.

The resources for this interaction can be various substances of food e.g., Glucose, CO_2, ammonia, biogenic amines, sulphuric compounds, ethanol, organic acid.

Most of concepts are based on a color change of the indicator.

RFID-Radio Frequency Indication, TI- Time Indicator, TTI-Time Temperature Indicator

"The direct freshness indicators directly detect or sense a particular freshness marker or compounds as an indication of the food freshness level. A variety of different freshness indicators has been proposed in the literature, such as spoilage indicators, ripeness indicators, leak indicators, and even microbial indicators. Mainly the indicators incorporated a color indicator for easy detection by the naked eye, where the rate of color change in the indicator correlated well with the rate of deterioration of the food in respect to temperature variation and time during transportation, distribution, and storage. The indirect freshness sensor works based on indirect detection, e.g. based on a reaction system similar to food degradation. In indirect indicators, these devices are expected to mimic the change of a certain freshness parameter of the food undergoing the same exposure to temperature or time. Some are designed to monitor the evolution of gases and changes in temperature during distribution, while others are designed to be used in consumer packages. In order for both types of indicators to be used as food freshness monitoring devices, the rate of change in the sensor must correlate well with the rate of deterioration of the food. The rate of sensor change must also correlate with the temperature variation over time during transportation and distribution" (Seldman, 1995).

Kaur *et al*. (2018) developed economically, highly efficient bioindicators devices which were quite sensitive and specific had opened new scope for identification of samples e.g. contaminated bio agents, microbial load, drugs, pollutants in atmosphere, and metabolites etc. To measure the amount of sample bio indicators work by transforming biochemical signals into quantifiable physiochemical signals. Various types of bioindicators like DNA based, enzyme-based

Table-1 : Mode of action of Freshness Indicators (Kuswandi, 2017).

Indicator	Principle/reagents	Indicates	Application
Time-temperature Indicator	Mechanical, chemical, enzymatic	Storage conditions	Food stored under chilled and frozen conditions
Oxygen indicator	Redox dyes pH dyes enzymes	Storage conditions package leak	Foods stored in packages with reduced oxygen concentration
Indicator of CO_2	Chemical	Storage conditions package leak	Foods package in MAP or CAP
Microbial growth Indicators	pH dyes, All dyes reacting with certain metabolites	Microbial quality of foods (i.e. spoilage)	Perishable foods such as meat, fish, poultry.
Pathogen indicators	Various chemical and immunochemical methods reacting with toxins	Specific pathogenic bacteria such as *E. coli* O157	Perishable foods such as meat, fish, poultry.

immune indicators, piezoelectric, tissue-based, and, thermal bioindicators had been reviewed here to highlight their various applications in number of fields. As bioindicators are used in numerous field but basic research is also necessary to improve sensing techniques also for new instruments and technologies to meet future demands in different industries. Various new techniques and methods like DNA bioindicators have been developed which are easy and less time consuming and are used for treatment for different diseases and for testing of genes.

Liu *et al*., 2018 studied that bioindicators are instruments that merge different technologies which contains electronics, physics informatics, biology, medicines etc. Technologies with the help of some bio recognition element bioindicator act as transducer and convert directly biochemical reaction on surface of transducer which can measures signals. Bioindicators have several advantages like economical, high accuracy, quick analysis they are widely used in different in different industries like to diagnose diseases, food pathogen detection medical, and fermentation industry. Among all the indicators enzymatic indicators showed outstanding application value like for fixed technology and for identification of specific characteristics, these can be combined with technology like point of care technology (POCT). This is very effective in clinical detection and because of this it got high attention.

Naik *et al*., (2017) studied that in food microbial analysis bioindicators were not frequently used but for detection of different toxins in foods and food spoilage pathogens they have very great prospective. They are very helpful in laboratory and field analysis for detection of microbial pathogens to detect these pathogens different applications had been invented that includes *Salmonella, Staphylococcus aureus, E. coli* and *Listeria* monocytogenes also different microbial toxins like *mycotoxins* and *staphylococcal enterotoxins*. "Bioindicators are based on specific biological recognition element in combination with a transducer for signal processing." Common aim of all producers in agricultures products is to increase the yield and shelf life. Nevertheless for consumer's excess use of xenobiotics showed potential risks. Eventually for food regulatory bodies, food industries and food control laboratories food safety is a concerned issue. Also with instrumental analytical protocol there is requirement for corresponding techniques to find out safety threats and quality parameters that can be applied on threat analysis and fast screening method i.e. Chemical assay, bioassays, lateral flow devices and immunoassays. Moreover for various analytical problems bioindicators are very interesting substitute.

Meshram1 *et al.,* (2018) studied that increasingly, food manufacturers are asking for effective quality control techniques to meet consumer and regulatory demands to enhance the feasibility of manufacturing, quality sorting, automation and cost and time decrease. In general, chemical and microbiological analyzes are carried out periodically by trained operators in the food and agricultural sectors, which are costly and involve pre-treatment measures of extraction or sample, improving the analytical time. By providing fast, non-destructive and inexpensive techniques for quality control, bioindicators can overcome all these disadvantages. Considering all these elements of the food and dairy industry, bioindicator growth and use has become a boon. This article shows bioindicator's fundamental ideas and applications in the food and dairy industry. Bioindicators have the capacity to bring about an analytical revolution to solve the food and industry problems. This review article provides an review of the different kinds of bioindicators used in the food industry and describes their opportunities for the future.

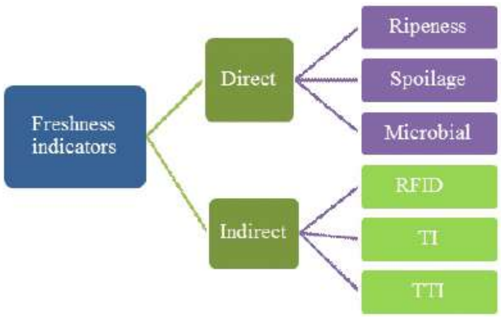

Fig-2 : Types of Freshness Indicators.

Applications of indicators in food industry

Cock *et al.,* (2008) studied that bioindicators are an significant option in the Food industry with efficient, quick and cost-effective techniques to guarantee the safety and quality of food products and process controls methods. Their technology is based on a signal processing transducer combined with particular component of biological recognition. Compared to standard analytical methods, the use of enzymatic bioindicator technology in food quality control, processing, and internet procedures is reassuring all these as it provides excellent benefits owing to size, price, specificity, rapid reaction, accuracy and awareness. This article focused on describing the most important analysis, applications, future possibilities and current situations, developments of enzymatic food bio indicators. Conclusion includes that for risk analysis, development of different quality systems and critical control point's enzymatic bio indicators is a very useful tool with large number of applications. Moreover their use in food industry is very limited because of less life of bioindicators, instead of this hemophilic enzymes had been proposed to use in food industry.

Rustagi and Kumar (2013) studied that bioindicator is a tool used to determine the sample concentration of the specific analyze. Bioindicator is usually categorized based on the use of biological elements and their use of the sort of transient elements. To observe the existence of microbes and to observe the various food elements bio indicators are used in food industries. On the basis of different techniques used in them there bio indicators are of different types like optical bioindicator, fluorescence label bioindicator, impedance bioindicator etc.

Mishra *et al.,* (2018) studied that rapid and accurate analytical instruments are crucial for tracking food safety and screening for any undesirable contaminants, allergens or pathogens that may pose substantial health hazards when consumed. Significant advances in analytical methods have enabled these contaminants to be analyzed and quantified. However, standard methods are restricted by delayed analytical times, costly and laborious preparation of samples, and the need for highly trained employees. Consequently, timely developments in electrochemical bioindicators have endorsed important gains in quantitative identification and screening of contaminants in food and have shown incredible potential as a means of defying such constraints. These bioindicators, apart from highly specific to the target analytes, also tackled the challenge of the food industry by offering elevated analytical precision within complicated foodmatrices. Hereweexploresomeofthelatestdevelopmentsinthisregi onandevaluatetheroleofelectrochemicalbioindicatorsin thefoodindustryandtheircontributions.This paper also r eviews the main difficulties we think that to become th e industry standard, bioindicators need to overcome.

Shahzad *et al.,* (2018) studied that foods in both direct as well as indirect ways helps us as it provides capacity and also improves our health. To stay healthy and fit, fresh and healthy diet is very important. Microbial growth is very fast at room temperature also chemical changes takes place very quickly in the food products that are placed there. Consumption of unhealthy and spoiled food contains pathogens and can cause food born diseases like food poisoning and result in bad health. Main aim of food bio indicators and electric bio indicators is to check the freshness and quality of food. There is need of a smart bio system which can check the freshness of food like meat, fruits, vegetables and dairy items. To ensure the freshness of food and its quality that food is consumable or not different moisture sensor, ph sensor and gas sensor need to be developed. To check the food various android applications are available now days.

Monosik *et al.,* (2012) studied that today, the significance of an observing and modifiable many different constraints in the areas like food industry, medical analyses, sanitation, ecological protection, medicine are rapidly growing. Consequently, there is an essential to ensure consistent systematic expedients accessible, which are able to achieve speedy and precise analyses. The best way is to overawed several hindrances of the conservative procedures is to use suitable deliberate bioindicator.

Wei N *et al.,* (2011) studied that in the food industry globally; to satisfy the requirements and needs of consumers for healthy, fresh and safe food science has made the most of its contributions to this sector. To address the issues of food spoilage and the destruction of foods spoiling biological and chemical agents that spread serious germs and cause diseases. To guarantee the safety and quality of processed foods different techniques and methods had been adopted by food industries to solve these problems.

According to Liu *et al.,* (2018) Bioindicators are highly sensitive, target specified and quickly responsive also useful therein reference to modify North American country to see the reason behind chemical activities that ends up in the spoilage of food , not solely all industrial food products and canned products, but are applicable on the food crops too. Firstly we should assess the quality of all food products to compute the scope of freshness of foods. Therefore one should be knowledgeable to judge all the quality parameters of different traits of food components that are underneath analysis.

Conclusions

Bioindicators offer an exciting alternative to traditional methods that combines living part with physicochemical identifier part and allowing rapid "real-time" and multiple analyses for diagnosis and estimations. Bioindicators technology has been developed encompassing a variety of applications and mainly emphasis on the development of sensing elements and transducers which are under current research.

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Chapter 8

Agroforestry Systems for Climate Change Mitigation and Livelihood Security in North-Western Himalaya

P.L. Bhutia[1,2], Sharmistha Pal[2], K.G. Bhutia[3], R.P. Yadav[4], Pekila Bhutia[5] and O.P.S. Khola[2]
[1]*ICAR-Research Complex for NEH Region, Medziphema-797106, Nagaland*
[2]*ICAR-Indian Institute of Soil and Water Conservation, Sector 27A, Madhya Marg-160019, Chandigarh*
[3]*Rain Forest Research Institute, Jorhat-785001, Assam*
[4]*Rani Lakshmi Bai Central Agricultural University, Jhansi-284003, Uttar Pradesh*
[5]*University of Horticultural Sciences, Bagalkot-587104, Karnataka*

Abstract

Agroforestry Systems across the Himalayan region offer major ecosystem services, providing livelihood opportunities and supplying food resources to humans and wild fauna. Apart from this, the system is known for its biological richness and other ecosystem services like carbon sequestration, water regulation, nutrient cycling and many more. In recent years role of agroforestry in livelihood security and climate change mitigation has been recognized. This chapter highlights some of the important agroforestry systems present in North-Western Himalaya and their role in climate change mitigation and livelihood security.

Key words : *Carbon stock, silvipasture, soil organic carbon stock, species composition.*

Introduction

Himalayan region is known for its diversified landforms, relief and environmental conditions supporting a wide range of land use and vegetation. Agroforestry is a sustainable integrated farming system where woody perennials like trees, shrubs, palms, bamboos are grown along with crops or pastures with or without livestock on the piece of land simultaneously or sequentially and managed as per the social as well as cultural compatibility and feasibility of the locals. Several agroforestry systems based on people's needs and site characteristics have been developed in the Himalayas over the years. They provide ecosystem services similar to forest ecosystems with variable products like provision of food, fibre, fuel, timber, fodder, biodiversity conservation, maintenance of soil health, water resources and their purification, cultural services, climate change mitigation (Yadav *et al.*, 2017) and income to sustain them above subsistence level (Kitti *et al.*, 2009). Agroforestry systems are the backbone of the Himalaya agrarian community for livelihood security (Yadav *et al.,* 2018). Massive reforestation has been proposed as a major means of stabilizing the concentration of carbon dioxide in the atmosphere, but the rate of deforestation in the tropics is high due to the growing need for additional agricultural land. Agroforestry offers a compromise solution, on one hand, it increases the storage of carbon on land and, on the other, it may enhance agricultural production. Although the storage of carbon per unit area is generally less in agroforestry systems than forest or tree plantations but the area suitable for agroforestry is large, worldwide. Thus, agroforests can be effective

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carbon sinks and livelihood options provided these are properly designed and managed.

Prevalent Agroforestry Systems of North-Western Himalaya

Several agroforestry systems have been developed based on the people's requirements. Some of the common agroforestry systems of North-Western Himalayas are as follows :

Agriculture based Agroforestry Systems

In this system, different agriculture crops are grown in the field along with multipurpose forest and fruit tree species. The multipurpose forest trees are irregularly retained on the bunds of the fields or risers of the terraces while fruit plants are planted either on the bunds/risers or at a standard spacing in the agriculture fields. Farmers cultivate the same piece of land twice a year mostly under rainfed conditions except in a subalpine or alpine area, where lands are fully covered with snow during the winter season. The common trees and agriculture crops of the region are listed in Table 1. Agriculture based agroforestry systems have been further categorized according to the nature and arrangement of the components or as per the primary role of the systems as 1. Agrisilviculture (Agriculture crops + Forest Trees); 2. Agrihorticulture (Agriculture crops + Fruit Trees); 3. Agrisilvi-horticulture (Agriculture crops+ Forest Trees + Fruit Trees); 4. Agrihortisilviculture (Agriculture crops+ Fruit Trees + Forest Trees); 5. Hortiagriculture systems (Fruit Trees + Agriculture crops); 6. Hortiagrisilvi0 culture systems (Fruit Trees + Agriculture crops + Forest Trees);7. Agrisilvopastoral Systems: (Agriculture crops+ Forest Trees + Grass).

Silvipasture Systems

In Silvipasture systems, woody perennials are grown along with pastures, fodder crops and/or livestock in the same piece of land. This is one of the most common sources of livestock fodder in this region and is locally known as Ghasni. The ground vegetations are the primary source of fodder and the farmers follow cut and carry systems. Woody perennials are grown primarily to produce supplemental fodder especially during dry seasons (lean period). However, they also supply fuelwood, small wood, timber, fruits, resins etc. and contributes towards soil conservation, water regulation and other ecosystem services. The common ground vegetation and tree species found in the North-Western Himalaya are given in Table-2.

Homestead Agroforestry

This indigenous system is present throughout the North-Western Himalayas. This is an integrated land-use system where different species of forest and fruit trees are grown closely along with agriculture crops especially vegetables or species crops in the homestead area. In some of the areas, livestock as well as pisciculture, apiculture are a very integral part of the systems.

Agroforestry for Livelihood Security

The important aspect of any agroforestry system is its utility to the local inhabitants. Any systems providing diverse output like fodder, food, timber, fuelwood *etc*. are always liked by people. In the Himalayan region, agroforestry system is the mainstay of rural livelihood providing food, fruits for home consumption and sale, essential fodder for their cattle, fuelwood for running kitchen in their houses, small timber for house building and making agriculture tools, etc. Agroforestry has provided an opportunity for diversification of existing land-use systems and beneficial environmental impacts and higher returns as compared to sole cropping systems (Chaturvedi, 1991). Chisang *et al.* (2013) studied the economical appraisal of different systems in different elevations in Kinnaur district of Himachal Pradesh and reported that fruit-based systems showed highest net profit than other systems as maximum net profit was attained by agri-horticulture system (Rs, 13,10,000/ha/yr), followed by horticulture (Rs 11,65,852/ha/yr). In the altitudinal ranges, the net profit enhanced with increasing altitudinal ranges. Silvi-pasture was found to have the highest benefit cost ration in all the three altitudinal ranges i.e. 1900-2170 m amsl (6.66), 2170-2240 m amsl (4.94) and 2440- 2710 m amsl (5.29). However, economic appraisal conducted in different agroforestry systems of Kangra District, Himachal Pradesh (Kaler *et al*., 2017) revealed that agri-silviculture system reported the highest net returns (Rs. 192725.33/ha/yr) and BC ratio (1.95) followed by Agri-silvi-horticulture and least in agrihorticulture systems. Like any other agricultural technology, the adoption of agroforestry practices depends on the potential economic benefits accruing to farmers.

Agroforestry for Climate Change Mitigation

Agroforestry plays important role in climate change mitigation mainly through its potential to sequester greenhouse gases (GHGs) mainly CO_2. Agroforestry also provides a unique opportunity of

Table-1 : Floristic composition of agriculture-based agroforestry systems of North Western Himalayas.

Sl. No.	Agroforestry Systems	Elevation	Major crops		Trees		References
			Rabi	Kharif	Forest Trees	Fruit Trees	
1.	Agri-horticulture	1900-2170 m	*Triticum aestivum, Pisum sativum, Hordeum vulgare*	*Zea Mays, Phaselous vulgaris, Brassica oleracea var. capitata*	-	*Malus domestica*	Chisanga *et al.*, 2013
2.	Agrihortisilviculture	1900-2710 m	*Pisum sativum, Triticum aestivum*	*Zea Mays, Phaselous vulgaris, Brassica oleracea var. capitata*	*Robinia pseudoacacia, Ailanthus altissima, Salix tetrasperma*	*Malus domestica*	Chisanga *et al.*, 2013
3.	Agrihorticulture	2911-2958 m	-	*Pisum sativum, Solanum tuberosum,*	-	*Malus domestica*	Nayak *et al.*, 2011
4.	Agrisilvipastoral System	2911-2958 m	-	*Pisum sativum, Grass*	-	*Salix fragilis*	Nayak *et al.*, 2011
5.	Agrisilviculture	2911-2958 m	-	*Pisum sativum, Solanum tuberosum, Phaselous vulgaris*	-	*Salix fragilis*	Nayak *et al.*, 2011
6.	Agrisilviculture	700-1151	*Pisum sativum, Triticum aestivum, Brassica campestris ssp. rapa, Allium sativum,, Solanum tuberosum*	*Lycopersicon esculentum, Capsicum annuum, Zea Mays, Phaselous vulgaris, Capsicum frutescens*	*Toona ciliate, Acacia catechu, Grewia optiva, Leucaena leucocephala, Bauhinia variegate, Pyrus communis, Dalbergia sissoo, morus sps*	-	Bhutia, 2018
7.	Agrihorticulture	1450-1850	*Pisum sativum,, Triticum aestivum, mustard, Allium sativum,, Solanum tuberosum, Brassica oleracea var. capitata*	*Zea Mays, Lycopersicon esculentum, Capsicum annuum, Phaselous vulgaris, Capsicum frutescens, Vigna unguiculata*	-	*Prunus persica, Prunus domestica, Prunus armeniaca, Pyrus communis, Malus domestica*	Bhutia, 2018
8.	Agrisilvihorticulture system	700-1151	*Pisum sativum,, Triticum aestivum, mustard, Allium sativum,, Solanum tuberosum*	*Lycopersicon esculentum, Capsicum annuum, Zea Mays, Phaselous vulgaris, Capsicum frutescens*	*Toona ciliate, Acacia catechu, Grewia optiva, Leucaena leucocephala, Bauhinia variegate, Pyrus communis, Dalbergia sissoo, Morus spp., Albizia lebbek*	*Pyrus communis, Punica granatum, Psidium guajava, Citrus spp., Mangifera indica, Prunus persica*	Bhutia,2018

Table-2 : Floristic composition of Silvipasture Systems of North Western Himalayas.

Sl. No.	Silvipasture Systems	Elevation	Grass/Shrubs	Trees	References
1.	Silvipastoral Systems	1900-2710 m	*Natural grass, Artemisia inbia, A. brevifolia, Lespedeiza*	*Pinus gerardiana*	Chisang *et al*., 2018
2.	Hortisilvipasture	1800-2100 m	*Chrysopogon gryllus, Apluda mutica, Setaria glauca, Chrysopogon fulvus, Cynodon dactylon, Dichanthium annulatum*	*Malus domestica, Prunus armeniaca, Juglans regia, Alnus nitida, Ficus palmata, Robinia pseudoacacia, Toona ciliate,Quercus leucotrichophora, Q. floribunda*	Kapoor, 2020
3.	Silvipasture	1800-2100 m	*Chrysopogon gryllus, Apluda mutica, Chrysopogon fulvus, Carex breviculmis, Principia utilis, Berberis lyceum, Rosa moschata, Indigofera gerardiana, Buddleja crispa, Indigofera dosua, Rubus biflorus, Sarcococca saligna, Rubus niveus,*	*Pinus wallichiana, Quercus floribunda, Pinus roxburghii, Robinia pseudoacacia,*	Kapoor, 2020
4.	Hortisilvipasture	2100-2400 m	*Chrysopogon gryllus, Dactylis glomerata, Chrysopogon montanus, Digitaria stricta, Dichanthium annulatum Apludamutica, Setaria glauca, Cynodondactylon, Desmostachya binnata, Themeda anathera, Festuca arundinacea*	*Malus domestica, Prunus armeniaca, Pinus wallichiana, /Malus domestica, Pyrus communis, Quercus florbunda/ Malus domestica, Prunus domestics, Prunus armeniaca, Morus serrata/ Malus domestica, Prunus armeniaca, Juglans regia, Quercus floribunda*	Kapoor, 2020

creating synergies between climate change adaptation and mitigation and enhance the resilience of the system. The integration of trees in farmlands and pastures i.e. agroforestry results in greater CO_2 sequestration from the atmosphere and its long-term storage in aboveground biomass, soil and belowground biomass (Nair *et al.* 2009; Sharma *et al.* 2014; Bhutia *et al*., 2021). Agroforestry can also have indirect effects on C sequestration when it helps to decrease pressure on natural forests, which are the largest sink of terrestrial C and the use of agroforestry technologies for soil conservation, which could enhance C storage in trees and soils. The amount of carbon stored in any agroforestry system depends on its structural components, primarily their type and number, which largely is dependent upon ambient environmental and socio-economic factors. Besides them, the growth habit of the species, site quality, soil properties, tree age and management practices regulate biomass production in an agroecosystem (Yadav *et al*. 2017; Bhutia *et al.,* 2021). Rajput *et al*. (2017) studied factors influencing biomass and carbon storage potential of different land-use systems along an elevational gradient in temperate northwestern Himalaya and reported that maximum total biomass of 404.35 Mg C ha^{-1} was accumulated by forest land use and followed a decreasing trend in the order as forest > silvi-pasture > agri-horticulture > horticulture > agriculture. Similar trends were also seen with respect to biomass carbon (C) density and C-sequestration potential of different land uses. Biomass and carbon density potential increased with the increase in the altitudinal range

Table-3 : Carbon storage potential of agriculture-based agroforestry systems in North-west Himalaya.

Land use system	Elevation / Elevation range	Biomass carbon (tC ha^{-1})				Source
		Aboveground	Belowground	Total	Soil (t/ha)	
Agrihorticulture	1500-2400 m	36-37.55	14.7-15.37	-	31.78-34.71 (0-50cm)	Sanneh, 2007
Agrisilviculture	1500-2400 m	20.55-74.45	3.43-24.82	-	2574-26.84 (0-50cm)	Sanneh, 2007
Agri-silviculture	468m & 1250m	47.50 & 13.58	14.01 & 4.86	-	40.14 & 59.42 (0-40 cm)	Minj, 2008
Agrihorticulture	468m & 1250m	20.03 & 12.35	6.97 & 4.66	-	35.27 & 59.75 (0-40 cm)	Minj, 2008
Agrihortisilviculture	468m & 1250m	15.98 & 24.35	8.12 & 5.63	-	45.89 & 79.06 (0-40 cm)	Minj, 2008
Agrihorticulture	1100 -2300m	36.31	11.49	47.8	-	Rajput, 2010
Agrisiliviculture	338m	15.32	5.38	20.7	-	Khaki and Wani (2013)
Agrihorticulture	1100-2300 m	-	-	46.9-51.6	-	Rajput et al., 2017
Agri-horticulture	1900-2710 m	-	-	12.51-17.32	24.84-34.27(0-20 cm)	Chisanga et al., 2018
Agri-horti-silviculture	1900-2710 m	-	-	23.11-54.28	23.68-26.69 (0-20 cm)	Chisanga et al., 2018
Agrihorti-silviculture	900–2100 m	27.66-33.98	8.30-10.10	-	46.96-56.70 (0-30 cm depth)	Singh et al., 2018
Agrihorticulture	900–2100 m	20.79-26.06	6.31-7.65	-	47.02-55.64 (0-30 cm depth)	Singh et al., 2018
Agrisilvihorticulture	900–2100 m	28.74-35.96	8.73-10.69	-	48.02-54.06 (0-30 cm depth)	Singh et al., 2018
Agrisilviculture	900–2100 m	20.72-28.44	6.33-8.36	-	47.20-51.66 (0-30 cm depth)	Singh et al., 2018
Agrisilviculture	365-914 m	18.37-26.65	5.74-6.73	-	51.58 (0-100 cm)	Singh et al. 2019
40Agrihorticulture	365-914 m	28.09-30.29	6.42-6.76	-	51.99 (0-100 cm)	Singh et al. 2019
Agrihortisilviculture	365-914 m	31.01-35.45	9.41-10.60		46.74 (0-100 cm)	Singh et al. 2019

from 1100–1400 to 2000–2300 m asl. The rate of C-sequestration potential increased from 1100 to 2000 m and then declined at 2000–2300 m asl. Several studies in the Western Himalaya revealed that different agriculture-based agroforestry systems have the potential to sequester 12.35 – 74.45 Mg C ha^{-1}, 4.66 – 24.82 Mg C ha^{-1} carbon in aboveground and belowground biomass, respectively (Table 3). However, in silvipasture systems, the carbon storage on aboveground, belowground biomass was reported in a range of 6.86 - 58.80 Mg C ha^{-1}, 2.41 - 19.60 Mg C ha^{-1}, respectively (Table-4).

Conclusions

Agroforestry systems are common land uses across the Himalayan region and could play a vital role in the livelihood security of rural people as well as climate change mitigation by sequestering carbon in biomass and soil. There is tremendous scope to strengthen the existing agroforestry systems of the North-Western Himalaya in terms of productivity and sustainability. Efforts should be given to improve the genetic attributes of the components for higher production as well as specific crop combination should be assessed. Systems that promise higher financial, ecological and social returns should be promoted. The

Table-4 : Carbon storage potential of silvipasture systems in north-west Himalaya.

Land use system	Elevation/Elevation range	Biomass carbon (Mg/ha) in silvipasture systems			Soil (Mg/ha)	Source
		Aboveground	Belowground	Total		
Silvipasture	1500-2400 m	43.42-58.80	14.52-19.60	-	18.96-24.75 (0-50 cm)	Sanneh, 2007
Hortipastoral	468m & 1250m	11.68 & 23.18	6.51 & 3.56	-	28.4 & 60.45 (0-40 cm)	Minj, 2008
Silvi-pastoral	468m & 1250m	22.27 & 22.99	7.63 & 6.73	-	52.97 & 76.81 (0-50 cm)	Minj, 2008
Silvipasture	1100 - 2300m	51.15	10.63	-	-	Rajput, 2010
Hortipastoral system	338m	6.86	2.41	-	-	Khaki and Wani, 2013
Silvipastoral system	338m	14.72	5.17	-	-	Khaki and Wani, 2013
Hortisilvipastoral system	338m	8.19	2.88	-	-	Khaki and Wani, 2013
Silvipastoral	1250m	-	-	-	-	Kumar et al.,2012
Silvipasture	1100 - 2300m	-	-	-	-	Rajput et al., 2017
Silvipasture	-	-	-	19.07-99.10	20.55-25.06 (0-20 cm)	Chisanga et al., 2018
Chir pine Silvi0 pasture	700-1850	27.79-33.67	7.90-9.30	-	68.63-70.97 (0-30 cm)	Bhutia et al., 2018
Silvopastoral system	365-914	11.97-22.52	3.36-5.65		64.25 (0-100 cm)	Singh et al., 2019

documentation, refinement of traditional agroforestry is a need of the hour for a sustainable future.

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Chapter 9

Principles and Effects of High Pressure Processing on Food Products and Their Quality

Byreddy Naveena
Department of Post Harvest Process and Food Engineering, JNKVV, Jabalpur, Madhya Pradesh
Email : naveenachittinavi@gmail.com

Abstract

People's unhealthy lifestyles in this fast-paced environment have prompted them to consider their health and diet. Food should be treated with processing technologies to prevent microbiological and chemical changes in order for the food items to meet the needs of the consumer while maintaining the main quality. High-pressure processing (HPP) is an emerging processing that makes food safer and increases its shelf life while preserving many of its natural features and healthy benefits. It can be used in nearly all food industries, from milk to meat, as a novel preserving method. HPP can make it easier to make food products with the freshness of fresh foods but the convenience and profitability associated with shelf life extension. This paper highlights the information of principles of HPP, its effect on some food product and their quality and its advantages and limitations.

Key words : *Microbiological, high-pressure processing, novel preserving method, profitability.*

Introduction

Around the world, there is a growing desire for more fresh and nutritious food. Many factors prevent food from reaching our fork. Enzymes, which are found in trace amounts in all living things and can control all life functions, continue to work after harvest, producing a natural breakdown of fresh produce (Ramaswamy and Tessema, 2010). Chemical and enzyme deterioration occurs when foods are subjected to external factors that cause enzymes to be released, causing chemical reactions to occur (James and Kuipers, 2003). Food should be treated with processing technologies to prevent microbiological and chemical changes in order for the food items to meet the needs of the consumer while maintaining the main quality (Daher 2017).

Controlling enzymatic, physiochemical, and microbiological activities would prevent undesirable changes in food product quality (Daher 2017). The following are some of the several strategies that can be used to preserve food: (Ramaswamy et al., 2010) adds or removes heat, dehydrates, freezes, and adds salt and sugar. Applying heat treatment is a very popular and simple procedure. However, sensory qualities and physicochemical parameters of foodstuffs, as well as sensory judgments, are affected due to heat treatment. As a result, non-thermal treatments were required as an alternative (Abera *et al.,* 2019). HPP, pulsed lights, pulsed magnetic field, pulse electric field pasteurisation and ozone treatment are among the non-thermal processing technologies used in food processing. HPP is popular not only for its ability to preserve food but also for its potential to have functional impacts (Chauhan *et al.,* 2019). This method can inactivate bacteria and enzymes, extending the shelf life of food with minimum reduction in nutritional and organoleptic quality. As a result, HPP treatment appears to be a better option to other standard

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food preservation processes such as thermal pasteurisation.

HPP is a non-thermal technique for preventing bacterial deterioration in food (Perez *et al.,* 2018). Liquids and solid foods are subjected to 100 to 900 MPa pressure in high-pressure processing, also known as high hydrostatic pressure, which is a high pressure that is specialised for inhibiting the growth of microbes in food. Foods will remain more fresh and appetising after HPP preparation than after other thermal treatments (Balasubramanium et al., 2015). HPP helps to preserve food quality, natural freshness, and microbiological shelf life. HPP is also known as High hydrostatic pressure processing (HHP) and ultra high-pressure processing (UHP). High-pressure treatment (HPT) is a nonchemical treatment that has been shown to kill bacteria by disrupting their membranes (Hoover et al., 1989). As lower molecule weight food ingredients, such as flavouring agents, colours, and some vitamins, are not affected by pressure, it preserves nutritional value with minimal effect on product quality and sensory qualities of fruit and vegetable products (Kasikci and Bagdatlioglu 2016). In contrast to high temperature treatments, which can disrupt covalent bonds in vitamins, amino acids, and other freshness-related chemicals, HPP mostly impacts non-covalent bonds (Hayashi 1989).

Principles of HPP

Le-Chatelier-Braun principle : It states that "any phenomenon *i.e.,* phase transition, change in molecular configuration, chemical reaction, accompanied by a decrease in volume is enhanced by pressure". When the pressure changes, the equilibrium moves in a way that tends to reduce the volume change. As a result, the system is shifted to the lowest volume.

Pascal's law or iso-static principle : It state that the uniform application of pressure acts equally in all directions. This makes the high hydrostatic pressure independent of the sample's size and geometry and shortens the processing time.

Principle of microscopic ordering : An increase in pressure expands the degrees of ordering of molecules of a particular substance at a consistent temperature. Pressure and temperature exert opposing influences on molecular structure and chemical reactions in this manner.

High Pressure Processing of fruits and vegetables

HPP is used in the processing of fruits and vegetables to kill bacteria and enzymes, lengthen shelf life, and improve organoleptic, sensory, and nutritional characteristics. Several commercial products, such as fruit juices *i.e.,* mandarin, grapefruit, apple, orange, carrot juices, and a broccoli-apple juice blend treated with HHP, are currently on the market (Ahmed *et al.,* 2005 and Barba *et al*., 2011). Tables 1 and 2 describe some of the most notable findings in this area.

HPP application and its effect on some food product and their quality

Physicochemical effects of HPP : Sharma (2011) detailed the effects of HPP on food colour and flavour. The iron in myoglobin in fresh or marinated meat transforms from ferrous to ferric and globin is denatured and the red colour is lost, but the colour of cooked meat is mostly unaltered, similar to that of cooked meals. Fruits and vegetables will be slightly altered, but fruit juices will have little or no influence, and flavours will be largely untouched. The influence of UHP on browning index and disease incidence of fresh-cut Chinese yam was demonstrated, and appearance loss, like other minimally processed fruits and vegetables, was the key issue that reduced the shelf life of fresh-cut Chinese yam. Even when kept at a low temperature, fresh-cut Chinese yam quickly loses its white hue. After 3 days of storage, browning marks formed, and after 6 days at 4 (browning index °C > 2.0), they were visible. The original bright colour of the control fresh-cut Chinese yam had largely faded after 9 days of storage, and roughly 22% of the slices had begun to decay.

Slices treated with UHP 600 MPa remained brightly coloured until the end of storage, and no disease development was noted (Guangjie and Bo, 2000). The overall carotenoid content or vitamin A value in orange juice were not affected by traditional heat treatments. In terms of flavanones, HP treatment raised (P 0.05) the amounts of naringenin (20.16 percent) and hesperetin (39.88 percent), whereas PEF treatment had no effect on individual or total carotenoids or flavanone content (Moreno *et al.,* 2005). Other researchers have found that high-pressure processing of liquid meals either increases or has no effect on antioxidant activity (Moreno *et al.*, 2005). HP treatment causes modifications in the cheese protein network, which can lead to alterations in the cheese structure, allowing for greater water absorption and water retention in cheeses (Trujillo *et al.,* 2000).

Effect of HPP on microbial food safety : Different microorganisms react to HPP treatment in different ways, and bacterial species and even strains might have a wide range of HPP sensitivity (Pagán and Mackey, 2000). Endospores, in comparison to

Table-1 : High Pressure Processing of fruit products.

Product	Conditions	Salient results	References
Apple juice	400 MPa for 10 minutes	Compared the sensory quality during storage of apple juice subjected to high pressure with that preserved by freezing (-17°C) or pasteurization (80°C, 20 min). The best samples were frozen juice, followed by pressurized, and then by pasteurized, juice with much substantial difference in aroma.	Novotna *et al.,* (1999)
Avocado paste	600 MPa for 3 minutes and stored for 45 days at 4°C	Reported a decrease in polyphenol-oxidase (PPO) and lipoxygenase (LOX) in avocado paste. Lactic acid bacteria counts were very low during storage. pH was consistently declining during the first 20 days of storage.	Jacobo-Velazquez *et al.*, (2010)
Guava puree	600 MPa, 25°C for 15 minutes	Storage up to 40 days at 4°C without any change in color and pectin cloud and with no loss of ascorbic acid. No change in water soluble, oxalate soluble and alkali soluble pectin with original flavor distribution and viscosity.	Gow and Hsin (1999)
Orange juice	600 MPa for 4 minutes at 40°C	The rate of degradation of ascorbic acid was lower for orange juice treated with high pressure, which led to a better retention of the antioxidative activity when compared with juice pasteurized in a conventional way using heat.	Polydera *et al.,* (2005)
Strawberry Juice	200-500 MPa	No major changes in strawberry aroma profiles, whereas a pressure of 800 MPa, induced significant changes in the aroma profile and new compounds were induced.	Lambert *et al.,* (1999)

vegetative cells, are particularly HPP resistant, withstanding treatments of over 1000 times (Smelt, 1998). HPP can cause bacterial spores to germinate to varying degrees depending on the growth medium and test organism (Black *et al.,* 2005b). According to Wuytack *et al.* (1998), spores could germinate at both low and high pressures; however, spores germinated under lower pressures were more susceptible to subsequent pressure treatments.

Information on the influence of HPP on the possibility of toxicity of HPP foods or associated allergies is rare, but research is necessary; similarly, research on bacterial and algal toxins is warranted (Torres and Velazquez, 2005; Rastogi *et al.*, 2007). The pressure sensitivity/resistance of bacteria is also determined by their growth phase. Cells in the stationary phase of growth are more pressure resistant than those in the exponential phase (Hayman *et al.*, 2007). This is likely due to the synthesis of proteins that protect against a variety of stresses, including high salt concentrations, elevated temperatures, and oxidative stress (Hill *et al.*, 2002).

HPP Effect on sensory attributes : By inactivating microbes and enzymes, HPP can protect the quality of fresh fruit slices (colour, smell, texture, and nutritional content) (Yordanov and Angelova 2010). The total plate count of fresh-cut pineapples was found to be reduced by nearly 3 log after a 15-minute pressure treatment (340 MPa) (Aleman *et al.,* 1994). Similarly, the browning of mango slices was controlled by applying 800 MPa for 5 minutes (Boynton *et al.*, 2002). HPP has been shown to have an incredible shelf life when used to preserve fruit juices and fruit drinks on an industrial scale. The shelf life of orange juice was extended by more than two months in the refrigerator by using HPP (350 MPa) at 30°C for one minute (Donsi *et al*., 1996). The effects of HPP on the quality of meat and its products have been studied in a variety of ways, including the colour of beef (Carlez *et al*., 1995), structural alterations in pork (Wackerbarth *et al*., 2009), microbial inactivation in beef (Jofre *et al.,* 2009), and lipid oxidation in beef and poultry (McArdle *et al.*, 2011 and Kruk *et al.,* 2011).

HPP advantages and disadvantages

Advantages

High pressure is independent of size and shape of the food.

High pressure is not dependent on time/mass, *i.e.,* it acts instantaneously thus minimising the processing time.

Table-2 : High Pressure Processing of vegetable and it's products.

Product	Conditions	Salient results	References
Broccoli	500 MPa for 10 minutes	High pressure processing (500 MPa for 10 minutes) of applebroccoli juice and noted that pressure inactivates more than 5 logs of the microbial population and preserves the content of sulforaphane, a compound that exhibits anticancer, antidiabetic and antimicrobial properties to broccoli	Houska *et al.,* (2006)
Onion	350 MPa at 25°C and 40°C for 30 minutes	Significantly reduced the microbial load of fresh onions but did damage onions membrane without inactivating undesirable enzymes which lead to changes in the odor and flavor of fresh onions. Pressures above 100 MPa damaged the cell structure, releasing polyphenoloxidase (PPO) and inducing then browning of the onions. Browning rate increased with increasing pressure.	Butz *et al.,* (2002)

It does not disrupt covalent bonds, therefore it prevents the production of flavours

that are not native to the items, preserving their inherent flavour.

It can be used at room temperature, which reduces the amount of thermal energy

required for food preparation in traditional methods.

The technique is environmentally beneficial because it uses only electricity and produces no waste.

Disadvantages

Enzymatic and oxidative breakdown of specific dietary components is caused by residual enzyme activity and dissolved oxygen.

Food enzymes and bacterial spores are very resistant to pressure and require extremely high pressure to be inactivated.

To maintain their sensory and nutritional properties, most pressure-processed foods require low-temperature storage and delivery.

The major limitation of this technology is its high cost; HPP equipment is costly and requires a large investment, depending on the type of equipment.

Conclusions

High-pressure processing is an industrially proven method that provides a natural option for the processing of a variety of foods. Despite the fact that this processing method necessitates a higher initial financial expenditure, it results in higher quality, higher value (premium) products. As a result, HPP not only enhances food safety but also increases its shelf life while preserving the food qualities traditionally associated with "minimally processed" goods. Both the food processing industry and customers profit greatly from this strategy. The fundamental drawback of employing this technology for high-pressure treatment is the inability to create high pressure safely and regularly.

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Chapter 10

Potential and Status of Potato Production in Madhya Pradesh

Bharti Choudhary
JNKVV-Zonal Agriculture Research Station, Chhindwara-480001 M.P.
Email : bharati.choudhary06@gmail.com

Introduction

Potato is one of the most important vegetable crops grown mostly throughout the Madhya Pradesh. Potato is a very efficient food crop, more dry matter, per unit area and time; the potato produces more dry matter, edible protein and minerals. When compared to other major crops like wheat, Rice and Maize .It fits well in multiple cropping due to short duration flexibility of planting and harvesting besides its high commercial value. Importance of Potato crop was rightly assessed by FAO (2008) before declaring 2008 as the International Year of Potato and indicating potato as future crop for fighting hunger and poverty. Impending food and nutritional security challenges in India and related policy implications have been aptly emphasized in various studies (Acharya 2009, Bhavani *et al.* 2010, Chand and Jumrani 2013, Kesavan 2015). Role of potato as food and income security crop for the global poor in general and the residents of developing countries in particulate, was adequately documented by Thiele *et al.* (2010) and Singh and Rana (2013).

The first mention of potato in India occurs in 'Terry's account of a banquet at Ajmer given by Asaph Khan to Sir Thomas Rao in 1615. Potato was grown in many gardens of Surat and Karnataka in about 1675. Cultivation of potato in northern hills started later than plains but became as cash crop much earlier. Cultivation of potato was beginning first in the Nilgiri hills in the 1822.Potato is a cool season crop. Its wider adaptability makes it possible to grow this crop in almost all the states of the country but by adopting suitable production technology. The plateau area and southern hills, which represent a sizeable area under potato cultivation differ from other parts of the country with respect to climatic and soil conditions. In India major potato area is concentrated in Northern plains (80 – 85%). The hilly areas of northern India accounts for 6-7 per cent and plateau areas of the country represents about 8 to 9 per cent area. The remaining area is present in problematic areas like Nilgiri and Palani hills of Tamil Nadu and Sikkim and North Bengal hills. In these different parts of the sub continent potato is grown under different climatic and soil conditions, which define the technology to produce good harvests of potatoes.

Potato Production Scenario in Madhya Pradesh :

Madhya Pradesh has 51 districts. Agriculture contributes 24% of the state GDP and employs 78% of the total workforce .The net sown area is 49% of total Geographic area. The gross cropped area is 182 lakh ha with a cropping intensity 135. Small and marginal farmers account for 60 % of lad holding and 22% operate area. Irrigation covers 31% of the net sown area while the remaining 69% of the net sown area is rain fed. Madhya Pradesh with high geographical diversity, eleven agro- climatic zones, and varied soil types is better placed for production of various horticultural crops.

Madhya Pradesh comes under west central plains and North -eastern plains agro-Climatic Regions**.** A potato crop of 90-120 days duration is grown during winter under mild temperatures and short days (10 hour day) from October to January/February. The

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region, in general, is free from potato diseases. Late blight does not follow a definite cycle of appearance in the region. Varietal features, namely adaptation to short days, early bulking, moderate resistance to blight and slow rate of degeneration are desirable.

Madhya Pradesh ranks fourth in the production of potato in India during 2013-14 In Madhya Pradesh, the area under potato is 1,34,136 hectares and the production is 2743001 tonnes with the productivity of 20.44 q/ha in 2015-16. In Madhya Pradesh now area, Production and Productivity is increased 113440 ha (6.8 times), 2357283 tones increased (14.03 times) and 20.78 t/ha (two times) as compare to 1970-71 respectively.

Reason for their preference : Due to early bulking, High yielding short duration crop, Heat tolerant like Kufri Surya, Some high yielding varieties like K. Sinduri due to red skin more acceptable to farmers because of good storage capacity as compared to white skin potato, good for processing purpose, Suitable in multiple cropping systems.

Varieties suitable for Madhya Pradesh and their Salient features :

Early Maturing Varieties (70-90 days) :

Kufri Ashoka : It is a wider adaptable variety released from CPIU, Shimla in 1996. It is a derivative of (EM/C-l 020 x Allerfi'uii lleste Gelbe). Plants are medium tall, erect, medium compact and vigorous. Stems are few, medium thick, lightly pigmented at base with poorly developed straight wings. Foliage is green. Leaves are intermediate having green rachis. Leaflets are ovate lanceolate, smooth glassy surface with entire margin, Flowers are light red purple. This variety has profuse flowering. Anthers are orange-yellow, well-developed and medium pollen stain ability. Stigma is round shaped. Tubers are white, large, oval long, smooth skin and fleet eyes with white flesh having purple sprouts. It is an early maturing (70-80 days) having yield potential of 400 q/ha. It is susceptible to late blight and not suitable for processing.

Kufri Lauvkar : It is a derivative of cross Serkoy x Adina released in 1973 by Central sub-committee on Release of Varieties for Decan Peninsula (Maharashtra). Plants are tall, erect and thick stems, large ovate lanceolate and incurring leaflets. Foliage is dark grey green and glossy, foliage many, large and mostly borne on rachis. Tuber is round, white, and flesh white, sprouts beet root red colour, cooking and peeling easy. Cooked flesh is white and good in taste. It has slow rate of degeneration. It is susceptible to late blight, leaf blotch; potato virus' Y' and leaf roll.111is variety escapes attack to tuber moth. It is susceptible to early blight. It is an early variety, which yielded 250 q/ha tubers in 75-95 days crop duration

Kufri Chandramukhi : It is a derivative of the cross S.4485 X Kufri Kuber and released in 1967 in Central Variety Release Committee for the plains of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar, West Bengal and Maharashtra. It also grows well in Himachal Pradesh hills and Jammu regions. Plants are medium tall with open foliage habit and free from secondary growth. Foliage is grass green and glossy. The small leaflets are not fully expanded especially on top, notched tip on one side of leaflets. Tubers are oval, white, flesh dull white, eye fleet, and sprouts light red and pubescent. The variety has slow rate of degeneration and early bulking. It possesses good keeping quality. It is mid season variety, matures 80-90 days in plains and 120 days in hills. An average yield is 200 q/ha in plains and 75 q/ha in hills. It is susceptible to common scab, late blight, brown rot, nematodes, charcoal rot and wilts.

Kufri Jawahar : It is a derivative of Kufri Neelamani x Kufri jyoti and released from Central Potato Research Institute, Shimla in 1996. Plants are short, erect, compact and vigorous; stem few, thick, lightly pigmented at base with well-developed straight wings. Foliage is light green, leaves open, rachis green, terminal leaflet cordate, smooth dull surface with entire margin. Flowers are white moderately flowering. Anthers are orange yellow, well-developed and low pollen stability. Stigma is round and slightly notched. Tubers are creamy white, medium sized, round-oval smooth skin, eyes fleet, and pale yellow fleshes having purple sprouts. It is an early maturing variety (80-90 days) yielded 400 q/ha. This variety is resistant to late blight. It is not suitable for processing. It is widely adaptable in Haryana and Punjab, plateau region of Gujarat, Karnataka and Madhya Pradesh. It is suitable for intensive cropping.

Medium maturing Varieties (90-100) :

Kufri Jyoti : It is a derivative of the cross 3069d(4) x 2814 Q(1) and released in 1968 by the Central Variety Release Committee for Himachal Pradesh and Kumaon Hills of Uttranchal and also plains where late blight is a limiting factor. Plants are tall, compact and erect. Terminal leaflet is a cottony or cordite and leaflet of top 2-3 leaves incurred at the base. Leaflets are broad and light green. Tubers are oval, white, eye fleet. Flesh is light white and waxy.

Table-1 : Status of potato in M.P after every 10 years.

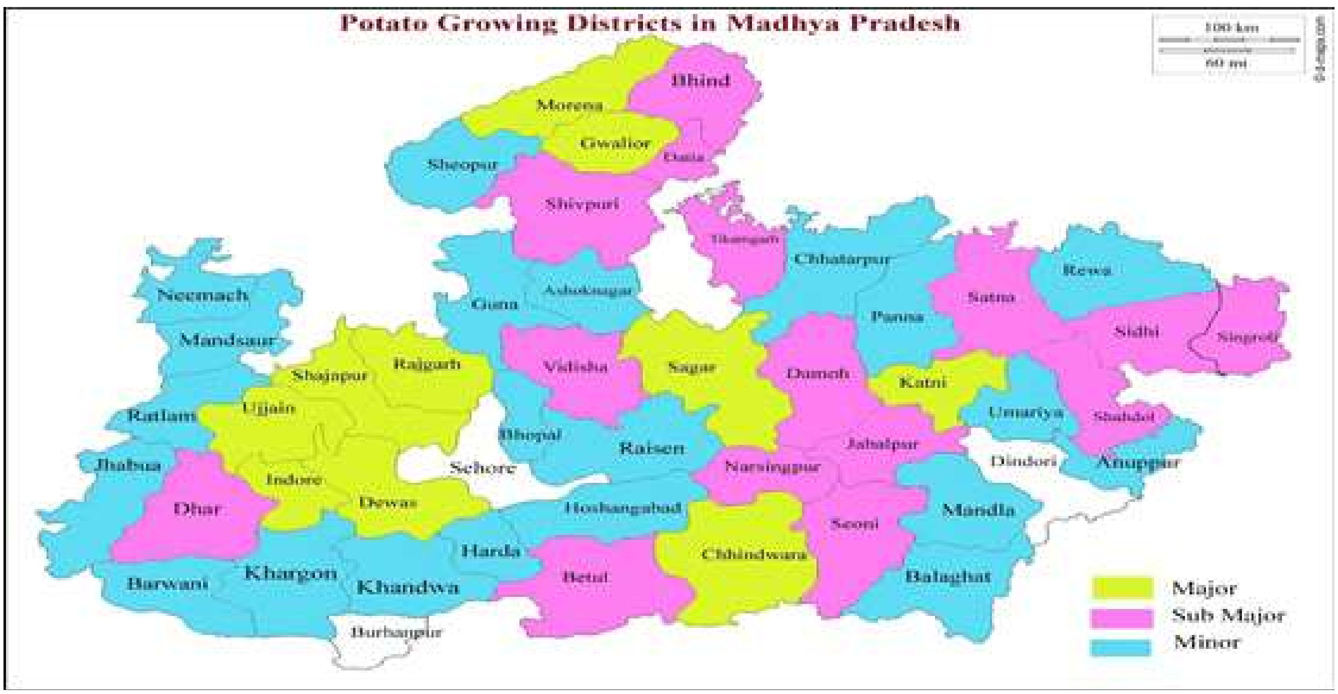
Year	Area '000' ha	Production (in '000 MT)	Productivity (in Mt/Ha)
1970-1971	16.500	168.000	10.18
1971-1980	19.183	212.500	11.09
1981-1990	29.222	347.740	11.89
1991-2000	45.131	635.147	13.87
2001-2010	53.793	695.543	12.93
2011-2015	113.440	2357.283	20.78

Source : Horticulture data base, 2015

Table-2 : Potato growing district in Madhya Pradesh.

S.N.	Districts	2013-14		2014-15		2015-16		2016-17	
		Area	Prod.	Area	Prod.	Area	Prod.	Area	Prod.
1.	Indore	34	748	34.25	753.5	39	858	45.40	998.80
2.	Shajapur	9.04	167.29	11.084	205.195	12.10	266.20	15.10	320.170
3.	Dewas	6.805	132.698	7.556	18.12	7.881	154.378	8.102	159.609
4.	Chhindwara	6.801	170.025	7.506	146.975	7.312	182.800	7.86	196.500
5.	Ujjain	4.805	125.891	7.099	177.475	12.120	233.310	12.76	244.976

Source : Horticulture data base, 2015



Sprouts are blue purple and medium thick. It has good keeping quality if given proper post harvest treatment. It is field resistant to late blight with immunity to race. It is resistant to early blight and wart disease. It matures 100 days in plains and 120 days in hills. The yield potential is 200 and 150 q/ha in plains and hills, respectively.

Kufri Bahar : It is a derivative of the cross Kufri Red x Ginek and released by Central Sub- Committee on Release of Varieties in 1980 for the plains of Haryana, Punjab and Western Uttar Pradesh. Plants are tall erect, medium compact and vigorous. Stem is thick, 4-5 stems per plant, succulent, semi-solid with moderately developed wings. Leaves are open, straight with 4-5 pairs of leaflets. Leaflets are grey green, medium, dull with entire margins. Foliage is of grey green colour. Tubers are large, white, round to oval, skin smooth with medium deep eyes, flesh white. Sprouts are bulbous and red. Stolens are medium long. This variety has moderate flowering, having white flowers, medium in size and sterile.

Keeping quality is average with medium

Table-3 : Recommended varieties for Madhya Pradesh.

S. No.	Duration and Type of variety	Recommended Varieties	Yield (t/ha)
1.	Early Planting	Kufri Surya, Kufri lima & Kufri Jyoti	17
2.	Early maturing (70-90 days)	Kufri Pukhraj, Kufri Ashoka & Kufri Chandramukhi, K. Lauvkar	28
3.	Medium maturing (90-110 days)	Kufri Pushkar. Kufri Jawahar Kufri Bahar & Kufri Chip. – 3	40
4.	Late maturing	Kufri Lalima Kufri Sindhuri, K. Aruna, K. Badshah	45
5.	Processing	Kufri Chipsona – 1, Kufri Chipsona – 2, Kufri Chipsona – 3, Kufri Frysona & Kufri Surya	40

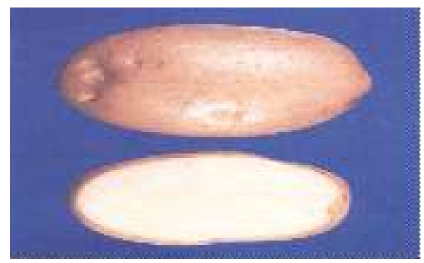
Table-4 : Varieties grown and its percent share in MP.

S.N.	Variety Grown	% share	S.N.	Variety Grown	% share
1.	K. Jyoti	26.3	7.	K. Chipsona-2	6.3
2.	K. Chipsona-1	25.5	8.	K. Pukhraj	1.5
3.	K. Lauvkar	13.5	9.	K. Surya	1.4
4.	K. Chipsona-3	10.3	10.	K. Ashoka	1.4
5.	K. Sinduri	10.3	11.	K. Pushkar	0.9
6.	K. Chandramukhi	8.5			

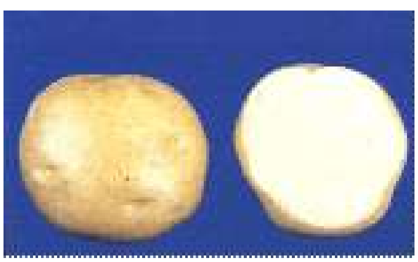
*Percent share vary as per availability of seed at the time of planting.

K. Ashoka

K. Jawahar

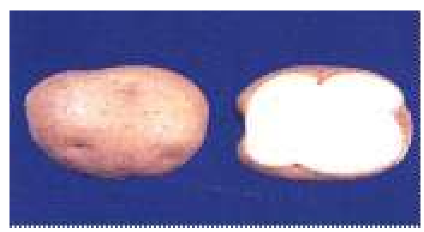


K. Jyoti



K. Bahar

K. Pukhraj



K. Sindhuri

dormancy. It is mid maturity variety (90-100 days). Yield is 250-300 q/ha. Resistant to late blight, early blight and potato virus ‘X’, ‘Y’ and leaf roll. It is susceptible to insect pests, drought and frost.

Kufri Pukhraj : It is a wider adaptable variety and a cross of Craig’s Defiance x JEX/B-687, which released in 1998 from CPRI, Shimla. Plants are tall, semi-erect, medium compact and vigorous. Stems are few, medium thick, green with moderately developed straight wings. Foliage is dark grey green. Leaves are closed with large sized foliage, rachis green. Leaflets are ovate to lanceolate, smooth glossy surface with entire margin. Flowers are white and moderate in flowering, anthers orange yellow, well-developed, high pollen stability and round stigma. Tubers are white, large, oval, slightly tapered, smooth skin, fleet eyes, and yellow flesh having blue purple sprouts. It is an early maturing variety (70- 90 days). The yield potential is 400 q/ha. It is resistant to early blight and moderately resistant to late blight. It is not suitable for processing.

Kufri Sutlej : It is a derivative of Kufri Bahar x Kufri Alankar and released in 1996 from CPRI, Shimla. Plants are medium compact and vigorous. Stem are few, thick, lightly pigmented at base with moderately developed wavy wings. Foliage is grey green. Leaves are ovate-lanceolate and chis slightly pigmented. Leaflet is ovate, smooth dull sur1ace with entire margin. Flowers are white moderates in flowering. Anthers are orange yellow, well-developed and high pollen stability. Stigma is round and slightly notched. Tubers are white, large, oval, smooth skin, fleet eyes, and white flesh and sprouts light red. It is medium maturing (90-100 days) variety yielded 400 q/ha. This variety is moderately resistant to late blight. It is recommended for cultivation in Bihar, Haryana, Madhya Pradesh, Punjab and Uttar Pradesh. This variety has good consumer quality because of easy to cook, waxy texture, and mild flavour and free from discolouration after cooking. It possesses medium dry matter. It is not suitable for processing.

Late maturing varieties (100-110) :

Kufri Sindhuri : It is derivative of the cross Kufri Kundan x Kufri Red and released by Central Variety Release Committee in 1966 for plains of Punjab, Jammu, Orissa, Bihar, Haryana, Uttar Pradesh, Madhya Pradesh and West Bengal. Plants are tall, erect, stems thick having pigment in most part of stem. Leaf rachis is pigmented and leaves open and stiff. Leaflets are dull, basal lobe unequal, petiole slightly pigmented but not midrib. Tubers are round, light red, with medium deep eyes. Flesh is dull white. Tubers are moderate in number, skin firm, not prone to brushing, bigger tubers having tendency to develop hollow heart. Keeping quality is good. It is late variety and matures in 120 days in plains and 165 days in hills. In plains, it yields 300 q/ha. It is slightly resistance to frost. It is Tuber Crops susceptible to late blight, common scab charcoal rot and wilts, moderately resistant to early blight and possesses field resistance to viral disease.

Kufri Badshah : It is a cross of Kufri Jyoti and Kufri Alankar and released in 1980 by Central Sub Committee on release in varieties for Indo-gangetic plains of North India, including Punjab, Haryana, Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh and Plateau region. Plants are tall, haulms erect, 4-5 stems per plant with a tendency for branching, semi-solid, flexible, slightly pubescent, red purple, well developed straight wings and short (about 7-8 cm) internodes. Leaves are green, medium long, prominent venation, rachis pigmented at base, disposition almost at right angles with the stem. Leaflets are broad, medium in size, slightly hairy, entire margin, ovate, glassy veins prominent, and petiole green, usually four pairs and one terminal leaflet. Tubers are mostly large to medium, oval, shining white, smooth, regular with shallow eyes, flesh dull white, sprouts stout, thick, bulbous white with light red pigmentation at the base. Stolen are thick, short and white. Flowers are scanty, white, and medium in size, fully stretching wings, pollen fertility 50-60 per cent and frequently set berries in the hills. This variety possesses medium dormancy. This variety has average keeping quality. It shows slow rate of degeneration. Tubers are tasty with good flavour. It contains 13.6 g/100 g starch and 18.6 per cent dry matter content. It matures in plains 90-100 days. It is tolerant to frost, resistant to late blight, early blight and potato virus 'X' but susceptible to soft.

Crop Management Practices for Potato Production in Madhya Pradesh :

Sowing Time : Potato crop is planted after mid rainy season (September-November) in different district of M.P. i.e. Chhindwara, Dewas, Dhar and Shajapur under irrigated condition .This crop is usually dug after 70days and sold in market as early crop to obtained maximum price for the fresh potatoes. Usually, this crop is planted as main crop from October -November onward and harvested at full maturity for transportation and cold storage. The yield from this crop is higher than early planted crop.

1.	Planting time	:	Ist fortnight of November
2.	Seed size & rate	:	30-45g & 25.35 q/ha
3.	Spacing	:	60 X 20 cm
4.	Manures and Fertilizers	:	20 tonnes FYM and 120:100:100 NPK kg/ha
5.	Irrigation	:	Generally 5-6 depending upon the soil type
6.	Plant Protection	:	Nov. IVth week: Mancozeb (0.2%) + Systematic insecticide (Three spray every 15 day)
7.	Haulm cutting	:	January IIIrd/IVth week
8.	Yield	:	25 to 40 t/h

Cropping System : The intensive cropping system utilizes resources efficient and produces high yields. Potato being short duration crop and highly responsive to fertilizer and irrigation was consider as suitable crops for inclusion in multiple and intercropping systems. Introduction of potato in crop sequence bring about considerable change in the performance of the cropping system, it is possible to get high yield of crop succeeding potato even grown under reduces input conditions

Weed Management : Weed compete with the Potato crop for nutrient, moisture, light , space and also serve as an alternate host of several insect pest and diseases. Weed must be controlled in about 4 weeks after emergence to gain competitive advantages for the crop. The most crictal period for weed competition was formed 4 to 6 weeks after planting. Hot weather cultivation in summer is particularly helpful in the destruction of weeds like *cynodon dactylon and cyprus rotundes L.* Paraquate @ 0.4 to 0.5 kg ai/ha as post emergence at 5% emergence found effective to control the weeds or proponil @ 1.00 kg a.i/ha as also effective.

Earthing Up : The potato haulms are to be earthed up to cover the growing stolen and developing tubers. Generally, one earthing up is enough when the crop is 15 – 20 cm tall and just starts stolen formation. Depending upon the variety and duration of the crop, a second earthing up can also be done for properly covering the tubers. Earthing up is done with the help of spade or ridge plough and this operation should be completed timely as it will have direct bearing on the final tuber yield.

Seed Potato utilization in Madhya Pradesh : Madhya Pradesh and Gujarat are one of the major potato producing states of India. They together contribute 9.3% area of total potato area in the country and produced nearly 11% of total production of India. Both of these states are having advantage in production of processing potatoes in the country due to suitable climatic conditions. However, seed potato for these states is mostly supplied by Punjab and UP.

Potato Storage : Unlike in the temperate regions of the world where potatoes are harvested and stored during the cold winters, in India potatoes are harvested in February-March. In Madhya Pradesh (Indore Gangetic Planes) when the temperature begin to rise and have to be stored during the hot summer months. Potato storage method in the state can be broadly divided into two categories, viz., refrigerated storage and non-refrigerated or traditional storage.

Table-5 : Ideal storage temperature and RH for different uses.

Intended Use	Temp (°C)	RH in (%)
Seed purpose	2-4	95
Table purpose	7	98
Processing purpose	8-12	95

Source : CPRI,Technical Bulletin

1. Refrigerated storage : Potatoes harvested in February, March have to be stored until October and refrigeration is essential for such long term storage. Low temperature storage is most common method of potato storage throughout the state. It is effective because of 4°C and below, no sprouting takes place and the metabolic process of potatoes are slowed down. Therefore, losses caused by respiration are minimum this type of storage is most suited for potato seed storage. The total capacity of multipurpose cold storage facility is over 7 lakh tones. Over 50% of this capacity is utilized by potatoes alone.

2. Traditional Storage/Non-refrigerated : Several traditional method of potato storage are being practiced by the farmers. The traditional method of storing potato in heaps and pits are very common in storing small quantity of potatoes (15-20 tonnes) for 3-4 months .These methods are very cheap and no investment is needed for storage structures & this type of storage methods are readily acceptable to farmers . The material required for covering the heaps are locally available and farmers can do it themselves on the cost of labour. Large quantities of ware potatoes are being stored in heap and pits in Madhya Pradesh. Farmers of Ujjain and Indore districts are practicing these methods successfully. Heaps are made by heaping potatoes in the shade under a tree. There are two types of pits viz. Pakka and katcha.

Processing : Potato is a semi-perishable commodity and it is harvesting time (March/April) coincides with the rise in temperature in Indo-Gangetic plains which contributes about 85 percent of total production in India. Therefore, the potato produce requires to be shifted in cold storage. It has been observed that all varieties of potato are not suitable for processing. The dry matter and reducing sugar content are two important parameter for selecting raw materials for processing. K.Jyoti (45%), K.Chipsona-1 (25%), K.Chipsona-3 (10%), K.Chipsona-2 (20%) and K.Surya (5%) percents of processing varieties under cultivation in the Madhya Pradesh.

The processing Potato products :

1. Fried Products : Potato chips (80 % process in this type), frozen French fries, other frozen fries

2. Dehydrated Products : Dehydrated chips, dices, flakes, granules, flour (20 % process in this type), starch, potato custard powder soup or gravy thickener and potato biscuits.

3. Non-Fried products : Potato jam, potato murraba, potato biscuits and potato cakes.

Major Constraints in Potato Production in Madhya Pradesh :

1. Non availability of quality seed of recommended variety timely : Although there are several improved potato cultures released for the cultivation to suit different agro-climatic conditions of the state, the demand is very high for more early maturing and processing cultivars.

1. Potato production and protection : Arable land and water resources are shrinking due to increase in population, urbanization and man made waste lands. This calls for identification of remunerative mixed/ relay cropping systems for different areas, standardization of package of practice for such cropping system and developing of integrated water and nutrient management practice. Other challenges are incidence of a wide range of biotic stresses (fungal, bacteria, viral and insect pests) and heavy use of agro-chemicals.

2. Planting material : Availability of pathogen-free planting material for assuring economic production is very important in potato. Low rate of multiplication necessitates several field multiplications of initial disease-free material, causing progressive accumulation of degenerative viral diseases in seed tubers. Aphids are the major vector for potato viruses.

3. High cost of potato seed : Expensive seed potato was found to be the second important constraints in the state Poor and inadequate source of irrigation

Future Strategies

There is a need to strengthen adaptive research and technology assessment, refinement and transfer capabilities so that the existing wide technology transfer gaps are bridged. For this an appropriate network of extension service needs to be created to stimulate and encourage both top down and bottom up flows of information between farmers, extension worker and research scientists. Reliable and timely availability of quality inputs at reasonable prices, institutional and credit supports, especially for small and resource poor farmers, and support to land and water resources development. Emphasis should be put on the establishment of new cold storages, processing industries in the production catchments to minimize transport cost, create employment opportunity in the rural sector to utilize process waste & by products for feed/ manure. There is much demand for processed products, baby potatoes, medium large sized tubers with yellow flesh and firm cooking quality as well as organically grown potatoes. Hence, the farmers are encouraged for value addition for better remuneration.

However, to harness the opportunities provided by globalization, certain exclusive measures need to be taken to develop globally competitive production technologies, infrastructure, and policies to boost production, utilization marketing, and exports.

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Chapter 11

Therapeutic Potential of Kair (*Capparis Decidua*)

Jyoti[1] and Aarzoo Jangra[2]
[1]*Department of Foods and Nutrition, CCS HAU, Hisar, Haryana, India*
[2]*Department of Life Science Pdm, Bahadurghad, Delhi, India*
Email : jyotirao12362@gmail.com

Abstract

Use of medicinal plants is an important part of traditional medicine. One of these plants which are anciently used for its beneficial properties in India is *Capparis decidua. C. decidua* is one of the traditional medicinally important plants available all over India. It is a medicinal plant of family *Capparaceae* grows abundantly in dry regions in India, Pakistan, Egypt and Tropical Africa. It is commonly known with hundreds of vernacular names; few common are Kari, Delha, Caper, Kair, Karyal, Hanbag, Karil, Kabra, etc. The whole plant of *C. decidua* is edible and used as a food. Unripe fruits are pickled and also used as vegetables. *Capparis decidua* is a drought- resistant plant. Besides many ecological and socioeconomic benefits, different parts of this plant have a several benefits in medicines. The plant is usually used to treat arthritis, toothache, asthma, inflammation, swelling, cough, malaria, intermittent fevers and rheumatism. Fruit pulp and root bark extract made in alcohol is claimed to have anti-helminthic activity. The seeds and fruits are used to cure dysentery, cholera and urinary purulent discharges. Della plant and its different parts have been traditionally used for the treatment of a variety of diseases. *C. decidua* contains generous quantities of alkaloids, fatty acids, terpenes, vitamins, fibre and oils that show greater medicinal and nutritive value.

Key words : *Capparis decidua, anti-helminthic, rheumatism, nutritive value.*

Introduction

According to World Health Organization (WHO), approximately 80% of the population of developing countries uses traditional medicine for their healthy livelihood. Medicinal plant constitutes the backbone of the traditional system of medicine. The medicinal plant includes the fresh or dried plant, part, whole, chopped or powdered form and plant extract in various solvents. WHO has reported that around 20,000 medicinal plants are being used in the pharmaceutical industry or in folk medicine. Now theses day's herbal medicinal system is being preferred over the conventional medicinal system as they are inexpensive, easily available and has no adverse effect during the treatment (Patil and Naikwade 2018). In this respect a herb commonly famous as teent or kair and scientifically known as *Capparis decidua.* The occurrence of various physiologically active constituents makes *C. decidua* beneficial for mankind. *Capparis decidua*, a medicinal plant of family *Capparaceae* grows abundantly in dry regions in India, Pakistan, Egypt and Tropical Africa (Eddouks, 2017). It is commonly known with hundreds of vernacular names; few common are Kari, Delha, Caper, Kair, Karyal, Karil, Kabra, etc. It shows the presence of various chemical constituents such as glucosinolates, phenolics, polyamine alkaloids, flavonoids. Ayurvedic and Unani system claim *C. decidua* possessed many pharmacological attributes

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such as antidiabetic, antihelmintic, antibacterial, antifungal, antirheumatic, hypolipidemic, antiathero-sclerotic, anti-tumor, antioxidant, anti-inflammatory, hepatoprotective, and anticonvulsant activities.

The abundance of various physiologically active constituents makes *C. decidua* beneficial for mankind (Moufid *et al.,* 2015). Traditionally bark of the plant has been used in boils, cough, asthma, inflammation and root is helpful in fever management, as anthelmintic and purgative, leaves are used in pyorrhoea. Wood coal is useful in muscular injuries. The plant is also used in rheumatism, liver infections, ulcer, piles, renal disorders, diarrhoea, febrifuge, skin diseases, constipation, lumbago, toothache, dysentery and cardiac troubles. The plant also acts as aphrodisiac, analgesic, alexipharmic, emmenagogue tonic, purgative, and appetite enhancer. In Sudan, *C. decidua* is useful in swelling, jaundice and infection of joints. In Unani system, leaves are beneficial as an appetizer, in cardiac troubles and in biliousness. In combination with shoots of *Peganum hermala* shoots of *C. decidua* are used as anti-fertility drug (Singh and Singh 2011). Presence of carbohydrates, protein, fibre and minerals including calcium, potassium, zinc, manganese, iron makes this plant a nutritional food. It is rich in vitamin C and is the richest source of beta carotene, moreover the oil content of the seed, sugar and protein content of flower contributes to its nutritional values (Baby and Jini 2011). *C. decidua* contains chemical constituents, which include the saccharides and glycosides, flavonoids, alkaloids, terpenoids and volatile oils, fatty acids and steroids that possess enormous pharmacological effects and shows anti-inflammatory, odynolysis, anti-fungus, hepatoprotective effect, hypoglycemic activity, anti-oxidation, anti-hyperlipemia, anti-coagulated blood, smooth muscle stimulation, anti-stress reaction, and improves memory. The edible fruits are rich in protein and minerals and have a high seed fat content. Seed contents 20% oil, 1.7% sugar and 8.6% protein. Root and bark in powder form is used in rheumatism, gout, dropsy, palsy and haemostatic. Bark is useful for cough and asthma. Root bark is given in intermittent fever.

Occurrence and Distribution

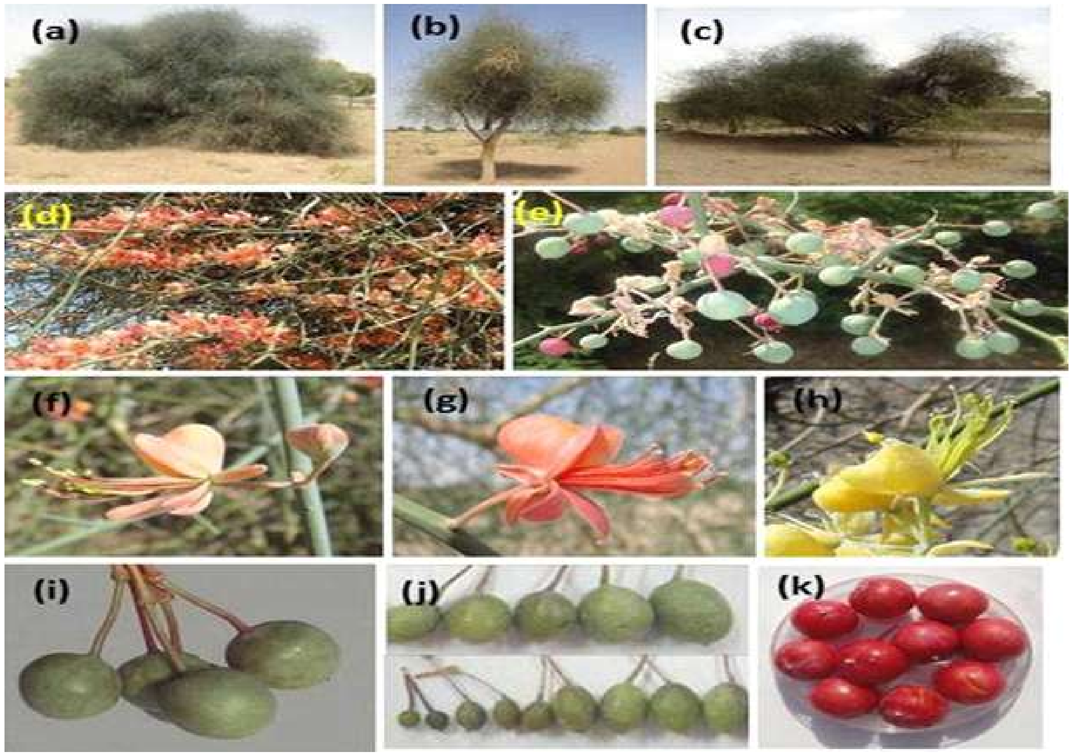
It is commonly existence in dry places in Sind, Baluchistan, Western Rajputana, Deccan Peninsula, Egypt, Socotra, Arabia, Tropical Africa, Central India, Punjab, Gujarat, Tinnevelly and Pakistan. *C. decidua* or Kair is a native medicinal plant of India having large biodiversity in different north-western states of India (Troup 1975). The plant usually grows in dry, exposed habitat, often on foothills, in wastelands. It is found in the deserts, especially of Rajputana, Punjab and Sind, southwards to Karnataka and Tamil Nadu, growing wild in Western Ghats, Rajasthan and Gujarat (Bown 2008). It can be found at the altitude range from 300-1 200m with mean annual rainfall of 100-750mm and mean annual temperature of 25-41°C. It has been found to be one of the best species for afforestation, reforestation and shelter belts to check the movement of sand in the Thar Desert, India (Pandey and Rokad 1992). It is highly drought resistant and tolerates some frost, resulting in an interesting plant because of its excellent adaptation to arid conditions. It can also tolerate fire and termites.

Table-1 : Nutritional composition of *C. decidua* fruits.

Components	Nutritional contents
Total carbohydrate (g)	73.48%
Protein	14.88%
Fat	7.43%
Dietary Fibre (g)	42.88%
Ash	5.96%
Calcium (mg)	90 mg/100g
Phosphorus	179 mg/100g
Zinc	1.6 mg/100g
Iron	3.5 mg/100g
Beta-carotene (mg)	5.4 mg/100g
Ascorbic acid (mg)	120 mg/100g

Traditional Uses

Plant has its vast utility in traditional folk medicine and is used as ailments to relieve variety of pains or aches such as toothache, cough and asthma heal. Many studies indicated that the plant have significant pharmacological benefits like hypercholesterolemia, anti-inflammatory and analgesic, anti-diabetic, anti-microbial, anti-plaque, anti-hypertensive, anti-helmintic activities. The compositional studies suggested *C. decidua* seeds as rich sources of all three major food components, i.e., carbohydrates, lipids and proteins. The plant and its parts are commonly used by traditional healers and tribal people for curing variety of ailments. Powder or infusion of root bark is used in gout, rheumatism, cough, dropsy, palsy, asthma, intestinal worms and intermittent fever. The powder is applied externally on malignant ulcer (Chunekar and Pandey 1999). A paste of coal obtained after burning the wood is applied to muscular injuries (Gupta and Shama 2007). The flowers contain a steam volatile sulphur compound



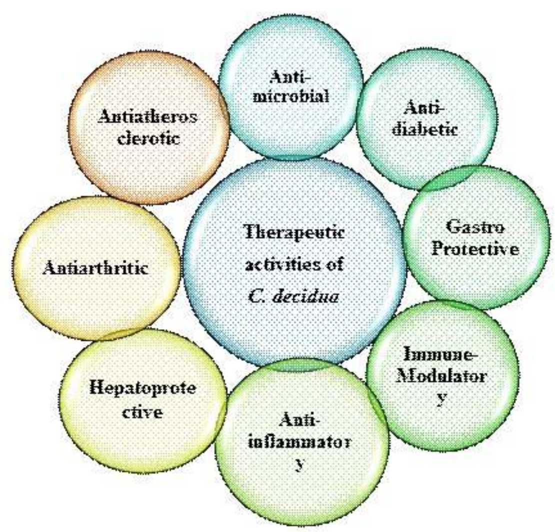
(0.4%), which is active against several micro-organisms.

The top shoots and young leaves are made into a powder and used in blister; they are also helpful in boils, eruptions and swellings and as an antidote to poison. They are very effective in relieving toothache when chewed (Kirtikar and Basu 2008) a decoction of ground stems and leaves are used for pyorrhea. Infusion of plant is used externally for eruptions, boils, joint diseases and internally in cough and as an antidote in case of poisoning. Juice of fresh plant is used to kill worms in ear. It is also advised as a good substitute of senega (Nadkarni 1954).

The green berries and flower buds of *C. decidua* are edible and commonly pickled or used in preparation of vegetable and curry due to the folkloric belief that they have hypoglycemic effect in diabetes (Marwat *et al.*, 2011). It is given in phthisis, heart diseases and scurvy. In Rajputana, the plant is used as a fodder for camels. Root powder is taken with water in liver problems (Shekhawat and Batra 2006). The root bark extract is given twice a day for 3 days in the treatment of haemorrhoids.

Roots are advised to be sudorific, thermogenic, expectorant, carminative, digestive, stimulant, antibacterial, aphrodisiac, anodyne, anthelmintic and useful in arthritis, dyspepsia, constipation, lumbago, odontalgia, amenorrhoea and dysmenorrhoea (Longman *et al.,* 1994).

The plant is used for the medicinal treatment in diabetes, rheumatism, hypertension and various stomach problems. Flower buds are eaten to relieve stomach ache; root paste is applied on scorpion bite; powdered coal from stem is taken during fractured bone (Meena and Yadav 2010).



Therapeutic uses of *Capparis decidua*

Anti-diabetic activity : Grover *et al.,* (2002) have been reported that *C. decidua* may have potential use as an anti-diabetic agent and in lowering oxidative stress in diabetes. Fruits maintain anti-diabetic activity. *C. decidua* powder has hypo-glycaemic activity,

Table-2 : Pharmaceutical/Therapeutic Potential of Different Caper Parts.

Part	Diseases	References
Stem barks	Toothache, cough, asthma, intermittent fever, rheumatism, inflammation, kidney infection, and treatment of wounds as poultice	Afsharypuor *et al.*,1998; Ahmad *et al.*, 1992; Ozcan, 2005; Marwat *et al.,* 2011
Fruits and flowers	Diabetes, respiratory diseases, skin, anthelmintic, diuretic, cardiac and biliousness diseases, anti-diabetic and eyesight smoothing properties, laxative potential, atherosclerosis, and plaque	Nadkarni and Nadkarni 1954; Rathee *et al.,* 2011; Sharma and Kumar 2008; Vaidya, 1995; Warrier et al., 1996
Roots	Digestive diseases, stimulant, anodyne, sudorific, constipation, lumbago, odontalgia, and amenorrehoea	Warrier *et al.,* 1996
Root bark	Gout, cough, flu, dropsy, palsy, asthma, and intestinal worms	Pandey *et al.,* 1998
Leaves	Toothache, swellings, and blisters	Vaidya, 1995
Shoot	Hypercholesterolemia	Goyal and Grewal 2003

decreases lipid peroxidation and alters free radical scavenging enzymes such as superoxide dismutase and catalase in erythrocytes, liver, kidney and heart in aged alloxan induced diabetic rats. *C. decidua* powder is used against alloxan induced oxidative stress and diabetes in rats. The aqueous & ethanolic extracts were orally administered to diabetic rats at 250 and 500 Mg/kg doses daily for 21 days to determine anti-diabetic activity. Purohit and Vyas (2006) studied that aqueous and ethanolic extract of stem has significant hypo-glycaemic and anti-diabetic potential.

Hypo-cholesterolemic effect : The unripe fruits and shoots extract of *C. decidua* cause reduction in plasma triglycerides, total lipids and phospholipids; hence used as hyper-cholesterolemic. It used to operate through increased fecal excretion of cholesterol as well as bile acids (Goyal and Grewal 2003). Fasting blood samples were analyzed for total, LDL and HDL cholesterol at pre and post of experiment. A significant decrease in the total cholesterol (13%) and LDL cholesterol (16%) was seen. However, no significant change in HDL cholesterol was recorded. *C. decidua* supplementation may have an important role in nutritional management of hypercholesterolemia (Goyal and Grewal 2010; Grover *et al.,* 2002).

Antioxidant activity : Yadav *et al.,* (1997) reported that powdered fruit of *C. decidua* decreased Alloxan induced lipid peroxidation significantly in erythrocytes, kidney and heart. Treatment with *C. decidua* lowers alloxan induced lipid peroxidation and alters superoxide dismutase and catalase enzymes to reduce oxidative stress. Anti-oxidant and -cell regeneration effect of stem extract in streptozotocin-induced diabetic rat have been evaluated. Methanolic extract and active fraction from stem part significantly decreased blood glucose levels in diabetic rats. Extract exerted rapid protective effects against lipid peroxidation by scavenging of free radicals therefore reducing risk of diabetic complications (Dangi and Mishra 2011).

Hypo-lipidemic activity : Chahlia, 2009 examined that the three different alcoholic extracts obtained from bark, flower and fruit have been shown to have hypo-lipidaemic activities in rats. The alcoholic extracts improved the elevated levels of serum lipids to normal and showed significant decrease in levels of total cholesterol, triglycerides, LDL and VLDL cholesterol. Alcoholic extract of husk of fruits, seeds and flowers were demonstrated to be antibacterial (Gaind *et al.,* 1969). In Purohit and Vyas (2005) studied that high fat diet caused significant (8-fold) increase in serum total cholesterol in rabbits. Administration of *C. decidua* fruit extracts (50% ethanolic) dosage of 500mg/kg body weight which significantly reduced serum total cholesterol (61%), LDL cholesterol (71%), triglycerides (32%) and phospholipids (25%). Similarly C. decidua shoot extract lowered serum total cholesterol (48%), LDL cholesterol (57%), triglycerides (38%) and phospholipids (36%). The cholesterol content of aorta was decreased by 44 and 28% in fruit and shoot extract treatment respectively. The results proved the hypolipidemic potential of *C. decidua* fruit and shoot. 50% ethanolic fruit extract showed hypolipidemic effect in cholesterol fed rabbits, by significant decreased in serum cholesterol, serum triglycerides and LDL and increase HDL ratio and excretion of cholesterol (Sharma *et al.,* 1991).

Antihypertensive Activity : Ethanolic extract of *C. decidua* caused a fall in systolic, diastolic and mean blood pressure in a dose dependent manner. The administration of 1,3,10 mg/kg doses of the extract manifested decreases of 20%, 30% and 47% in mean arterial blood pressure respectively. It was observed that hypotensive effect was short as far as onset of duration ultimately returning to normal within 2 min (Eldeen S and Staden 2008). On the whole it can be logically deduced that the alcoholic extract of *C. decidua* produces non-specific relaxant effects on cardiac and smooth muscle tissue and that this action is probably responsible for its hypotensive and bradycardiac effects (Singh *et al.*, 2011).

Conclusions

C. decidua fruits, leaves are highly nutritive and contain considerable amount of vitamins and minerals especially calcium, Phosphorus, iron and -carotene. Aqueous extract of C. decidua stem reduces the blood glucose level moderately but the ethanolic extract significantly reduces the high blood glucose levels in diabetic rats. Administration of *C. decidua* extract markedly improving serum total cholesterol, Triglyceride level, LDL-c and HDL-c levels in cholesterolfed rabbits. The higher dose of extract or dried powder works better than that of lower dose. Administration of *C. decidua* (100 and 200 mg/kg) hydroalcoholic extract significantly decreased the level of ALP, AST and ALT and increased the level of total protein that confirms the anti-arthritic activity of the extract. *C. decidua* fruits, leaves and bark are rich in dietary fibre and bioactive compounds. Their consumption is beneficial on diabetes mediated kidney damage either by directly decreasing blood glucose or through the action of various compounds that decreased oxidative stress. To keep the traditional practices alive it is necessary to preserve the plants in larger habitat, by modifying and making environment more pleasing for conservation of all kinds of plant diversity in deserts. Efforts should be made to start field cultivation of various Capparis species for its in situ conservation for future creation. Therefore, there is a necessity to grow Capparis by afforestation in all climatic conditions according to their basic adaptations. Its cultivation should be widen to fetch industrially important compounds.

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Chapter 12

Invasive Insect Pests in India and their Management

Naveen Rao* and Rajan Kamboj
Department of Entomology, College of Agriculture, CCS Haryana Agricultural University, Hisar, Haryana
**Corresponding Author Email : naveenrao402@gmail.com*

Abstract

Alien species are non-native or exotic organisms that occur outside their natural adapted habitat and dispersal potential. The alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express their capability to establish, invade and outcompete native species. Globalization has increased international agricultural trade; the movement of seeds and planting materials has enhanced the risk of alien pests into India. Free trade propelled by economic liberalization has intensified the movement of goods across frontiers and geographic barriers without much quarantine, enhancing chances of introduction of exotic pests into agroecosystems. If not accompanied by the natural enemies that keep them in check in their native range, these species can multiply in large proportion and cause damage to economically important plant species and crop plants. Alien Species (IAS) is now recognized as one of the greatest threats to the country's ecological and economic well-being. These species cause enormous damage to biodiversity and the valuable natural agricultural systems upon which we depend.

Key words : *Invasive, alien species, agroecosystem, natural enemies.*

Introduction

Alien species are non-native or exotic organisms that occur outside their natural adapted habitat. The alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and outcompete native species (Raghubanshi *et al.,* 2005). International Union for Conservation of Nature and Natural Resources (IUCN) defines Alien Invasive Species as one which becomes established in natural or semi-natural ecosystems or habitats and threatens native biological diversity. These invasive are widely distributed in all kinds of ecosystems throughout the world and include all categories of living organisms.

Globalization has increased international agricultural trade; the movement of seeds and planting materials has enhanced the risk of the introduction of alien pests. If not accompanied by the natural enemies that keep them in check in their native range, these species can multiply in large proportion and cause damage to economically important plant species and crop plants. Every species has a natural geographic area in which it is considered part of the native flora and fauna that make up the region's biodiversity. Some species have a very small geographic range, while others may be found over multiple provinces or even one or more continents.

Dreaded invasive alien insects in India

In the last three decades, at least 11 species of insect and mite pests have gained entry into our country such as Subabul psyllid, *Heteropsylla cubana*

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Crawford; American serpentine leafminer, *Liriomyza trifolii* Burgess; coffee berry borer, *Hypothenemus hampei* Ferrari; Spiralling whitefly, *Aleurodicus disperses* Russell; *Coconut mite, Aceria guerreronis* Keifer; silver leaf whitefly, *Bemisia argentifolii* Bellows and Perring; *Papaya mealybug, Paracoccus marginatus* Williams and Granara de Willink; *Eucalyptus* gall wasp, Leptocybe invasa Fisher and La Salle; *Madeira mealybug*, *Phenacoccus madeirensis*; Pseudococcus jackbeardsleyi Gimpel and Miller; Tomato leafminer Tuta absoluta Meyrick and Phenacoccus solani Ferris (Shylesha *et al.* 2012). Due to changes in the climate, change in the agricultural practices, the introduction of Bt cotton, and free movement of planting material, some insects flare up locally and cause considerable damage to our economy, as it happened with the woolly sugarcane aphid, Ceratovacuna lanigera Zehntner and the cotton mealybug, Phenacoccus solenopsis Tinsley. Problems caused by such invasive species in agricultural ecosystems, primarily through accidental introductions, are manifold.

These alien pests find the new habitat ideal and conducive for breeding and establishment without any restriction through natural regulating factors like natural enemies that keep these species under check in their native range. Managing such invasive species is ideally attempted through classical biological control involving the introduction of effective exotic natural enemies from the native range of the introduced pests to re-establish the lost balance between the pests and the natural enemies. In the coming years, many more alien insect pests are expected to find their way into India. These exotic insects are already causing considerable losses to several crops in the neighboring countries.

Blue Gum Chalcid, Leptocybe invasa Fisher and La Salle (Eulophidae: Hymenotpera)

The blue gum chalcid is a gall-inducing wasp native to Australia. It has become a pest of planted eucalypt forests in various parts, including Kenya, Morocco, New Zealand, Tanzania, and Uganda. Recently it has been reported from Mandya, Karnataka during 2001 in planted forests and nurseries of *Eucalyptus camaldulensis* Dehnh and *E. tereticornis* Smith.

Hosts **:** *Eucalyptus camaldulensis*; *E. tereticornis*; *E. grandis*; *E. deanei*; *E. globules*; *E. nitens*; *E.botryoides*; *E. saligna*; *E.gunii*, *E. robusta*; *E. bridgesiana* and *E. viminalis*.

Spread : The movement of eucalyptus seedlings is one of the ways by which the wasp spreads. The adult wasp is very small and hence cannot fly long distances.

Oviposition : Eucalyptus gall wasp lays eggs in the bark of shoots or the midribs of leaves

Damage : *L. invasa* lays eggs in the bark of shoots or the midribs of leaves. The eggs develop into minute, white, legless larvae within the host plant. Damage is caused when the developing larvae produce galls on the leaf midribs, petioles, and twigs. The galls can cause the twigs to split, destroying the cambium. Small circular holes indicating exit points of adults from pupae are common on the galls. Repeated attacks lead to loss of growth and vigor in susceptible trees. Severely attacked trees show gnarled appearance, stinted growth, lodging, dieback, and eventually tree death (Mendel *et al.,* 2004).

The invasive insect *L. invasa* is presumed to have arrived from Australia on eucalyptus plantations and nurseries in several localities in Tamil Nadu, Puducherry, Karnataka, and Andhra Pradesh. This tiny wasp induced galls on shoot terminals and petioles and midribs in saplings and trees of eucalyptus. The likely source of introducing this pest insect to India could be through the exchange of vegetative materials of eucalyptus. In the future, care needs to be taken to incorporate appropriate genetic diversity with periodic introductions and to phase out of different clones or provenances in plantation programs to minimize economic damage due to invasive pest attacks (Ananthakrishnan, 2009).

Economic loss : During 2008 in Gujarat, 13.63 to 100 percent infestation was found in different nurseries with an average of 62.35 %.

Current Status of Eucalyptus Gall Wasp and its native Parasitoids in Karnataka

A roving survey was conducted during 2010-11 to assess the impact of native parasitoids on eucalyptus gall wasp in Belgaum, Dharwad, Haveri, Davangere, Chitradurga, Tumkur, and Bengaluru Rural districts of Karnataka, India, and the Gall incidence declined drastically due to the activity of native parasitoids. Among the native parasitoids, *Megastigmus dharwadicus* was the most dominant (Ramanagouda *et al.,* 2011).

Biological control : *Quadrastichus mendeli* and *Selitrichodes kryseri* are promising parasitoids.

Erythrina gall wasp (EGW) Quadrastichus erythrinae Kim (Eulophidae: Hymenoptera)

EGW is an invasive insect pest on *Erythrina spp*. in prominent black pepper (*Piper nigrum* L.) areas of Kerala and Karnataka. EGW was first reported damaging *Erythrina spp.* in Taiwan in 2004 and was recorded in India from the southern districts of Kerala, including Thiruvananthapuram District in 2006. Later, it was observed on *Erythrina spp.* in Pune, Satara, Sangli, and Kholapur districts of Maharashtra, Belagavi, and Dharwad districts of Karnataka during the same year. Surveys conducted recently by the Indian Institute of Spices Research, Calicut, in major black pepper areas of Kerala and Karnataka, indicated that the EGW was present in all the districts surveyed (Idukki, Kozhikode, Kannur, and Wayanad in Kerala and Kodagu in Karnataka), damaging *Erythrina spp.* to various levels. The percentage of trees and branches infested by EGW was highest in Wayanad District (59.6 and 41 respectively). Kozhikode and Kannur districts recorded the lowest EGW infestation on trees (31.7%) and branches (15.6%), respectively. The surveys indicated that the infestation of *Erythrina spp*. by EGW is one of the significant constraints for the growth and production of black pepper vines in recent years.

Nature of damage : Shoots become swollen, forming many thick-walled glob galls. After feeding within the galls, the larvae pupate, and the adult wasp cut exit hole through plant gall material to emerge.

Present status of Erythrina gall wasp : At present, there is no severe incidence in Karnataka because promising parasitoids like *Aprostocetus gala* (Plate 3) was recorded 7 to15 percent parasitization (Ramanagouda *et al.,* 2010)

Papaya mealybug, Paracoccus marginatus Williams and Granara de Willink (Hemiptera: Pseudococcidae)

Papaya mealybug is native to Mexico. The infestation was first noticed in 2007 on papaya, at Coimbatore, Tamil Nadu. By 2009, the pest assumed the major pest status across the country and caused massive damage to mulberry, tapioca, jatropha, cotton, several fruits, flowers, and plantation crops in Tamil Nadu, causing 90 percent damage. In June 2010, the occurrence of papaya mealybug in Karnataka on mulberry in Chamarajanagar. The incidence was to the tune of seven percent, and the intensity was recorded to be 42.9 percent. It was confirmed that the pest has just made its entry from Talawadi in Tamil Nadu through infested mulberry cuttings. It was also observed on other plants such as jatropha, okra, parthenium, and abutilon.

Nature of damage : Nymphs and adults of *P. marginatus* suck the plant sap and weaken. The leaves become crinkled, yellowing, and wither. The honeydew excreted by the bug and associated black sooty mold formation impairs the plant's photosynthetic efficiency.

Economic losses : Nearly 576 ha of papaya in Coimbatore districts had been affected, inflicting severe damage to tapioca and mulberry in the neighboring districts of Tamil Nadu. There are 60 plant species as hosts for papaya mealybug; the pest has spread to almost all ecological niches in India through the transport of infested papaya fruits. Fortunately, the pest has been successfully managed through the intervention of classical biological control, wherein *Anagyrus loecki*, *Pseudleptomastix mexicana,* and *Acerophagus papaya* were imported from the USA. There is no severe incidence of papaya mealybug in Karnataka, Kerala, Andhra Pradesh, Maharashtra, and Tamil Nadu due to promising parasitoids like *A. papayae* and *P. Mexicana*; more than 85 per cent parasitization was noticed.

Cotton mealybug, *Phenococcus solenopsis* Tinsley (Hemiptera: Pseudococcidae)

Cotton mealybug is native to Central America; In India, the first incidence of *Phenacoccus solenopsis* in cotton was reported from Punjab in 2006. The widespread damage it caused in the country in 2006 has been of utmost concern to the entire continent. This species was not known to occur in India or Pakistan before 2005, indicating that the pest must have been introduced through planting materials into India. India is a major producer of cotton globally, and cotton cultivation is the livelihood for over 60 million people in India. Cotton mealybug is a major threat to cotton cultivation all over the country and causes significant economic damage. The pest has invaded all cotton-growing areas in the country.

Economic loss caused by cotton mealybug in India : During 2006 mealybug caused 40 to 50 percent damage in Gujarat. Two hundred acres of the cotton crop were destroyed due to the mealybug infestation in the Bhatinda district of Punjab, and the losses caused by the mealybug were estimated to be Rs. One hundred fifty-nine crores to cotton growers during *Kharif* season 2007.

Coconut hispine beetle, Brontispa longissima Gestro (Chrysomelidae: Coleoptera)

It is native to Indonesia and first introduced to India from Sri Lanka in 2009 through infected planting material from Sri Lanka to India.

Current Distribution of *B. longissima* : The pest has been expanding in areas around Southeast Asian countries, and it was found in Myanmar in 2004, followed by the Philippines in 2005.

Hosts **:** Betel nut palm, Coconut, African oil palm, Bottle palm etc.

Biological control : Removing coconut and other palms to prevent the beetle from spreading and using *Asecodes hispinarum and Tetrastichus brontispae*.

Tomato leaf miner Tuta absoluta Meyrick (Gelichiidae : Lepidoptera)

It is native to South America and was initially observed in Pune on tomato plants during October 2014. The infestation of *T. absoluta* ranged from low to high (up to 15 mines/plant) in different tomato fields surveyed in six districts of Karnataka State *viz.,* Bengaluru, Kolar, Chikkaballapur, Ramanagar and Tumkur. The percent infestation was to the tune of 87 percent (Sridhar *et al*., 2014). In Punjab state, *T. absoluta* was observed for the first time on tomatoes at Punjab Agricultural University, Ludhiana, during February 2017 with percent leaf damage ranging from less than 1 percent. In Telangana state, the incidence of *T. absoluta* was observed for the first time on tomatoes at Vegetable Research Station, Rajendranagar, during January 2015, with percent leaf damage ranging from 14.4 to 97.9 (Kumari *et al*., 2015).

Nature of Damage : Larva mines the leaf and feeds on the mesophyll of the leaf.

Alternate hosts : Tomato, Potato, Eggplant, Pepper, Tobacco and other solanaceous plants and weeds.

Economic loss : In Spain, in the first year of introduction, pesticides were applied 15 times more per season. The cost went up by 450 Euros per hectare. If *T. absoluta* invades the world, the tomato pest management cost will increase by $500 M per year.

Cultural Control :

Pest free seedlings

Crop rotation with non-host crops

Soil solarization

Egg parasitoids : *Trichogramma exiguum*, *Trichogramma nerudai*, *Trichogramma pretiosum*

Larval Parasitoids : *Goniozuz nigrifemur* (Bethylidae), *Apanteles spp*. (Braconidae) *Bracon spp*. (Braconidae), *Chelonus sp*. (Braconidae), *Dineulophus phthorimaea* (Eulophidae), *Diadegma sp*. (Ichneumonidae), *Neochrysocharis formosa* (Eulophidae)

Invasive alien insects on fruits and forest trees

The spiraling whitefly, *Aleyrodicus disperses* is an example of an exotic insect invading native crops. It is a native of Central America and spread westward across the Pacific, Southeast Asia and entered India through Sri Lanka in 1994. This insect feeds on more than 150 species, including fruit plants, vegetables, and avenue trees. This insect also feeds on the leaves of intensively managed teak plantations (Varma *et al*., 2001).

Native insects becoming invasive on native plants are also an issue. For example, the Rhinoceros beetle, *Oryctes rhinoceros* is an established pest of coconut palms in India. Very recently, it has become a problem for oil palm in the Southern states of India. The pest incidence in oil palm plantations closer to natural forest areas has been noted in many places. Beetles were also collected from wild forest areas – decaying logs served as breeding grounds, and the adult beetles later migrated to susceptible crops like oil palms and coconut. This is also an example of a pest connection between the agriculture and forestry sectors.

There are several cases of invasion of indigenous insect pests on indigenous tree crops in forest plantations, for example, *Hyblaea puera*, a major defoliator pest of teak. There are periodic outbreaks of this pest in all age classes of teak plantations. Though teak is indigenous only to India, Myanmar, and Thailand, this pest has been reported in other countries where it is exotic. The level and extent of *H. puera* invasion in these countries need to be monitored.

Many pest issues, which earlier were considered minor, have attained pest status in India owing to intensive management practices, especially for teak. Also, new and emerging pests have been attributed to agro-silvicultural practices. For example, *Helicoverpa armigera*, which is known to be a notorious agricultural pest, was found to feed on the terminal shoots of young teak in Tamil Nadu. Here, groundnut was introduced as an intercrop in a young teak plantation to increase the nutrient content of the soil and obtain extra revenue. But the agroforestry practice generated a new pest problem. The spiraling whitefly (*Aleyrodicus disperses*) native of Central America rapidly spread westward across the Pacific and Southeast Asia and entered India from Sri Lanka in 1994. It predates more than 150 species, including fruit, vegetables, avenue trees, and hedge plants. It has already wreaked havoc on 72 plants belonging to 38 genera. The invasion of the coconut mite (*Aceria guerreronis*) causes damage worth Rs 200-250 crores annually in Kerala (Vastrad, 2004).

Conclusions

The spread of invasive alien species is creating complex and far-reaching challenges that threaten both the natural biological riches of the earth and the well-being of our people. At the same time, the global problem, the nature, and severity of the impacts on society, economic life, health, and natural heritage are distributed unevenly across nations and regions. Some aspects of the global IAS problem require solutions tailored to nations' specific values, needs, and priorities, while others call for consolidated action by the larger world community. Preventing the international movement of invasive alien species and coordinating a timely and effective response to invasions requires co-operation among governments, economic sectors, non-governmental organizations, and international treaty organizations.

At the national level, consolidated and coordinated action is required. This could be part of a national biodiversity strategy and action plan, with close involvement of the economic sectors and identifying people responsible for actions involving potential IAS as a critical prerequisite. Clear responsibilities for each relevant sector would need to be identified.

The capacity and expertise to deal with IAS are not yet sufficient in many countries. Therefore further research on and capacity building around the biology and control of IAS and biosecurity issues needs to be given attention and priority. This also relates to financial institutions and other organizations responsible for environment and development co-operation at national and international levels. A global information system regarding the biology and control of IAS is also required. Tools, mechanisms, best management practices, control techniques, and resources must be provided and exchanged. Such a proposed system is currently developed as part of the Global Invasive Species Information Network (GISIN) and is intended to link to the Clearing House Mechanism of the Convention on Biological Diversity. Awareness-raising and education regarding IAS should be given high priority in action plans, and the development of economic tools and incentives for prevention are urgently needed.

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Chapter 13

Organic Farming : Development and Strategies in Indian Perspective

G. Santhosh Kumar[1]*, K. Swathi[1], U. Nagabhushanam[2] and D. Kumaraswamy[3]
[1]*Department of Agronomy, Agricultural College, PJTSAU, Warangal*
[2]*Department of Agricultural Economics, Agricultural College, PJTSAU, Warangal*
[3]*AICRP on rice, Rice section, Regional Agricultural research station, PJTSAU, Warangal*
Email : santhugupta.gangam@gmail.com

Abstract

Organic agriculture is one of the broad spectrums of production methods, being considered in support of the environment and human health. Organic farming aims at "feeding the soil" rather than "feeding the plant". Organic agriculture is one of the fastest-growing sectors of agricultural production. It is based on minimizing the use of external inputs through efficient use of on-farm resources compared to industrial agriculture. Thus the use of synthetic fertilizers and pesticides is avoided. India has now become a leading supplier of organic herbs, organic spices, organic basmati rice, etc. India produced around 3.49 million MT of certified organic products which includes all varieties of food products. The organic food export realization was around INR 707849.52 Lakhs (1040.95 million USD). In spite of such impressive statistics, on the contrary farmers are also reluctant to convert to organic production because of constraints in availability of adequate quantities of organic manures and other organic inputs in the local market, lack of complete knowledge about organic farming principles, practices and advantages, complex and costly procedures of certification and the risks of marketing of organic produce at premium rates in domestic market. However, these issues need to be addressed before we go for a large-scale conversion to organic agriculture.

Key words : *Organic farming, development, strategies, perspective.*

Introduction

The food grain production in India has been doubled during the post green revolution period with virtually no increase in net cultivated area; it increased from 95 million tonnes in 1967-1968 to 308 million tonnes in 2020-21, without much increase in net area under cultivation (140+/-1 m ha). This marvelous achievement in agricultural production was mainly due to the increased use of inputs like fertilizers, pesticides and farm machinery (Krishnaprabu, 2019) (Roychowdhury *et al.,* 2013). The green revolution has been a double edged sword to India. It has successfully freed India from food shortage but simultaneously trapped her in the clutches of environmental deterioration. As time went by, extensive dependence on chemical farming has shown its darker side. The land is losing its fertility and is demanding larger quantities of fertilizers (Kurmi *et al.,* 2021).

The intensive modern agriculture for the past five decades has led to several environmental and health issues. Pests are becoming resistant requiring the farmers to use stronger and costlier pesticides. It is estimated that over 3 million tonnes of pesticides is used annually and there exists about 1600 of pesticides. India is the second largest producer of pesticides after China in Asia. The over-use of

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pesticides resulted in residues much. It is also reported that nearly 20,000 people in developing countries die each year because of pesticide consumption through their food (Bhardwaj *et al*., 2013). On the other hand the farmer suicide toll is on rise. In spite of huge claims of farmer empowerment through green revolution they seemed to be still trapped in poverty, debts and crop failure. The increasing health consciousness and demand for healthy food has triggered a need to improve the organic agriculture status in India.

As per the definition of the United States Department of Agriculture (USDA), "organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc.) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection".

Organic production systems are based on specific standards precisely formulated for food production and aim at achieving agro-ecosystems, which are socially and ecologically sustainable. Scialabba (2007) describes organic agriculture as 'neo-traditional food system', which combines modern science as well as indigenous knowledge. Organic farming primarily aimed at raising crops by keeping the soil alive and in good health by use of organic wastes and other biological materials along with beneficial microbes to release nutrients to crops for increased sustainable production in an eco-friendly pollution free environment (Makadia and Patel, 2015).

Organic farming and India is intertwined together since many years. Organic farming was a part of the traditional farming systems. The ancient repertoires of knowledge like the "Vrikshayurveda" and "Brihat Samhitha" contain separate sections on Indian agriculture depended on natural inputs from nature (Dhiman, 2020). Traditional farmers were well aware of efficient utilization of land and experts in judging the nature of the soil. Organic farming is a form of agriculture that relies on crop rotation, green manuring, compost, biological pest control and mechanical cultivation to maintain soil productivity and control pests, excluding or strictly limiting the use of synthetic fertilizers and chemical pesticides.

Organic farming is not a destination but a long journey to a mission. To accomplish the mission it becomes mandatory to identity all the possible threats and difficulties in the existing system. The Government of India launched the National Programme for Organic Production (NPOP), under the guidelines of international organic production standards such as CODEX and IFOAM (International Federation of Organic Agricultural Movements) (Deshmukh and Babar, 2015). Present paper deals with the issues and opportunities in implementing the organic farming in India.

Global Statistics

Currently 1.5% of the world's agricultural land is organic. In 2019, 72.3 m ha of organic agricultural land, including non conversion areas were recorded (Willer *et al*., 2021). Australia account for the largest certified organic surface area, with 35.7 m ha, followed by Argentina (3.7 m ha) and the Spain (2.4 m ha). The highest organic shares of the total agricultural land, by region, are in oceania (9.6%) and Europe (3.3%). Some countries reach far higher shares than the global share. Liechtenstein (41%) and Australia (26.1%) have the highest organic share. In 16 countries 10% or more of the agricultural land is organic.

The regions with the largest organic agricultural land areas.

S. No.	Region	Area (in million ha)	% Contribution
1.	Oceania	35.9	50
2.	Europe	16.5	23
3.	Latin America	8.3	11
4.	Asia	5.9	8
5.	NorthAmerica	3.6	5
6.	Africa	2.0	3

Status of organic farming in India :

About 2.78 million hectares of farmland was under organic cultivation as of March 2020, according to the Union Ministry of Agriculture and Farmers' Welfare. This is 2% of the 140.1 million ha net sown area in the country. NPOP scheme covers about 70 per cent of the organic area of the country, of which 30 per cent is under conversion.

Organic agricultural land (including in conversion areas) in India is 2299222 ha (Willer *et al.,* 2021). In 2020-21, India produced around 3.49 million tonnes of certified organic products which includes all varieties of food products namely oil seeds, sugarcane, cereals, millets, cotton, pulses, aromatic & medicinal plants, tea, coffee, fruits, spices, dry fruits, vegetables, processed foods etc. Madhya Pradesh has covered largest area (756000 ha) under organic certification followed by Rajasthan (350000 ha), Maharashtra (284000 ha). These three states account for about half of the area under organic cultivation. India has over 1.9 million farmers as of March 2020, which is 1.3 per cent of 146 million agricultural landholders. India ranks 8th in terms of world's organic agricultural land and 1st in terms of total number of producers as per 2020 data.

The total volume of export during 2020-21 was 888179.68 MT. The organic food export realization was around INR 707849.52 Lakhs (1040.95 million USD). Organic products are exported to USA, European Union, Canada, Great Britain, Korea Republic, Israel, Switzerland, Ecuador, Vietnam, Australia etc. In terms of export value realization Processed foods including soya meal (57%) lead among the products followed by Oilseeds (9%), Cereals and millets (7%), Plantation crop products such as Tea and Coffee (6%), Spices and condiments (5%), Medicinal plants (5%), Dry fruits (3%), Sugar (3%) and others.

Organic farming status in India (2020-21) :

Data for Organic Products (2020-21)	
Total production	3.49 million tonnes
Total quantity exported	888179.68 MT
Value of total export	1040.95 million USD (Rs. 707849.52 Lakhs)
Organic agricultural land (including in conversion areas) in India is	2299222 ha

Benefits of organic farming :

The benefits of organic farming are relevant both to developed nations (environmental protection, biodiversity enhancement, reduced energy use and CO_2 emission) and to developing countries like India (sustainable resource use, increased crop yield without over-reliance on costly external inputs, environment and biodiversity protection, etc). A number of studies showed that, under drought conditions crops in organic agriculture systems produce significantly higher yields than comparable conventional agricultural crops (Pretty, 2000). One of the components of organic farming is crop diversity, it promotes agricultural output through the control of pest infestation and replacement of agricultural soil, directing to better farm income, constancy and security. Organic farming is, therefore, a unique method of farming which promotes agro-ecosystem health such as soil biological activity, biological cycle and biodiversity. Elayaraja and Vijai (2020) asserts that organic farming can contribute to sustainable development with the application of organic principles, which translates into efficient management of local resources like manure and local seed varieties, which in turn, results in cost-effectiveness. In brief, organic farming is capable of contributing to sustainable development since it reduces the risk of yield failure and stabilizes returns, let alone improving the quality of life of small farmers' families. Organic source of nutrient also helps to combat with the problem of multi nutrient deficiency and low organic content in our soil which is affecting productivity of major food crops at farmer field (Singh *et al.,* 2017).

Safety, quality and taste of organic food:

A general perception propagated in public minds is that organically grown food is more nutritious, healthy and safe. A crude analysis of the literature, however, favours organic products in this area. A significant improvement in nutritional quality with combined application of 2 or more organic sources in organic farming with Pusa basmathi 1scented rice variety was reported by Singh *et al*., (2007). Saha *et al.,* (2007) also studied the grain quality parameters and reported that organic nutrient sources can perform comparatively well as regards chemical and physico-chemical properties and cooking quality of rice. Quality after storage has been reported to be better in organic products relative to conventional products after comparative tests. Nitrates are significant contaminants of foods, generally associated with intensive use of nitrogen fertilizers. But there are no consistent and valid reports of differences in the mineral contents of organic and conventional food. However, N applications generally improve both the protein and bread-making quality. Regardless of whether the nutrients are from organic or inorganic sources, plants absorb the same in form of inorganic ions: ammonium, nitrate, phosphate, potassium etc. There are many factors, environmental and cultural, that influence the nutritional composition of the produce. There is no difference between the protein content and other quality parameters such as vitamins and trace minerals of conventionally and organically grown crops, which at best could be linked to the varietal characteristics (Woese *et al*., 1997).

Organic Farming in relation with environment and economics :

Organic farming is eco-friendly and keeps the soils healthy without polluting environment. Organic agriculture has the potential to reverse the ongoing trends of soil and environmental degradation under conventional farming and reduce carbon dioxide, nitrous oxide and methane- green house gases that contribute to global warming. Organic agriculture could double the carbon sequestration in livestock based system and decrease green house gasses by 48-60% (Pandey and Singh, 2012). For example organic system has decreased the use of fossil fuel by 10-70% in Europe and 29-37% in the USA (Prasad and Gill, 2009). Studies revealed that using organic manures recorded significant improvement in soil physical, fertility and biological properties, minimized energy use, promoted biodiversity and minimized water pollution, compared with conventional agriculture (Surekha *et al.,* 2010) (Regnold and Wachter, 2016). The interest in organic agriculture in developing countries is growing because it requires less financial inputs and places more reliance on the natural and human resources available. Studies to date seem to indicate that organic agriculture offers comparative advantage in areas with less rainfall and relatively low natural and soil fertility levels. Organic agriculture does not need costly investments in irrigation, energy and external inputs, but rather organic agricultural policies have the potential to improve local food security, especially in marginal areas. By adopting organic agriculture, farmers are challenged to take on new knowledge and perspectives, and to innovate. This leads to an increased engagement in farming which can trigger greater opportunities for rural employment and economic upliftment.

Considering the global scenario of organic agriculture, National Policy for Farmers-2007 (Government of India) has clearly favoured the development of organic farming in India (Prasad and Gill, 2009). However, there are certain issues that need to be addressed before we go for a large-scale conversion to organic agriculture. Some of the important issues are: Can organic farming produce enough food for everybody? Is it possible to meet the nutrient requirements of crops entirely from organic farming? Is the food produced by organic farming superior in taste and quality? Is it economically feasible?

Limitations of organic farming :

In India the net cropped area has more or less stabilized at 143 m ha. The population of 1 billion plus is expected to grow by 14 to 15 millions each year. The land to man ratio has fallen rapidly in the past half century from 0.34 in 1950 to 0.14, and is projected to be 0.10 in 2025. At present, each hectare of net sown area has to support more than 7 persons. This pressure will increase in the coming years. By 2025 the country will be required about 40 to 45 mt of NPK from various sources by 2025. Organic manure is an alternative renewable source of nutrient supply. The biggest myth about the organic farming as indicated by Chhonkar and Dwivedi (2004) is that the country has enough organics available to replace chemical fertilizers to sustain present level of crop production. A large gap exists between the available potential and utilization of organic wastes. However, it is not possible to meet the nutrient requirements of crops entirely from organic sources, if 100% cultivable land is converted to organic farming. The most optimistic estimates at present show that, only about 20-30% nutrient needs of Indian agriculture can be met by utilizing various organic sources (Saini and Pandey, 2009). At present, there is a gap of nearly 10 mt between annual addition and removal of nutrients by crops which is met by mining nutrients from soil.

The cultivated area, required to maintain the present level of food grain production in India without using the fertilizers, reaches more than the total geographical area of the country. It is neither possible nor feasible to replace chemical fertilizers completely to sustain present level of crop production. Chhonkar and Dwivedi (2004) warned that if a section of pro-change farmers of agriculturally important areas currently engaged in food grain production began to convert their farms to organic with the intention of getting premium price, there will be no option left for the country other than importing food grains as it has practiced a few decades back. On long-term basis, conjoint application of inorganic fertilizers along with various organic sources is capable of sustaining higher crop productivity, improving soil quality and soil productivity. But data from Long term fertilizer experiments (LTFE) showed that supplementation of entire N through farmyard manure sustained crop yields at much lower level. Results of initial 4 years of a long-term experiment on rice - wheat system at Modipuram also go against the myth, as the yields of both rice and wheat remained sizeable low under organic farming compared with conventional farming owing to lesser number of ears i.e. effective tillers and fewer number of grains per ear (Yadav *et al*., 2002) in the former case. There are dependable research evidences to show that balanced inorganic fertilization and integrated nutrient management have sustained crop yields on long-term basis (Swarup and Wanjari, 2000; Dwivedi *et al*., 2002).

Most of the farmers in India are small and marginal, they are not directly connected to markets to buy or sell food (Chandra (2014), Kaur and Toor (2015). Since organic farming's main attraction is export, small farmers are less able to compete when the international trade brings down prices even in local markets.

There is tremendous lack of infrastructural facilities for processing, packing, storage etc. to meet the organic standards (Kaur and Toor, 2015).

Readily available and abundant organic sources are not enough to meet the requirements of composts, vermicomposts etc. Because of difficulty in collection and handling of farm waste, lot of organic wastes and plant residues get wasted in the fields. Moreover, people in rural areas use plant residues like straw and stubbles for producing charcoal as an energy source (Sharma *et al*., 2011).

Local or farm renewable organic resources like neem cakes, groundnut cakes, cow dung, earthworms etc., are becoming costlier day by day than the conventional or industrially produced chemical fertilizers and pesticides. Chemical fertilizers are easier to purchase if the farmer has purchasing power (Wani *et al.*, 2017)

The comparatively lower yields and dependence of manure from low-yield cattle has prompted criticism that organic farming is environmentally unsound and incapable of feeding the world population. Nitrate is the main end product of organic manure decomposition; moreover it is continuously released from the organic matter under decomposition. Since nitrate release is not synchronized with either crop demand or its uptake, it tends to accumulate in excess in soil and pose environmental risk. In addition, the trace elements and heavy metal concentrations present in the animal wastes and sewage sludges vary widely and at times very high and often exceed concentrations normally found in the inorganic fertilizers and there will be every chance to enter in to food chain and create health hazard. A few case studies pertaining to organic production of wheat, cotton, tea and coffee in India were reported by Marwaha and Jat (2004). The overall economics of these initiatives was not in favour of organic farming, because of limited a availability and restricted use of organic resources and ever growing need for food and feed. Critics argue that due to lower productivity, a wider adoption of organic agriculture would exacerbate the challenge of providing sufficient food to feed the world (Connor and Minguez, 2012) (Pickett 2013).

Farmer's reluctance to go organic:

The common complaints of the farmers are about the certification criterions. According to the organic certification norms a two-three years of conversion period is required to transform from conventional to organic farming, during which no inorganic fertilizer and agrochemicals are used on the farm before which the produce can be marketed (Pandey and Singh, 2012). Since crop yields during this transitory period are low, farmers intending to go for organic farming would suffer losses, unless some compensation is made for this. The recession in the crop yields during initial phase of transition from conventional to organic agriculture and recovery in yields after 2-3 years was reported by Sharma and Singh (2004). The rate of success in general, is more in horticultural ecosystem but, in annual crop ecosystem their establishment is always questionable. The cost of these products is further increased by the fact that the production in organic farming is generally 20-38% low compared to those using modern agricultural practices. It is also noticed that the amount of organic manures required is more than the chemical fertilizers to achieve a particular amount of NPK status (Roy and Dhumal, 2011). Above all, farmers may afraid to adopt the organic agriculture without adequate support from the government and premium price for their produce. Further more, the current standard of organic farming is quite stringent in respect of organic manure used, animal feed/fodder used, minerals or soil amendments used, quality of surface irrigation and underground water and agricultural practices adopted at farm in the neighborhood. All these reasons make it difficult for an average Indian farmer to adopt organic agricultural practices.

Strategies for organic farming in India:

Only 30% of India's total cultivable area is covered with fertilizers where irrigation facilities are available and in the remaining 70% of arable land, which is mainly rainfed, negligible amount of fertilizers is being used. Logically, increasing the yields in the rainfed drylands areas is the key to ending hunger and achieving food security (Sharma, 2014). Organic farming is growing rapidly among Indian farmers and entrepreneurs, especially in low productivity areas, rain-fed zones, hilly areas and the northeastern states where fertilizer consumption is less than 25 kg/ha/year (Mitra and Devi, 2016). The North-Eastern region of India provide due to least utilization of chemical inputs. The report of the Task Force on organic farming appointed by the Government of India also observed that in vast areas of the country, where limited amount of chemicals is used and have low productivity, could be exploited as potential areas for organic agriculture. It is estimated that 18 m ha of such land is available in the N-E, which can be exploited for organic production. With the sizable acreage under naturally organic/default organic cultivation, India has tremendous potential to grow crops organically and emerge as a major supplier of organic products in the world's organic market.

Studies showed that in rainfed areas, crops in organic agriculture system produce significantly higher yield than comparable conventional agriculture crops by 7-15% due to better nutrient and rainwater management (Yadav and Gahlot, 2011). A survey of 208 projects in developing tropical countries in which contemporary organic practice were introduced showed average yield increase of 5-10% in irrigated crops and 50-100% in rainfed crops (Pretty and Hine, 2001).

Conclusions

During the last four decades of the 20th century, the global population doubled from 3 to 6 billion and today it has crossed the 7.9 billion mark. Food and nutritional security is therefore a global concern. Neither conventional farming with inorganic alone nor the organic farming only with the use of organic inputs can face this challenge. To ensure the food and nutritional security, it would be desirable to carefully delineate areas for organic farming. In India, there is ample scope for pure organic farming in the rainfed areas, where there is little or not use of fertilizers and other agro-chemicals. The combination of both organic and inorganic is undoubtedly the best option as on today for developing country like India. Hence, efforts need to be taken to address these issues with a view to promote the organic farming with great confidence in India.

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Chapter 14

Post Harvest Technology and Value Addition in Fruits and Vegetables

H.K. Rahangdale[1], N.R. Rangare[2], Kamleshwar Goutam[3], Shristi Mehra[3] and G.K. Rana[1]
[1]*Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna*
[2]*National Institute of Agricultural Extension Management (MANAGE) Hyderabad*
[3]*Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur*

The diverse climate of India ensures the availability of a wide range of fresh fruits and vegetables. After China, it is the world's second-largest producer of fruits and vegetables (Rangare *et al.,* 2017). India is the world's leading vegetable producer. Although our country grows more than 70 different types of vegetables, more popular vegetables such as tomato, brinjal, chilli, cauliflower, cabbage, peas, potatoes, onions, and a few common cucurbits and green vegetables receive greater attention. Bananas (26.04 percent), papayas (44.51 percent), and mangoes (including mangosteens and guavas) are the top fruits produced in the country (40.75 percent). Juices and concentrates, pulp, canned and dehydrated products, jams and jellies, pickles and chutneys, and other items are made from fruits and vegetables. The degree to which fruits and vegetables are processed differs by country. These also create a lot of money and jobs, especially for small farmers. Mangoes, walnuts, grapes, bananas, and pomegranates make up the bulk of the country's fruit exports, while onions, okra, bitter gourd, green chiles, mushrooms, and potatoes make up the majority of the country's vegetable exports.

Fruit and vegetable post-harvest losses are more severe in developing countries than in developed countries. Total losses from harvest to consumer point are estimated to be in the range of 30-40 percent, amounting to thousands of crores of rupees. Fresh fruits and vegetables shrivel and stale about 10-15% of the time, diminishing their market value and customer acceptability. It is possible to boost their supply by reducing these losses. It will also help to keep pollutants to a minimum. Tissue disintegration occurs as a result of improper handling and storage. Bruising, cracking cuts, and microbial deterioration by fungi and bacteria are examples of mechanical losses, while transpiration, pigments, organic acids, and flavour are examples of physiological losses. Fruits, which are now underutilized, can help meet the demand for healthy, beautifully flavored, and visually appealing natural meals with significant therapeutic potential. They are generally thought to be high in vitamins, minerals, and dietary fibre, making them an important part of a balanced diet (Table). Apart from their nutritional, therapeutic, and medical properties, several of these tropical fruits have exceptional flavour and a pleasing appearance. Fruits like jamun and phalsa have a short shelf life. The bael fruit is difficult to consume by hand. Fresh Aonla fruit is disliked by many people due to its strong astringent flavour. These fruits, on the other hand, have limitless potential in processed form, and people all over the world can enjoy them in the form of processed products.

A Glimpse of Post-Harvest Loss

Because food resources are finite and the world population is growing at an alarming rate, feeding the world's population will be one of the greatest challenges of the twenty-first century. Fruits and vegetables have become much more important as a result of population trends and dietary changes. Nutritionists too place these products on the pedestal of essential ingredients for good health as they constitute the staple diet. Essential minerals, vitamins, and

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dietary fibers are found in fruits and vegetables (Sharma et al.,1998). After harvest, from 10% to 30% of total world grain production is wasted due to inefficient handling and poorly deployed post-harvest technologies (Chelkowski, 1991). India is a land of large varieties of fruits and vegetables due to its vast soil and climatic diversity. India is the world's second-largest producer of fruits and vegetables, behind Brazil and China, with 38 and 71 million tonnes produced, respectively. It is also a matter of concern that there is a wide gap between availability and the per capita nutritional requirement of fruits. The low availability of quality fruits and vegetables is mainly because of high post-harvest losses due to lack of proper storage and processing facilities. Further a considerable amount of horticultural produce goes waste. Post-harvest losses of vegetables and fruits are experienced all over the world but the extent varies. According to an estimate, the magnitude of post harvest losses in our country varies from 22-40% due to lack of proper storage and transportation facilities. The post-harvest losses in vegetables and fruits can be minimized by creating proper storage facilities in urban and rural areas. However, the food, which remains fit for human consumption after storage, suffers a reduction in its nutritional value during processing.

Any change in the amount or quality of a product after harvest is referred to as a post-harvest loss. There are two types of losses that occur during storage: those caused by primary causes and those caused by secondary causes. Biological and microbiological, chemical and biochemical, mechanical, physical and physiological alterations are the primary reasons. Secondary causes of loss are those that lead to conditions in which the primary causes of loss can occur. They include poor organization of the marketing system, inadequate use of available technology during various phases of production, harvesting, selection, packing, transportation, storage, processing and distribution etc. (Sharma *et al.,* 1998). National Research Council Commission of the United States and Food and Agriculture Organization of United Nations stated that the minimum overall loss for perishable food products is approximately 20%. Reported losses for individual crops are often much higher, ranging from 0.5 to 100%. As a result, post-harvest handling has a significant impact on the level of post-harvest losses, ultimate quality, and crop market value (Kim, 2006).

Objective of post-harvest handling

The goal of post-harvest handling is to provide a thorough understanding of all operations involved, from harvest through distribution, so that people can use the appropriate technology at each step and reduce losses while maintaining the highest possible quality throughout the distribution chain. The farmer must pay special attention to the following steps of the post-harvest chain, among other things :

Market demand for the produce they are planning to grow

Market requirements and buyers

Knowledge of the fresh produce Cultivation practices

Factors affecting post-harvest deterioration

Harvesting and field handling

Packing in the field

Handling and packing in the packing house

Common storage and refrigeration

Transport

Sale to agents, traders or consumers

Market handling, and

Shelf-life of the produce.

Post-harvest technology procedures

Storage : Temperature is one of the major environmental factors affecting the post-harvest rate of respiration and other related physiological activities of fresh fruits and vegetables. In general, the rate of respiration increases with increase in temperature (ratio of rate of respiration at a given temperature to that at a temperature 10°C lower) with values of 2-3 being common between 10-32°C (Biale, 1960). Low temperature has long been used in developed countries to retard senescence of fresh produce. In developing countries, however, it has found limited use due mainly to economic reasons and the lack of adequate technology.

In addition, the use of low temperature in certain fruits and vegetables is restricted by the manifestation of various types of tissue browning known as chilling injury. The produce from tropical and subtropical regions are generally more susceptible to develop chilling injury than the produce from temperature zones (Pentzer and Heinze, 1954). On the basis of the minimum safe temperature for storage, Wills et al., (1977), have grouped various fruits and vegetables into three categories.

Those which can be stored at low temperature (below 5°C) with minimal risk of the development of chilling injury, e.g. most stone fruits, pome fruit and many vegetables;

Produce with intermediate sensitivity to develop chilling injury that should be stored at temperature between 5-10°C, e.g. citrus and many ripe subtropical fruits.

Those that are very susceptible to chilling harm and require a safe storage temperature of around 10°C. Tropical fruits and vegetables are important commodities in this group.

Principal of Storage : The primary goal of storage is to regulate the rate of transpiration and respiration, prevent disease transmission, and keep the commodity in the best possible condition for consumers (Pantastico *et al.,* 1975). Post-harvest diseases can be controlled, the environment regulated, chemical treatments, irradiation, and refrigeration can all help to extend storage life. The most popular methods of food preservation rely not only on the killing or removal of microbes, but also on delaying the onset of development and hindering growth after it has started (Frazier, 1988). The quality of produce is altered by transpiration and respiration rates during storage.

Transpiration : The main cause of deterioration of fresh horticulture products during storage is water loss through transpiration. It causes shriveling, weight loss, an unattractive look, and vitamin-C deficiency (Tranggono and Sutardi, 1990). Controlling temperature, relative humidity, and vapour pressure differential could help to prevent the deterioration of fresh goods (VPD). To limit shrinkage, the product must be kept at a low temperature, have a high RH, and have a low VPD. Furthermore, careful packing, protective coating, and maintaining the refrigerant as close to the required air temperature as feasible could all help to limit weight loss (Pantastico *et al.,* 1975). Moisture loss in fresh commodities is influenced by surface area, natural wax coating, and mechanical injury, according to (Tranggono and Sutardi 1990).

Respiration : Respiration is a fundamental reaction of all plant material, both in the field and after harvest. It is a vital metabolic process in which plants take in oxygen and expel carbon dioxide, and it has a significant impact on the quality of harvested food. For the maintenance of life, fresh fruits and vegetables require a constant source of energy, and respiration is the overall process that turns food reserves into energy. Stored organic stores are depleted during respiration. Senescence is hastened as reserves are depleted, and flavour quality suffers. Respiration is dependent on temperature fluctuations within the physiological temperature range because it includes a series of enzyme processes. As a result, temperature is the most critical factor that determines respiration rate as well as the rate at which fresh product deteriorates. When fruits and vegetables are kept just above their freezing point, respiration is greatly reduced, resulting in the longest possible storage life (Kim, 2006).

Refrigeration : Refrigerators are one of the most effective preservation tools. Refrigeration is the only known technology for storing fresh fruits and vegetables for long periods of time. However using of refrigerator it has some constrains, the storage temperature must be kept constant. The inability to control the temperature of the refrigerator results in significant temperature fluctuation which results in water condensation on the fruit surface. Low temperature stress is undesirable for fruits and vegetables which cause injury, the degree of injury varies with products. Moreover in most of the villages there is no electricity and farmers cannot use refrigerators as they are expensive one. More over refrigerators in all households cause a greater pollution discharge. Hence, an alternative to refrigerators that can store the post-harvest fruits and vegetables for a considerable time is essential.

Zero energy storage system : However, there is a feasible, low-cost solution for on-farm fruit and vegetable storage that makes use of evaporation's cooling effect. Zero-energy cool chambers maintain a relative humidity of roughly 90% and stay 10-15°C cooler than the outdoor temperature. They're also simple to construct with locally available materials like brick, sand, bamboo, straw, and gunny bags. The use of a low-cost "Zero Energy Cooling Chamber" for short-term on-farm storage of perishable farm produce has a lot of potential. The Indian Agricultural Research Institute (lARI), Pusa, New Delhi, devised the Zero Energy Cool Chamber on the basis of evaporative cooling, or the cooling effect caused by water evaporation. The cool chamber maintains a lower temperature than the ambient temperature, and temperature variations inside the cool chamber are extremely modest compared to outside mercury fluctuations. In the same way, the relative humidity within the cooling chamber is higher than it is outside. During peak summer months, the temperature within the cool chamber can be as low as 15-16°C lower than

Table-1 : Composition of some tropical fruits (per 100 g if edible portion).

Treatment	Organoleptic score				
	Color (10)	Flavor (10)	Taste (10)	Consistency (10)	Total (40)
Guava jelly	8.1	8.1	7.8	7.6	31.6
Guava–Roselle (85-15)	8.6	7.9	8.0	8.1	32.6
Guava–Roselle (80-20)	8.3	7.6	7.0	8.4	31.3
Roselle	7.3	7.2	7.4	7.7	29.6
CD 0.05	0.72	0.63	NS	NS	1.91
SE	0.25	0.22	0.32	0.29	0.66

Source : Gopalan et al., (1978) * Tamarind is the richest source of Tartaric acid (8-18%).

Table-2 : Pre-harvest factors influencing post-harvest management of fruits.

Selection of varieties	Higher yield, better keeping quality, slower ripening, longer shelf life under ambient condition and better processing quality.
Cultural operations	Pruning, thinning, irrigation, fertilization.
Pre-harvest treatments	Mango: Three sprays of Topsin-M (0.1%) or Bavistin (0.1%) at 15 days interval before harvest can control anthracnose and stem end rot. Tomato : Three pre-harvest sprays of 0.2% Difolatan at 10 days interval.
Maturity	Peel colour : Mango, pineapple, custard apple and tomato. Pulp colour: Mango and tomato. Shape : Fullness of cheeks in mango, flattening of eyes with slight hallowness in pineapple.
Post harvest factors are :	
Pre-cooling	Aircooling, Hydrocooling Mango : Hydrocooling at 12-15oC with 500 ppm Bavistin increases shelf life.
Washing and drying	
Dis-infestation	Vapour heat treatment, fumigation with EDB et: mango
Control gripping process	Packing, low temperature, ethylene absorbents, skin coating, sulphur guards.
Ripening of fruits	Ethephon / Ethresl, calcium carbide
Storage	Cool stores, zero energy cool chambers

Table-3 : Recommended temperature, relative humidity and storage life of fruits.

Fruit	Temperature (°C)	Relative humidity (%)	Approx.storage live (weeks)
Custard apple	7-10	85-90	1-2
Guava	5-10	90	2-3
Jackfruit	11-12.8	85-90	3-5
Mango	13	95-90	2-3
Pineapple	7-13	85-90	2-4
Pomegranate	0-5	90-95	2-3 months

Source : T.K.Bose *et al*., (1999)

the maximum outside temperature. The relative humidity is also kept between 85 and 90 percent throughout the year.

Humidity in storage systems : Controlling humidity is crucial to maintaining the quality of many horticultural goods. Humidity control has become a crucial aspect of modern storage facilities. Fruits and vegetables should be stored at 80-90 percent relative humidity, while leafy vegetables and root crops should be stored at 90-95 percent relative humidity (Sharma *et al.,* 1998). Too much moisture or too little moisture will encourage the growth of fungus and ruin the preserved fruits. As a result, the moisture should be controlled. The lARl-developed zero energy cool chambers are a double-walled building composed of bricks. The double wall cavity is filled with river bed sand and water. Dry green straw or a bamboo frame was used to make the lid. Watering the chamber twice a day could result in a rise in relative humidity (90 percent or more) and a drop in temperature (10-120 °C) compared to the ambient state (Roy and Pal, 1991). In the chamber, the different mature green fruits were stored and also the appearance, texture, taste and flavour of the different food materials were retained good.

Controlled atmosphere : Controlled atmosphere refers to the addition or removal of gases to produce an atmosphere surrounding the commodity that differs from that of the surrounding air (79 percent nitrogen, 21% oxygen, and traces of carbon dioxide). In a hermetically sealed chamber, this usually entails a drop in oxygen and an increase in carbon dioxide. The use of controlled atmosphere can be considered only as a supplement to the proper temperature and humidity procedures. Controlled atmosphere is used for a certain number of crops to extend shelf-life, reduce disorders such as chilling injuries, reduction of pathogens and some insect control.

Supplemental procedures : The following treatments may be applied to horticultural commodities:

Curing of certain roots, tubers and bulbs vegetables (see details on specific chapter);

Sorting for defect elimination

Waxing and other surface coatings

Hot water treatment

Treatment with post-harvest fungicides or bactericides

Use of sprout inhibitors

Special post harvest chemical treatment

Fumigation for insect control

Films wrapping and

Ethylene treatment for de-greening and ripening certain fruits, such as citrus, bananas and mangos.

Ripening fruits with ethylene gas

Ethylene plays an important role in the post-harvest physiology of most horticultural crops, both beneficial (improving the quality of the produce by allowing for faster and more uniform ripening prior to retail distribution) and deleterious (improving the quality of the produce by allowing for faster and more uniform ripening prior to retail distribution) (increasing the rate of senescence and reducing shelf-life). Systems for ethylene treatments. Handlers can equip existing rooms for use as ripening chambers or they can install specially built ones. Both need automatic control of temperature (for heating and cooling), humidity and ventilation. The room should be as tight as possible, to prevent leakage of gas, but not essentially hermetically sealed.

Amount of gas needed. It is recommended100 ppm of gas. The ripening process will not be sped up by increasing the concentration. An explosive air-gas mixture might develop from too much gas. Safety precautions have to be followed.

Temperature and humidity : Optimum temperature varies from 18 to 25°C. At lower temperature ripening is slowed, from 25 to 30°C ripening may be inhibited and decay accelerated. Relative humidity should be as high as possible.

Other technologies for using ethylene : Fruits ripening could also be induced with the following methods :

Explosion-proof ethylene mixed with an inert gas.

Ethylene generators, widely used in developed countries

Ethephon

Calcium carbide which, in a furnace, releases acetylene (which has an ethylene like response) when combined with water

Fruits already ripe (included in the high ethylene producing category) can be used in very small commercial operations, or at home, to ripen other fruits.

Deleterious effect of ethylene : The powerful influence of ethylene on perishable commodity senescence can drastically lower the shelf life of products that are sensitive to it. Techniques to eliminate it (such as potassium permanganate, ozone, hypobaric storage, and oxidizers) or mitigate its effects (such as loss of green colour in certain plants, faster ripening, sprouting, and shorter shelf-life) are critical. Storage of perishables sensitive to the gas should not be done in the same room where products which have a high or very high production of ethylene are kept. See more details in the first part of this chapter.

Postharvest deteriorations : The interaction of metabolic and environmental factors is responsible for many post-harvest deteriorations. Among the main causes of wastage are the following :

General senescence

Water loss

Diseases and pests

Physical damages (mechanical injury)

Injuries from temperature effects (chilling injuries)

Other causes

Processing

(a) Primary processing : Sorting, trimming, grading, washing, surface drying, and packaging are all simple primary processing activities that can be utilised to prepare fruit and vegetables for immediate marketing. Farm level fruit and vegetable washing machine, basket centrifuge, shrink packaging of fruits and vegetables, hydro cooler-cum-washer for fruits and vegetables, vegetable dryer, tamarind dehuller and deseeder, pomegranate aril remover cumin cleaner are among the available equipment and technologies for various unit operations of primary processing. Turmeric washing and polishing machine, cum-grader, and so on.

(b) Secondary processing

(i) Drying : The oldest and cheapest method of horticulture produce preservation is drying. There is a lot of information out there about using a solar dryer to dry fruits, vegetables, plantation crops, and spices. Medicinal and aromatic plants, on the other hand, can be dried using a sun dryer, a poly tunnel solar dryer, or a mechanical dryer. Fruit and vegetable pretreatments such as peeling, slicing, blanching, sulphuring, and other methods are used to prepare fruit and vegetables for drying.

(**ii) Osmotic dehydration :** Osmotic dehydration, which involves removing some of the water from a product by dipping it in sugar syrup before rinsing it in a mechanical dehydrator, is currently a widely acknowledged method for producing intermediate moisture products with acceptable sensory attributes. This method can also be used to dry fruits that would otherwise be unsuitable for drying due to their strong acidity and astringent flavour. Pineapple slices, mango slices, banana slices, sapota, apricot, apple, and grapes, among other fruits, are good for osmotic dehydration.

(iii) Processing of lesser utilized fruits : Large quantities of lesser-used horticulture crops such as bael, aonla, jack fruit, aloe vera, and others cannot be consumed fresh. They have a wide range of therapeutic/medicinal as well as nutritional characteristics. Processing such crops can help meet the demand for nutrient-dense, beautifully flavored, and appealing natural meals with significant therapeutic value.

In India, the bael fruit, which has a hard shell and a mucilaginous texture, is widely enjoyed as a dessert fruit.

Fresh kokum and hill lemon are unsuitable due to their high acidity, while fresh aonla has a strong astringent flavour.

Unripe mango drink (mango pana), which is strong in fibre and antioxidants, is one of the items made from such mangoes.

Cashew apple powder fortified with 2% cereal flour.

Ripe bael drink, squash, RTS (ready to serve) drink jam and jelly, and bael dry powder are among bael goods.

Aonla preserves, candies, shreds, chayawanprash, squash, dried powder, aonla drinks, toffees, and more Aonla products are available.

Value addition : Fruit and vegetables that are not suitable for sale in the fresh market can be used to make a variety of value-added goods. Juice, concentrate, fruit-based carbonated juices, canning, pulp extraction, pickling, chutney and sauce making, preserves and candies, beverages such as squashes, ready-to-serve (RTS) drinks and appetisers, and other value-added products made from various fruits and vegetables are among the value-added products. v) Fermented foods: Fermented foods are foods that have been fermented. The production of alcoholic beverages such as cider, wine, vermouth, vinegar, and other similar beverages is now a common technique for utilizing various fruits.

Champagne (sparkling wine), still wine, and brandy are commercially produced from grapes in the country. Cider, wine, and vermouth made from apple, plum, apricot, wild apricot, peach, strawberry, and banana are examples of fermented beverages.

By product waste utilization : By-products from fruit processing factories include pomace, seeds, stones/pits, skin, and peel, all of which are discarded as garbage. Though such waste produce still contains a significant amount of nutrients, it can be used to make a variety of value-added goods for industrial application.

Pomace can be used for extraction of pectin, dietary fibre and industrial alcohol.

Oil recovered from fruit stones/seeds left over after the pulping of stone fruits can be utilised in food preparation, pharmaceuticals, and cosmetics.

Vinegar extracted from mango peel.

High fiber containing biscuits from aonla and apple pomace.

Peel oil, pectin powder, peel candy and animal feed are some of the citrus peel products.

Oil and fiber from oil palm.

Advantages of processing :

Helps in converting perishable fruits in to durable form

Fruits, which are very difficult to eat out of hand can be processed in to a range of highly acceptable fruit product.

Helps in reducing wastage.

Value addition.

Methods of processing of fruits into products :

Preservation by heat treatment.

Aseptic packaging.

Preservation of by removal of heat.

Quick freezing.

Preservation by removal of moisture.

Preservation by addition of chemicals.

Minimal processing.

Guava (*Psidium guajava*) : The most popular method of harvesting guava fruits is by hand. The mature fruits, which are firm yellow to half-yellow in colour, are gathered. Fruits that are overripe are readily damaged during transportation and handling. Fruits that are picked before they are fully mature do not ripen into high-quality ripe fruits. Guava fruits can be stored for 10 days in ventilated polyethylene bags at room temperature 18-20oC.

Guava is a popular fresh fruit due to its delicious flavour, rich nutritional content, and complete edibility. This fruit is very vital to the food processing sector. Guava is used to make a wide range of processed items. Guava produces a high-quality natural jelly due to the presence of a large amount of pectin. Processed guava pulp is an ideal raw material for making guava nectars, drinks, jams, toffee, cheese, ice cream toppings, and other guava items. Guava pulp can be successfully maintained in bulk by using heat (aseptic packaging) or adding a chemical preservation agent (SO_2). Other notable goods include canned guavas with sugar syrup (40o Brix), dehydrated guavas, and guava powder.

Jackfruit (*Artocarpus heterophyllus*) : Both the immature and ripe stages of the fruit are employed. Jackfruit is commonly consumed raw as a vegetable. Fruits that are fully developed yet unripe are collected, and their look and a dull sound when tapped determine fruit maturity. Jackfruit is eaten as a dessert fruit when it is fully ripe. Fried ripe or semi-ripe fruits are used to make jackfruit chips. The ripe or semi-ripe fruit can also be used to make jackfruit leather. Sugar, citric acid, and water can be used to make a tasty beverage concentrate from jackfruit pulp. High-quality canned, frozen, and dried products, such as nectar, preserves, and confections, can also be made from ripe fruits. Green jackfruit is used to make pickles, canned vegetables, and curried vegetables. The wastes (skins, peels, and cores), which account for roughly 45 percent of the total weight of the fruit, have been discovered to be a good source of pectin.

Aonla (*Phyllanthus emblica*) : The fruit is highly nutritious and is a rich source of pectin and polyphenols apart from ascorbic acid. The medicinal qualities of aonla fruits are well established. Chronic diarrhoea, bronchitis, and diabetes are all treated with the fruits. The maturity of Aonla at harvest determines how long it can be stored. The fruit lasts 17-18 days in a chilly chamber, compared to 8-9 days at room temperature.

The Aonla fruit is rarely consumed fresh, although it is highly prized in the Ayurvedic medical system. Aonla is one of the primary constituents in Ayurvedic preparations such as ‘Chyavanprash’ and triphala. Aonla is used to make fruit goods such as pickles, preserves, sweets, jam, syrup, and dried shreds. Aonla preserves are a vital part of the economy and are in high demand. Prior to processing, the fruit might be streamed or blanched to reduce ascorbic acid loss in the products. It’s used in the tanning and dyeing industries as well.

At CRIDA, a steaming technique for separating aonla segments and removing the nut has been developed. These segments were utilized for making a variety of items. In a study comparing the suitability of several types for making candy, murabba, and pickles, the Chakkiya candy came out on top in terms of colour, flavour, texture, total score, and overall ranking. Banarasi took first place for texture and variation, while Francis took first place for colour. The cultivar Chakkiya placed highest in all attributes except flavour after a 4-month preservation period at ambient temperature. Banarasi sweets came in second place overall. In the instance of murabba, the variation Krishna came out on top in every attribute, followed by Chakkiya, which came in second in every category except texture, where it came out on top.

Squash was made by combining Aonla juice with ginger, roselle, pineapple, and lime juice. The addition of ginger and Roselle improved the colour, flavour, and consistency of the squash, according to organoleptic examination. In all attributes, including overall ranking, the blend of aonla, ginger, and roselle

(80:15:5) came out on top, followed by the blend of aonla, lime, and ginger (75:20:5). Squash's colour is improved by roselle, while its flavour is improved by ginger.

Ber (*Zizyphus mauritiana*) : Ber fruit can be eaten raw or processed into a variety of fruit products. Juicy kinds are superior for extracting pulp and juice. The juicer extracts juice from completely ripe, well-developed fruits that have been rinsed and de-stoned. Ber juice can be used to make a drink that is ready to drink. Ber carbonated beverage is quite popular and has a long shelf life. Dehydrated for is made by treating ber fruits with 3.5-10 g/kg sulphur dioxide for 3 hours, then sun drying or cabinet drying below 15% moisture. Ber can be used to make candy, and the pulp can be used to make wine. Diluting the pulp, adding pectinase enzymes, regulating proper Brix with sugar, yeast addition, fermentation, stability, and clarity are among the stages.

Jamun (*Syzygium cumini*) : Jamun fruits are used to make jam, jelly beverages, wine, and vinegar, and its sections of the tree, particularly the seeds, are used to treat a variety of maladies, the most common of which is diabetes mellitus (Agrawal *et al* 2017). By shredding the fruit, heating it to 70°C, and pressing it via a basket press, the highest output of jamun juice with a high level of anthocyanins and other soluble elements can be obtained. The jamun juice is then reheated to 85°C before being chilled to room temperature. Before the juice is stored, sodium benzoate (500 pm) is added. Heat pasteurisation can also be used to preserve pure jamun juice. Because the juice is highly acidic, it is not consumed as is. With 25% juice, 18o Brix, and 0.6 percent acidity, a ready-to-serve beverage (nectar) is created. Jamun seeds are also renowned for their anti-diabetic, anti-diarrhea, and anti-dysentery qualities.

Phalsa (*Grewia subinaequalis*) : The fruit is exceedingly perishable; it must be consumed within 24 hours of being picked. The phalsa fruit's popularity stems from its appealing colour, which ranges from crimson red to dark purple, as well as its pleasant taste. The juice has a deep crimson red to dark purple colour when extracted and is quite popular. It has a high ranking in the indigenous medical system. The juice is incredibly refreshing and is thought to have a cooling effect, which is especially beneficial during the hot summer months. The highest recovery of juice with an appropriate amount of anthayanin and other soluble and insoluble elements comes from heating the crushed phalsa fruit to 50°C. The addition of cane sugar to the juice has been proven to have a protective impact on colour stability in studies.

Tamarind (*Tamarindus indica*) : The tamarind fruit is a pod that is 5 to 15 cm long and contains 3 to 10 seeds surrounded by edible pulp that is used as a souring factor in sauces, chutneys, drinks, and general cooking. Pulp is a carminative and laxative that is used as an infusion to treat biliousness and fever. It's also used in tanning and dyeing, as well as polishing and cleaning metals. Unripe fruits are used to extract tartaric acid. Seeds are used to extract the polysaccharide (jellose), which is utilised as a sizing material in the cotton and jute industries. Polyose derived from the seed is also a good substitute for fruit pectin for making jam, jelly, or marmalade. Tanning is done with the bark and leaves. Tamarind balls are made after the seeds have been removed from the fruit. The other commercial items are tamarind paste and tamarind juice concentrate.

Mango (*Mangifera indica*) : In general, mangoes attain harvest maturity 12-16 weeks following fruit set, depending on variety. Mango is andro-monoecious, meaning it has both hermaphrodite and staminate blooms in each inflorescence (Rangare *et. al.* 2019) The specific gravity of the fruit is a helpful indicator for determining its maturity. If the pickers can reach them, mangoes are gathered by hand. Fruits on high branches are picked with a picking pole equipped with a cloth bag and a cutting knife. Fruits should be harvested with a short stalk to avoid latex dripping and stem end rot. Mangoes are typically harvested when they are physiologically mature, and ripening takes 6-14 days in ambient circumstances. The ripening process is linked to the conversion of starch to sugars and the loss of fruit firmness.

Mango is one such fruit that may be processed at practically any stage of growth, development, maturity, and ripening. It is a good amount of vitamin A and C (1082 IU and 36.4 mg fruit–1), as well as calories (60 kcal) and protein (Rangare et al 2020). (0.82g). Mango powder, pickle, and chutney are all made from raw mango fruits. Green mangoes can also be used to make a delicious cocktail. Ripe mangoes are used to make slab, toffee, and a variety of beverages such as nectar, squash, and so on. Ripe mango slices can also be preserved by drying after being exposed to sulphur fumes. Methods for producing cryogenically (liquid N) frozen mango slices have also been standardized.

Custard apple (*Annona squamosa*) : Custard apple is picked in several intervals, but the optimal time to pick it is when the hard fruit starts to turn colour. When it turns a creamy yellow between the segments and starts to crack slightly, it's time to pluck it. If the fruit is left on the tree for too long, it will burst open. Custard apple is perishable and cannot be kept for long periods of time. It can be kept for 9 weeks at 7-10 degrees Celsius with a RH of 85 to 95 percent. Chilling damage is caused by a drop in storage temperature. Custard apples treated with 50 ppm Bavistin and placed in a polythene bag with Kmno4 can be preserved for 9 days against 5 days for untreated fruits. Custard apples aren't used for processing in large quantities. When the pulp is heated, it becomes bitter. To pulp can be frozen successfully for use in ice cream, confectionery, certain milk products and in making preserves as jam, jelly and other products (Sumit *et al.,* 2017). Custard apple is used to make ready-to-drink beverages. Peptic enzyme can be used to remove the bitterness from the pulp.

The pulp can be frozen and used in the ice cream industry. At CRIDA, a simple method for manually extracting custard apple pulp has been devised using a rotatory motion of a circular hair comb in the scooped fruit kept in a stainless steel sieve. This pulp is suitable for use in the ice cream industry.

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Chapter 15

Climate Change and its Impacts on Agriculture

Sarita[1*], S.M. Kumawat[2], Anita[3] and Rubina Khan[3]
[1]*Department of Agronomy, S.K.N. College of Agriculture, Jobner, Jaipur-303329 Rajasthan*
[2]*College of Agriculture, Mandawa, SKRAU, Bikaner, Rajasthan*
[3]*Department of Plant Breeding and Genetics, S.K.N. College of Agriculture, Jobner, Jaipur-303329 Rajasthan*
**Corresponding Author Email : saritasheshama8386@gmail.com*

Introduction

Agriculture has an important role to play in responding to climate change, both mitigating its causes and adapting to its unavoidable impacts. Agriculture contributes to mitigation through minimizing GHGs (Green house gases) emissions, sequestering atmospheric carbon, and sustainably producing biofuels. The overall aim of the response to climate change is to ensure food security and other essential human enterprises, while protecting ecosystems and their vital service. As early as 1896, the Swedish chemist and Nobel Prize winner Arrhenius published a paper discussing the role of carbon dioxide in the regulation of the global temperature and calculated that a doubling of CO_2 in the atmosphere would trigger a rise of about 5–6° C. Climate change also promises new and unprecedented challenges, and demands new and urgent efforts to meet these. We need to take rapid strides forward in understanding what is going to happen to our farming, fishery and forest systems as the climate changes; the interactions that will occur with other global changes that are also under way; and within this complex and dynamic situation, the trade-offs we may face between food security, livelihoods and environmental security. In general, management practices that increase agricultural production and reduce production risk also tend to support climate change adaptation because they increase agricultural resilience and reduce yield variability under climate variability and extreme events, which might intensify with climate change. To a large extent, the same practices that increase productivity and resilience to climate change also provide positive co-benefits with respect to agricultural mitigation of GHGs. There are three main mechanisms for mitigating GHGs in agriculture: reducing emissions, enhancing removal of carbon from the atmosphere, and avoiding emissions through the use of bioenergy or agricultural intensification rather than expansion. Climate change conditions are likely to be characterized by increased frequency of extreme events, such as heat waves, hail storms, excessive cold, heavy and prolonged precipitation and droughts, with negative impacts on crop yields. Extreme weather events such as heavy rain, hail storms and flooding can physically damage crops, while extremely wet conditions in the field can delay planting or harvesting. Prolonged droughts lead to outright crop failure. The agriculture-dependent people are likely to be worse off in the face of climate change, due to their present marginality and vulnerability to risks as well as the limited resources and capacities to withstand global warming led crises.

Role of agriculture in climate change : The gases which are released from crop field eg. CO_2 (from respiration), CH_4 (from rice field), N_2O (from metabolic process of soil micro- organism) increases the environmental temperature.

CO_2 : Increase Elevated atmospheric CO_2 levels stimulate leaf photosynthesis and leaf stomata closure, potentially increasing plant growth and yield and improving the efficiency of plant water use. However,

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in real agricultural fields, these benefits to crop production are expected to be lower than in CO_2 plant experiments, because of limiting factors such as soil and water quality, water supply, crop-weed competition and infections by pests and diseases. In addition, CO_2 temperature interactions are recognized as a key factor determining plant damage from pests in future decades; CO_2 precipitation interactions will likewise be important. Carbon dioxide (CO_2) is the most abundant of the increasing greenhouse gases. Land plants fix atmospheric CO_2 via photosynthesis and respire part of it back to the atmosphere. When plant biomass is harvested, burned, or returned to the soil, much of the carbon in plant matter is oxidized and released as CO_2 to the atmosphere as a result of soil microbial respiration or direct combustion. Otherwise, plant matter exists in soil and is broken down over time.

CH_4 : Agricultural sources of methane include flooded rice paddies, enteric (bacterial) fermentation by domesticated ruminants (e.g. cows, goats, bison, sheep, and buffalo), farm animal wastes, and biomass burning. Drainage of wetlands for agriculture can also result in methane emissions, as can thawing of permafrost in boreal (subarctic and subantarctic) regions. Methane (CH_4), is a short-lived gas with a low atmospheric concentration (only 0.5% that of CO_2), however its per-molecule absorption of infrared radiation is over 20 times stronger than CO_2.

N_2O : In the soil, N_2O evolves mainly from the metabolic process of soil microorganisms. Factors that determine the level of N_2O emissions include soil aeration, temperature, moisture content, soil texture and the amount of nitrogen fertilizer. Nitrous oxide also originates from the decomposition of livestock manure and other organic residues incorporated into the soil.

Climate change Effects on Soils : According to ASA, CSSA, SSSA Climate Change Group, climate change effect the soil by following ways :

Higher soil temperatures alter nutrient and carbon cycling by modifying the habitat of soil biota, which in turn affects the diversity and structure of species and their abundance.

Heavier downpours in some regions will lead to increased soil erosion. In addition increased precipitation will result in water-logging of soils, thereby limiting oxygen supply to crop roots and increasing emissions of nitrous oxide and methane. Altered rainfall, whether through increased or decreased precipitation, will affect soil chemistry and biology.

Soil water retention capacity will be affected by rising temperatures and by a decline in soil organic matter due to both climate change and land-management changes. Maintaining water retention capacity is important to reducing the impacts of intense rainfall and droughts, which are projected to become more frequent and severe.

Prolonged spells of heat and drought between rainy periods may cause wilting, desiccation, and soil salinization, which may in combination reduce crop yields

Increased temperature and decreased moisture tend to accelerate the decomposition of organic material in soils, leading to a decline in soil organic carbon stocks and an increase in CO_2 emissions to the atmosphere.

Climate change Effects on Crops : According to ASA, CSSA, SSSA Climate Change Group, climate change effect the crops by following ways :

Higher temperatures and heat waves affect the growth and development of crops, influencing potential yields. A critical variable is the numbers of days a crop is exposed to temperatures exceeding specific thresholds during critical growth stages- e.g. flowering, pollination, fruiting, or grain filling – reducing the quantity and quality of yield.

Changes in the patterns of precipitation alters water supply for crops. Climate change is expected to destabilize pre-existing rainfall regimes in many regions, resulting in changes in duration and intensity of flooding episodes and periods of drought. This is likely to increase the extent and intensity of erosion, water-logging, and periods of desiccation, with negative effects on yields.

Increased atmospheric carbon dioxide (CO_2) concentrations may have positive effects on some crops, the effects being species-dependent. The photosynthesis, growth, and yield of C_3 plants such as wheat and rice tend to benefit more from high CO_2 than do C_4 plants such as maize. Higher CO_2 in the air also increases the efficiency of water use by crops.

Changes in temperature, precipitation, and CO_2 will interact with other environmental stresses, such as ozone, which tend to reduce crop productivity.

The Future costs of climate change : A recent study by the International Food Policy Research Institute (IFPRI), titled 'Climate change: Impact on agriculture and costs of adaptation', highlighted some of the anticipated costs of climate change :

25 million more children will be malnourished in 2050 due to climate change without serious mitigation efforts or adaptation expenditures

Irrigated wheat yields in 2050 will be reduced by around 30% and irrigated rice yields by 15% in developing countries

Climate change will increase prices in 2050 by 90% for wheat, 12% for rice and 35% for maize, on top of already higher prices.

At least US$7 billion a year are necessary to improve agricultural productivity to prevent adverse effects on children.

Strategies to cope up under changed scenario of climate

We do not need to wait for the uncertain conditions of the future to evolve – the climate today is already having significant negative impacts on the lives and livelihoods of poor people around the world. Indeed, droughts and floods are far from new phenomena, and farmers have developed various ways of coping with them, and other weather extremes, over the centuries. But poverty limits options, and the risk that the climate presents to agriculture plays a significant part in keeping farmers, and their families, in poverty. Without the back-up of insurance, small-scale farmers can lose everything if there is a weather 'shock'. To survive, they will probably have to sell any assets they possess, such as animals or farming tools, and when it is over they will be in a much worse position than they were before. The impacts of an extreme weather event can therefore last much longer than the actual event (from Climate, agriculture and food security : A strategy for change, Dec. 2009)

Currently Available Agricultural Adaptation Strategies : According to ASA, CSSA, SSSA Climate Change Group, current agriculture adaptation strategies are :

Increasing crop diversity – including both widening the array of crop varieties and broadening the range of crops – can be an effective way to moderate the effects of weather variability and extreme events associated with climate change.

Use of drip irrigation can help to manage limited water supplies more efficiently as hydrological regimes become more unstable and periods of drought become more severe.

Integrated pest management is a means to help agricultural systems respond to changing pest regimes resulting from climate change.

Soil management such as reduced tillage and residue management can be used to conserve water, reduce erosion, and increase soil productivity

According to American Society of Agronomy (ASA), Crop improvement Society of America (CSSA), and Soil Science Society of America (SSSA) major task under changed climate scenario are :

Ensure food security in a changing climate :

Develop and evaluate locally-based adaptive management and mitigation strategies to enhance the resilience of cropping and rangeland/pasture production systems.

Develop and employ transdisciplinary assessment tools that incorporate the systematic resource constraints that affect agricultural productivity and include climate and socioeconomic scenarios, including improved characterization of policy and program environments and options

Undertake integrated research in genetics, crop physiology, and soil-nutrient-water-crop management to enhance agricultural yields and environmental quality

Actively conserve genetic resources to safeguard these assets for use in the future development of improved varieties

Use private and public breeding programs to improve overall abiotic and biotic stress resistance of crops, increase nutrient and water use efficiency, and capitalize on atmospheric CO_2.

Understand the effects of elevated carbon dioxide and climate variability on soils and crops :

Advance understanding of the potential impacts of elevated abiotic stresses (increased CO_2, variable temperatures, and unpredictable precipitation patterns) on biological factors in managed and natural systems.

Characterize interactions among plants, microbes, and soils that affect the resilience and adaptability of agroecosystems.

Improve efficacy of agricultural mitigation practices :

Adopt a whole-systems approach to greenhouse gas mitigation in agro-ecosystems by incorporating assessments of both carbon and nitrogen cycling.

Evaluate agronomic practices based on optimization of both soil carbon sequestration and nitrogen use efficiency.

Study the role of microorganisms in soil carbon and nitrogen stabilization.

Develop and incorporate life-cycle analysis to evaluate the energy efficiency of current and alternative farming practices at the local, regional, and national scale.

Carbon Dioxide :

Quantify carbon sequestration resulting from various management practices and evaluate and document other beneficial services, such as changes in soil quality, productivity, erosion, and water and air quality

Conduct long-term field studies that enhance process-based understanding and improve models to ensure carbon sequestration practices that result in soil carbon with long-term stability.

Create programs that coordinate national and international on-farm measurements to reduce uncertainty in estimates of carbon stock change, incorporating existing datasets

Build a monitoring network of multiple sites to provide observations that support model-based systems which integrate information from existing long-term field experiments and are capable of using site-specific data on climate, soils, and management practices.

Methane :

Research ways to reduce CH_4 emissions from enteric fermentation.

Develop methods for livestock manure management that lessen CH_4 emissions.

Improve efficiency of rice-production systems to reduce CH_4 emissions.

Nitrous Oxide :

Analyze the potential for nitrogen fertilizer-use reduction without negatively impacting crop quality as a climate-change mitigation strategy through studies of cover-crop management, residues, and microbial and physical processes that regulate soil nitrogen cycling and availability.

Establish monitoring networks, field agricultural experimental sites, and measurement programs for indirect sources to create an inventory of accurate annual N_2O flux estimates in agriculture.

Improve adaptation options :

Use appropriate models to define crop traits that can provide tolerance to environments with increased climate variability and that take advantage of rising CO_2.

Develop drought- and/or heat-resistant crops that have been tested for yield stability when subjected to periods of extended water shortage.

Organize long-term global testing sites and data collection and dissemination efforts, using standard protocols, to conduct adaptive breeding and assess the performance of existing and new genetic material and management systems in today's range of agroclimatic conditions.

Establish continuous field testing programs to track climate change, resistance to new diseases and pests, and changes in pollinator distribution in order to address adaptation of crops. Field testing should extend beyond traditional areas of crops in order to begin anticipating the performance of crops and cropping systems to new environmental conditions.

Conduct multi-climate and crop-model ensemble simulations to better characterize uncertainty in agricultural impacts and adaptation projections

Model path dependence and optimal timing for a range of adaptation strategies by region.

Develop management systems that will increase the genetic diversity in the landscape. In many areas, the crop plant genetic diversity has decreased to a point where unexpected climate or pest problems can threaten world food security.

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Chapter 16

Latest Trends in Equipments for Pesticide Residue Analysis

Rajan Kamboj and Naveen Rao
Department of Entomology, C.C.S. Haryana Agricultural University, Hisar, Haryana
Corresponding Author Email : rajankamboj@hau.ac.in

Introduction

Pesticides and their metabolites have received particular attention in the last few years in environmental trace organic analysis because they are regularly detected in surface and ground waters especially throughout Europe, Asia and North America as a consequence of their widespread use for agricultural and non-agricultural purposes (Hennion and Pichon, 2001).

The determination of pesticides in food and environmental samples at low concentrations is always a challenge. Ideally, the analyte to be determined would be already in solution and at a concentration level high enough to be detected and quantified by the selected final determination technique i.e., HPLC or GC (Turiel and Martin, 2007). However, in environment, in food or in biological samples they are present at trace levels and despite the advanced techniques available for separation and quantification, no sample can be directly analyzed, therefore an extraction and concentration stage is required.

Even when the analyze is already in a liquid media (*i.e.* water, juice, serum), the presence at different concentration levels of the matrix-interfering compounds, imposes the need to overcome several difficulties related to the required selectivity and sensitivity of the analytical technique. Consequently, the selection of an appropriate sample preparation procedure involving extraction, concentration and cleanup steps becomes mandatory to obtain a final extract, enriched in the target analyte, as free as possible of the interfering compounds.

Major Objectives of Pesticide Residue Analysis

- To estimate the persistence of pesticide in or on the soil, plant and water
- To establish Maximum Residue Limits (MRLs) of pesticides
- To establish safe waiting periods or pre-harvest intervals (PHI)
- To conduct market survey of agricultural produce
- To screen various methods for effective decontamination of pesticide residues

Steps in Pesticide Residue Analysis

(i) Sampling (collection, transport and storage of samples)

(ii) Sample preparation

(iii) Extraction

(iv) Clean-up

(v) Identification, quantification and confirmation

Extraction methods which is able to save time as well as amount of solvents.

Solid Phase Extraction (SPE) and Clean up : It is an extraction method using a solid phase and a liquid phase to isolate one, or other type of analyte from a solution. It is usually used to clean up a sample before using a chromatographic or other analytical method. The principle of action is based on simple adsorption chromatography where the mobile phase moves through the stationary phase and gets separated based on their respective K value (Kumari *et al*., 2002).

Gel Permeation Chromatography (GPC) : It is

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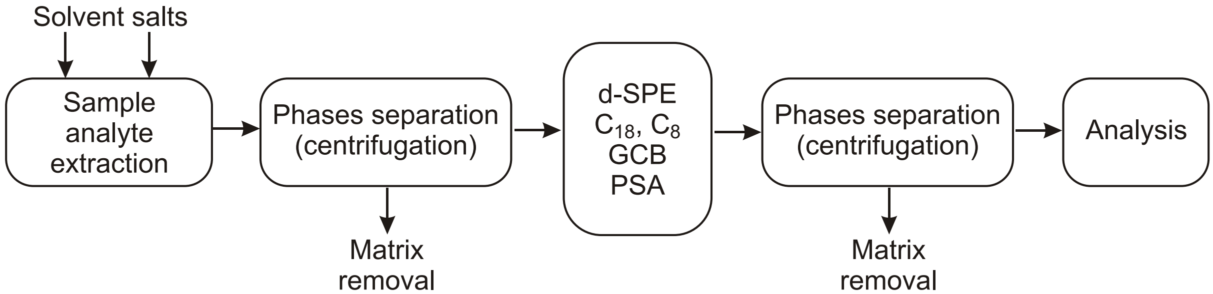

also known as size Exclusion Chromatography (SEC). Technique which separates components of a sample based on their molecular size. It is widely used in the analysis of polymer molecular weights (or molar mass). Extraction process for determining semi volatile organic compounds in environmental samples extracts the compounds of interest along with a number of other constituents. These other constituents are detrimental to the performance of the analytical method, causing deposits in the injectors of GC and GCMS instrumentation, leading to erratic results.

Supercritical Fluid Chromatography (SFC) : SFC is a unit operation to exploit high dissolving power of fluids at temperature and pressure above critical values for extracting analytes from sample matrixes. Liquids chromatography is fairly readily adapted to industrial scale. On the other hand gas phase chromatography has a role primarily in the lab, because gas densities are 1000 times lower than the corresponding liquid phase. CO_2 is the most common supercritical solvent (Savant *et al.,* 2010).

QuEChERS Method (catchers) Quick, Easy, Cheap, Effective, Rugged, Safe.

The QuEChERS method was developed by *Michelangelo* in the year 2001 for the analysis of veterinary drugs in animal tissues. After realizing its great potential in the extraction of polar and particularly basic compounds it was also tested on pesticide residue analysis in plant material with great success.

The recently introduced QuEChERS method avoids the use of nonpolar solvents inducing LLP by addition of $MgSO_4$ and NaCl to acetonitrile extracts, which leads to removal of majority of water and highly polar matrix components, yet achieving high recoveries of wide range of both GC and LC amenable pesticides (Anastassiades *et al.,* 2003). Additional SPE clean-up is performed to remove mainly sugars and fatty acids. QuEChERS is a sample preparation approach entailing solvent extraction of high-moisture samples followed by clean up using d-SPE. Basically, the sample is firstly extracted with a water-miscible solvent (for example, acetonitrile-ACN) in the presence of high amounts of salts (for example, sodium chloride and magnesium sulfate) and buffering agents (for example, citrate) to induce liquid separation and stabilize acidic and basic labile pesticides, respectively. Upon shaking and centrifugation, an aliquot of the organic phase is subjected to further clean up using dispersive – solid phase extraction (d-SPE), by adding small amounts of bulk SPE packing sorbents to the extract. After sample clean up, the mixture is centrifuged and the resulting supernatant can be directly analyzed, or can be subjected to another concentration, when solvent exchange step if necessary.

Now QuEChERS is known as a multiclass, multiresidue method (MRM) for analysis of pesticides from high water content (80-95%) matrices. The QuEChERS method now published as AOAC method 2007. This method is validated for the analysis pesticide residue in dry products like cereals, dried fruits, tea and fatty foods like fish, meat.

Advantage

Conventional method	QuEChERS
Time-Consuming, Complicated or Error-prone Steps	Simplified Alternatives
Sample Processing/Homogenization	No Way Around this
Blending/shaking for long time	Homogenisation for 30 Sec
Filtration	Centrifugation
Multiple Partitioning Steps	Single Partitioning
Separation/Transfers of Entire Extract	Take Aliquots
Use of a Lot of Glassware	A few glassware
Evaporation/Reconstitution of large volume	Evaporation/Reconstitution of small volume
Classical Steps/Classical SPE with Columns and Manifold	Dispersive SPE

Procedure schematically (for 10 g sample)

Weigh 10 g of sample

add 10 mL acetonitrile and internal standard

agitate intensively

add NaCl, $MgSO_4$ and buffering salts for phase-separation and pH-adjustment

agitate intensively and centrifuge **Raw extract**

take an aliquot of the upper organic phase and subject it to dispersive SPE cleanup (d-SPE) by mixing it with $MgSO_4$and a sorbent (*e.g.* PSA) to remove water and undesired co-extractives.

agitate shortly and centrifuge (optionally add Analyte Protecting Agents) ? Final extract.

the final extract can be analyzed directly by GC and / or LC techniques.

Both, extraction and cleanup can be scaled up or down as desired. With QuEChERS a single analyst can prepare 8 samples in 45 minutes. Lab efficiency is improved not only with respect to labor reduction and consumable savings.

Advanced Methods of Pesticide Residue Analysis

Gas-liquid chromatography (GLC) : Invented by James and Martin (1952). A separation technique in which the mobile phase is a gas (usually helium or nitrogen) and the stationary phase is a liquid. The basis of gas chromatographic separation is the distribution of a sample between two phases. One of these phases is a stationary bed of large surface area, and the other phase is a gas which percolates through the stationary bed.

Gas chromatography – mass spectrometry (GC- MS) : It is a method that combines the features of gas-liquid chromatography and mass spectrometry and mass spectrometry to identify different substances within a test sample. The gas chromatograph utilizes a capillary column which depends on the column's dimensions (length, diameter, film thickness) as well as the phase properties. The difference in the chemical properties between different molecules in a mixture will separate the molecules as the sample travels the length of the column. The molecules take different amounts of time (called the retention time) to come out of (elute from) the gas chromatograph, and this allows the mass spectrometer downstream to capture, ionize, accelerate, deflect, and detect the ionized molecules separately. The mass spectrometry process normally requires a very pure sample while gas chromatography using a traditional detector (*e.g.* Flame Ionization Detector) detects multiple molecules (Pareja *et al*, 2011).

GC MS/MS : Gas Chromatography coupled to Tandem Mass Spectrometry is used to separate the organic compounds in the mixture (fire debris). This technique is increasingly becoming the analytical tool of choice when analyzing target compounds in very complex matrices. In many GC MS/MS applications the matrix is virtually eliminated. GC MS/MS is ideal for fire debris analysis and has been used for the analysis of target compounds in various matrices such as complex environmental samples, pesticides in foods, drug metabolites and other forensic trace evidence. This method is designed to provide a better analysis for weak, highly weathered or older samples.

The Basic GCMS/MS sequence

(i) Ion creation

(ii) Ion selection

(iii) Ion dissociation

(iv) Mass analysis

High Performance Liquid Chromatography (HPLC) : It is a chromatographic technique that can separate a mixture of compounds to identify, quantify and purify the individual components of the mixture. Uses high pressure pumps, short and narrow column packed with micro particulate phases and a detector. The mixture to be separated is dissolved in a solvent and then forced to flow through analytical column along with the mobile phase. In the column, the constituents of the mixture get resolved. A suitable detector detects the separated constituents of the mixture. By a proper choice of the column, mobile phase and detector, HPLC can be a technique of high degree of versatility (Gonzalez *et al,* 2012).

Advantages of HPLC : It allows analysis to be done in a shorter time and achieves a higher degree of resolution, that is, the separation of constituents is more complete. It allows stationary columns to be reused a number of times without requiring that they be regenerated, and the results of analysis are more highly reproducible.

High performance thin layer chromatography (HPTLC) : Enhanced form of thin layer chromatography (TLC) to automate the different steps, to increase the resolution achieved and to allow more accurate quantitative measurements. The spot capacity can be increased by developing the plate with two different solvents. After the plate is exposed to the first solvent, the solvent is removed; the plate is rotated 90° and developed with a second solvent. If the two solvents show different selectivity, then the spots may be spread over the entire surface of the plate. This is obviously a form of two-dimensional chromatography.

Liquid chromatography–mass spectrometry (LC-MS or HPLC-MS) : It is an analytical chemistry technique that combines the physical separation capabilities of liquid chromatography (or HPLC) with the mass analysis capabilities of mass spectrometry. A powerful technique used for many applications which has very high sensitivity and selectivity.

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Chapter 17

Hay and Silage

Kartik Tomar[1], Deepak Kumar[2], Sameer Pandey[1] and Shiwanshu Tiwari[3]
[1]Department of Animal Husbandry, College of Agriculture, S.V.P. University of Agriculture & Technology, Meerut, U.P.
[2]Department of Livestock Production and Management, C.S.A. University of Agriculture & Technology, Kanpur, U.P.
[3]Department of Animal Breeding, G.B.P. University of Agriculture and Technology, Pantnagar, Uttarakhand
Email : kktomar996@gmail.com

Introduction

Failed crops can be cut for hay or silage to cover some costs of growing the crop and in some instances can be profitable, but markets can be volatile. Crop hay and silage can be of very good quality if managed correctly. Crops cut for hay can be at risk of weather damage due to longer curing times. Crops cut for silage have less curing time (24 to 48 hours), reducing exposure to possible weather damage. Silage is cut at an earlier growth stage, making it of higher quality than hay, but is less cost effective to transport long distances. In droughts, fodder can be in high demand. Growers should have a market for hay before cutting their crop, unless the forage is intended for their own stock. Most hay is sold on nutritional specifications. If sold on contracts, growers need to thoroughly understand hay contracts in terms of agreed quality. Hay or silage can be fed to all types of ruminant livestock, provided necessary precautions are taken when introducing these feeds to the diet. Animals generally find canola hay and silage palatable and waste very little, but can take one or two days to become accustomed to the taste. Feeding hay and silage is safer than grazing a standing crop because animals will selectively graze plant parts with a potentially higher concentration of nitrates. Hay and silage have caused very few problems, especially considering the large quantities of canola hay and silage consumed over recent years. However, farmers must exercise care at all times to minimise risks to stock health.

Lower forage quality is linked to an increase in lignin and structural cell wall components, as well as a decrease in crude protein and digestible plant cell components such starches, monosaccharides, and sucrose (Aman and Lindgren, 1983). Because delaying mowing service and poor technique of ensiling grass silage mass produce poor nutritional content and low intake, feeding production animals with grass silage only can be similar to feeding them fresh grass (Aston *et al.,* 1994). The concentration of nutrients per unit of dry matter and the amount of forage an animal can consume determine an ingredient's value in animal feed. There is a negative correlation between moisture content and consumption of forage dry matter (Steen *et al.,* 1998) and positive correlation between grass silage digestibility and milk production in dairy cows fed ad libitum (Castle, 1975). The nutrition of the crop will affect the hay and silage quality. Adequate nitrogen will lead to higher protein levels than deficient crops. However, stressed crops with high soil nitrogen levels are at higher risk of causing nitrate poisoning in livestock if precautions are not taken. The quality of canola and cereal hay and silage can vary enormously; quality testing is suggested before feeding to livestock.

Hay

Hay is a herbage and especially grass mowed and cured for fodder. Hay is grass, legumes, or other herbaceous plants that have been cut and dried to be stored for use as animal fodder, particularly for large grazing animals raised as livestock. Hay can be used as

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animal fodder when or where there is not enough pasture or rangeland on which to graze an animal, when grazing is not feasible due to weather (such as during the winter), or when lush pasture by itself would be too rich for the health of the animal.

Silage

Silage is described as grass or other green fodder compacted and stored in airtight conditions, typically in a silo, without first being dried, and used as animal feed in the winter. The fodder (such as hay or corn) converted into succulent feed for livestock through processes of anaerobic bacterial fermentation (as in a silo). Silage is a type of fodder made from green foliage crops which have been preserved by fermentation to the point of acidification . The fermentation and storage process is called ensilage, ensiling or silaging. The efficiency of this process, as well as the factors that influence it, such as humidity, temperature, oxygen availability, soluble carbohydrate concentration, and plant silage productive properties, all affect silage quality (Neumann, 2001).

Conservation of forage crops

Seasonal variation creates surplus forages at one point of time that would be wasted if not conserved. There are two methods of conserving forages, the simple method is to drive off moisture in forages, while in the other method, natural fermentation is facilitated to retain succulence in the preserved forage. The driving off moisture from forage forms the basis in hay making while retaining forage's succulent forms the basis for silage making. The amount and type of concentrate feed, as well as protein supplements, have the greatest influence on the amount of dry matter silage (Chamberlain *et al.,* 1989).

Crop residues

Hay making

Reducing the moisture content of the green crop to a level low enough (12-14%) to inhibit the action of plant and microbial enzymes is the aim of hay making. The harvested crop can be dried either by natural drying or through artificial drying, but natural drying is preferred as there it can be done without incurring expenditure towards electricity. Hay can be stored satisfactorily in a stack or bale.

Requisites for good hay

Selection of crop–The crop to be made as hay should have a soft pliable stem.

Harvesting of crop–The crop should be harvested at 2/3rd flowering stage as it is at that time the plant will have the maximum nutrient in it. Hay should be leafy and green in colour as they reflect the nutritive value of hay.

Hay should be free from moulds and weeds.

Hay should have the characteristic aroma of the crop.

Schedule for harvesting and curing of hay

Good quality hay can be produced by harvesting the crop early in the morning and left in the field as such for curing.

The harvested crop should be allowed to dry in the field until the moisture content is reduced to about 40%.

Frequent turning is necessary to facilitate uniform drying.

On sunny days field drying of harvested crops for two days is sufficient to make hay.

The air dried crop may be turned with the rake and made into small feathery windrows at the end of the first day.

The windrows may be baled at the end of second day and if further drying is required in spite of two days of sun drying, they may be placed over tripods or tetrapods or over the fence to facilitate airation during drying.

Hay should always be stored in a well ventilated place as they catch fire easily.

Average quality hay will have 25-30 percent crude fibre and 45-60 per cent TDN.

Chemical changes

Plant and microbial enzymes : Plant continues to respire even after harvest and during respiration, the sugars are oxidised to CO2 and H2O leading to increase in concentration of cell wall constituents like cellulose and lignin.

Oxidation : During drying, oxidation occurs leading to reduction in the carotene concentration and that is why sun drying should be stopped when greenery starts fading.

Leaching : Leaching causes loss of soluble minerals, sugars and nitrogenous constituents in addition to facilitating mould growth.

Microbial action : Microbes flourish during drying for prolonged periods under bad weather leading to moldy hay that are unpalatable & harmful to farm animals & man. Such hay may cause allergic diseases affecting man known as hay fever or farmer's lung.

Plant Species : Legume hays are richer in protein and minerals than grass hay. Non-legume hay has more carbohydrates but less palatable.

Stage of growth/cutting : The nutritive value of hay depends on the stage of growth of the crop at the time of cutting. Harvesting matured crop results in hay with lower digestibility, lower net energy value and lower palatability but with larger yield. Harvesting immature crop results in hay with higher digestibility, higher net energy value and higher palatability but with lower yield. Two third flowering stage is the optimum period for harvesting to make good quality hay.

Mechanical damage : Since leaves lose moisture more quickly than the stems, they become brittle and easily crushed by handling.

Changes during storage

Dark brown colour observed in overheated hay stored at higher moisture level during stacking is due to oxidative degradation of sugars combining with amino acids or proteins. Plant respiration ceases at about 40°C, but thermophilic bacteria continue to be active until 72°C and therefore oxidative degradation continues in hay containing thermophilic bacteria. The heat tends to accumulate in hay stored in bulk and eventually combustion may occur.

Losses in nutritive value of hay are due to :

Losses due to late cutting.

Losses of leaves by shattering.

Losses due fermentation.

Losses due to leaching.

Artificially dried forages

Artificial drying is a very efficient process but an expensive method of conserving forage crops. Drying is brought about by allowing hot gas (150oC) to pass through herbages for about 20 to 50 minutes depending upon the drier design and the moisture content of the crop. There are driers wherein gases in the range of 500-1000oC are allowed to pass through to dry herbages within 0.5 to 2 minutes.

Silage

Silage is the preserved material produced by the controlled fermentation of crops under anaerobic conditions in a structure known as silo. Ensilage is the name given to the silage making process. The main purpose of silage making is to preserve succulent fodders for usage at the time of scarcity. Silage making involves natural fermentation in anaerobic condition with due care to discourage activities of undesirable bacteria.

Advantages of Silage Making

Silage can be made even on weather that does not permit hay making.

More animals can be reared per unit of land.

Year round supply of high quality succulent fodder is possible.

Satisfactory silage can be produced in spite of weeds, as the ensiling process kills many kinds of weed seeds.

Silage making converts stemmy forage crops to soft that are better utilized by the livestock.

Factors to be considered in silage making

Selection of crop : Crop with soft and pliable stem is most suitable for silage making.

Time of harvest : Crop should be harvested when 50% of the crop is in the near emergence stage as at this stage the crop will be nutritious as well as with high biomass yield.

Wilting of the crop : Crops with high moisture (85%) will produce more effluents that would go as waste. To reduce effluent loss, crops with high moisture content are wilted for a few hours, until moisture level is reduced to 60%.

Chaffing of the crop : The success of silage depends on the ability to provide anaerobic condition in silo. Anaerobic conditions prevent oxidation of nutrients in crops and promote a conducive environment for desirable organisms to survive and produce lactic acid. Thus in order to prevent the development of air pockets in silo, compression of ensiling materials is important. Compression can be achieved better by chaffing the crop.

Preparation of the silo : Several types of containers are used as silo. The silo should be cleaned and re plastered to make the silo walls smooth and strong.

Additives : Molasses at the rate of 2% (Weight of forage) provides readily available carbohydrates necessary for increasing the lactic acid production by lactobacillus. Further Molasses increases palatability and nutritive value of silage. Molasses is sprayed over the forages to facilitate uniform distribution. Salt at the rate of 1% (Weight of forage) is also added to improve palatability of silage.

Filling up of the silo : Rapid filling of silo is desired for anaerobic condition.

Compaction : Compaction of chaffed material can be brought about by manual trampling or by engaging tractor. Compaction is the key step in silage as it removes the air pockets to promote anaerobic fermentation.

Sealing of the silo to prevent the entry of air or water : To sustain anaerobic condition and to prevent entry of atmospheric air / rain into silo, the silo should be sealed as soon as the silo is filled. It is advisable to fill the silo pit to form a dome shape and cover it with insulators like tarpaulin sheet or plaster it with mud. Dome shape filling will facilitate rainwater to run off and prevent seepage. Silage will be ready in four weeks time. Upon opening the silo, the silage should be taken out daily to feed animals. Silage making should not be undertaken during rainy days.

Principles of fermentation in silo : The fermentation in silo can be regulated by encouraging lactic acid formation by bacteria present on the fresh herbage or addition of preservatives such as sodium metabisulphite or by direct addition of a weak acid solution. The first method soluble carbohydrates present in the plant material is fermented to lactic acid, resulting in a lowering of pH to within the range of 3.8 – 4.2. Material of this type has a lactic acid content (8-12% dry matter) and is described as 'well preserved silage. As long as the silage mass is kept under anaerobic conditions, its pH will remain stable at 4 and the silage can be stored for 3-4 years. If, however, rain is allowed to enter the silage (or) if lactic acid concentration is scarce, secondary clostridial fermentation take place. There are two types clostridium, while one group cause a break down of the lactic acid with the production of butyric acid, the other group of clostridia attack amino acids, with the formation of ammonia, organic acids, amines and CO2. Either or both of these types of clostridia may become dominant in poorly preserved silage which will have a comparatively high pH value of above 5.

Factors affecting the nutritive value of silage

Chemical changes : Plant continues to respire as long as oxygen is present or until the plant sugars are used up. Sugars are oxidised to carbon dioxide and water, with the production of heat causing rise in temperature of the mass. In addition, proteolysis also occurs immediately after the herbage is cut. Protein is rapidly broken down to simpler substances, mainly amino acids. Packing the silo compactly eliminates air pockets and prevents this activity. However, if the herbage is not well consolidated, then air may penetrate into the mass and the temperature will continue to rise. Thus overheated product will be dark brown or black in colour with low feeding value due to excessive loss of soluble carbohydrate and a lowering of the protein digestibility.

Microorganisms : In anaerobic condition, the microbes present on the plant surface multiply, using the contents of a cell as medium to produce lactic acid. Thus the acidity of the mass drops to about pH 4.0 – 4.2 and at this pH, organisms other than the lactic acid bacteria are inhibited as long as conditions remain anaerobic. These lactic acid bacteria are classified into 2 main groups, the homofermentative lactic acid bacteria and the heterofermentative lactic acid bacteria. Homofermentative lactic acid bacteria are more efficient at converting hexose into the acid than the heterofermentative organisms. During ensilage about 60% of the proteins are broken down to amino acids even in well preserved material.

Characteristics of a good silage

Very good silage : It is clean, the taste is acidic, and has no butyric acid, no moulds, no sliminess without proteolysis. The pH is between 3.5 and 4.2. The amount of ammoniacal nitrogen should be less than 10 percent of the total nitrogen. Uniform in moisture and green or brownish in colour. Taste is pleasing, not bitter or sharp.

Good silage : The taste is acidic. There may be traces of butyric acid. The pH is between 4.2 and 4.5. The amount of ammoniacal nitrogen is 10-15 percent of the total nitrogen. Other points are the same as of very good silage.

Fair silage : The silage is mixed with a little amount of butyric acid. There may be slight proteolysis along with some mould. The pH is between 4.5 and 4.8, ammoniacal nitrogen is 15-20 per cent of the total nitrogen. Colour of silage varies between tobacco brown to dark brown.

Poor silage : It has a bad smell due to high butyric acid and high proteolysis. The silage may be infested with moulds. Less acidity, pH is above 4.8. The amount of ammoniacal nitrogen is more than 20 per cent. Colour tends to be blackish and should not be fed.

Haylages

Haylages are low moisture silage with

characteristics between those of hay and silage. It is made from grass and/or legume to a moisture level of about 45-55%. To use up the oxygen and to trap and hold the produced CO_2 within the silo, the silos should be as airtight as possible. This condition will prevent the forage from spoiling by moulding, oxidising, heating etc.

Advantages

Haylage has a pleasant aroma, palatable and high quality feed.

Partially dried forage can be made into haylage.

Disadvantages

Fine chopping, good packing and complete sealing against air entrance inside the silo is more critical than with silage.

The danger of excessive heating that lowers protein digestibility is more.

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Chapter 18

Production Technology of Grapes

N.R. Rangare[1] and Anay Rawat[2]
[1]*National Institute of Agricultural Extension Management (MANAGE), Hyderabad*
[2]*Jawaharlal Nehru Krishi Vishwa Vidyalaya, Adharatal, Jabalpur*
Email : nrrangare@gmail.com

Common Name - Grapes
Botanical Name - *Vitis vinifera*
Chromosome Number - 2*n* = 38
Family – Vitaceae
Origin – South China
Type of Fruit - Berry
Edible Part – Pericarp and Placenta

Introduction

Grape is a subtropical fruit but adapted to tropical conditions. It is a vine spreading on a support, native of Armenia, a district near the Caspian sea in Russia. It was introduced into India by the in values of Iran and Afghanistan. It is one of the most delicious refreshing and nourishing fruits. Fifty percent of the total production of fruits in the world is contributed by grapes. Cultivation of grapes is called Viticulture. There are about 10,000 varieties in the world.

Flowering and Fruiting :

Soil and Climate

It is a fruit of semi arid subtropical regions requiring warm dry summer and a cool rainy winter. During winter the grapes shed off their leaves and take rest.

During spring they put forth new leaves and flowers. The fruits mature during summer when there are no rains.

A long, warm to hot dry summer is needed for proper maturity and ripening.

Grapes do not thrive in the region of humid summer as it causes fungal diseases.

The distribution of rains in more important than the total amount of rainfall.

In North India heavy rains during July – September hence low production. The plant takes rest during winter since the winter is very severe and put forth new growth in summer.

When the crop reach as ripening stage during june there is heavy rain resulting in poor production In Western India grapes do not takes rest because of warm winter.

The climate in South India such as Bangalore in Karnataka, Dharmapuri and Madurai districts of Tamil Nadu is slightly humid and tropical.

Here the maximum temperature goes upto 35°C and the minimum temperature does not fall below 12°C due to warm winter condition there is practically no rest period.

Cited as : Rangare N.R. and Rawat Anay (2021). Production technology of grapes *GRISAAS–An Edited Book*. Volume-1 : 131-134. Rama Publishing House, Meerut (U.P.) India.

Almost rainless period during November – June favours heavy as well as sweet crop.

Here the vines are pruned twice. Early December pruning yields a sweet crop during April and summer pruning (May) yields a slightly sour crop during September.

The climatic conditions are favourable is parts of Tamil Nadu so that 5 crops are taken in 2 years by staggered pruning techniques.

Soil

Although grape can adapt to a variety of soils, it grows and performs best in deep mediumtextured soils (loams and sandy loams) with good drainage and low salt content. Salinity is the major hindrance in the development of grapes. It grows well in soils with a pH range of 6.5 to 7.5

Propagation

Propagated by hard wood cuttings prepared from matured canes (one year old shoot) of healthy, moderately vigorous, virus tree vines. Cuttings of 25-30 cm length are prepared by making the lower cut just below a bud and upper cut slightly above the bud. Cuttings should be tied and stored in moist sand for a month for callusing. The callused cuttings start well in the nursery. While planting only one bud in left above the ground level and remaining portion

buried in soil. At the end of winter the sprouted and rooted cuttings can be lifted and planted in the main yield. Grafting and budding is practiced with a particular root stock for specific requirement. The rootstocks are supplied by NRC Grapes, Maharashtra Grape Growers' Association etc. The rootstocks are raised by planting hard wood cuttings on flat beds at desired spacing, depending upon the variety and method of training.

(a) Phylloxera resistant root stock
Vitis riparia, *V. rupestris*

(b) Nematode resistant root stock
Dogridge, Salt creek

(c) Saline tolerant: Solanis, 1616
Preparation of main field and planting

Trenched of 0.6 m width and 0.6 m depth are dug at a distance of 3 m apart for Muscat. Other varieties 1 m3 pits are drug. Well decomposed FYM or compost or green leaf manure has to be applied in the trenches or pit and then covered with soil. The rooted cuttings are planted during June – July.

Spacing :

3 x 2 m for Muscat

4 x 3 m for other Varieties

Varieties

Clone A – 18/3 :

This clone is suitable for table purpose.

Amenable for double pruning and double cropping.

Medium sized bunches weighing 250 – 300 g.

Dark blue coloured oblong berries with rudimentary seeds or seedless.

Red Globe :

Characterized with prolonged juvenility.

Amenable for double pruning and single cropping.

Bunch weight: 600 g to 750 g.

Attractive pinkish red coloured berries.

Bold sized berries (>20 mm) with crisp pulp.

Fetches premium price in the domestic and export market.

Enhanced shelf life 20-25 days in ambient conditions.

Manjari Medika :

Suitable for juice making and table purpose.

Amenable for double pruning and double cropping.

Berries are attractive dark blue in colour with ashy coating.

Bunches are medium sized (250 g to 350 g).

Juice is teinturier with dark red colour

Sharad Seedless :

This variety is a selection from Russian selection from Kishmish Chernyi suitable for table purpose.

Berries take 125 days for ripening.

Berries are attractive dark blue in colour ellipsoid berries with high crisp pulp, low water content and high TSS.

Fantasy Seedless :

This grape is a complex hybrid derived from a cross between B36-27 x P 64-18 at USDA Fresno, California.

Vines are vigorous require high sunlight exposure for adequate fruitfulness.

This variety does not require GA3 for thinning / sizing.

Berries are medium bold, deep purple to black, seedless, thin skin and firm and obovate in shape.

Clusters are medium in size, conical shape, and medium to loose in compactness with excellent flavour.

It is mid late ripening variety and takes not less than 130 days from pruning.

Late harvesting and excess soil moisture / humid conditions sometimes lead to berry

White seedless varieties : Tas-a-Ganesh, Sonaka, Superior Seedless, Thomsan Seedless, 2A Clone

Coloured seedless varieties : Flame Seedless, Sharad seedless, Maroo Seedless, Cardinal, Nana Saheb purple, Krishna Seedless, Cone a 18/3, Rizamat,

Red Wine Varieties : Shiraz, Merlot, Zinfendal

White wine varieties : Chenin Blanc, Sauvignon Blanc

Other varieties : Muscat (Panneer), Pachadraksha, Anab-e-Shahi, Arka Shyam, Arka Kanchan, Arka Hans, Manik Chaman, Sonaka.

Training and Pruning :

Training is helps to maintain the stature and spread of the vine and facilitates operations like pruning, intercultivation, spraying and harvesting. There are many systems of training. The common systems in India are Bower, Kniffin, Telephone, Trellis and Head system. Under the climatic conditions of Maharashtra, Bower and Trellis system has been found to be the best for commercial varieties like Thompson seedless, Sharad Seedless and Tas-A-Ganesh. In Bower system, a bower of 2.1 m height is erected using stone pillars as support and galvanized iron wire of 8 and 10 guage thickness for mesh. One vigorous growing shoot is selected by nipping off other shoots and this single shoot is allowed to grow up straight with the support of bamboo or plastic wire stake.

Pruning :

Removal of any vegetative part in a vine is called pruning. It is a critical operation in grape cultivation. Therefore much care and precision needs to be exercised in pruning a vine. The main objective of pruning grapevine is to increase productivity, facilitate interculture operations and maintain desired vine framework and vitality of the vine for consistent productivity. In organic grape cultivation, the vines are forced to undergo rest for about a month immediately after harvest. This helps in storing the food material in the mature parts of the vine. The canes are cut back in April by keeping 1-2 buds which develop into canes in 4-5 months. The removal of dried canes is called 'back pruning' or 'growth pruning'. In the month of September-October these canes are pruned for fruiting. This pruning is called 'forward pruning' or 'winter pruning'. Vines, which have attained the age of one year can be subjected to this pruning.

Field preparation : The field is prepared by ploughing it twice and harrowing it thrice

Irrigation : Immediately after planting 3rd day and once in a week. Irrigation with held 15 days before pruning and also 15 days before harvest.

Manuring and Fertilization

Manuring is done by applying FYM at the rate of 55 t/ha. Biofertilizers like Azatobacter, Phosphate Solubilizing Bacteria(PSB), Effective Microorganism (EM), Neem cake and vermiwash are being used to supplement the nutrient requirement of crop. Trichoderma, Azatobacter and PSB are applied at the rate of 25 g/plant. Neem cake is applied at the rate of 1.25 t/ha. Jeevamrut is prepared by adding 10 kg cow dung, 5 l cow urine, 2 kg black jaggery, 2 kg ground pulses powder, handful of bund soil in 200 l of water. The solution is kept for 2 to 7 days in shade for fermentation. During the fermentation, the solution is stirred daily. To improve the quality of grapes, a solution of sugar, humic acid and coconut water is sprayed at bud development stage.

Pests and diseases

Carbofuran – 60 g/vine a week before pruning and irrigated profusely. The soil should not be disturbed to atleast 15 days. Application of neem cake 200 g/vine also controls nematode. We can afforded for application of *P. fluorescens*.

Flea beetles

Phosalone – 2ml/lit after pruning and followed with 2 or 3 sprayings.

Thrips : Dimethoate – 2 ml/lit

Mealy bug : Monocrotophus – 2 ml/lit

Powdery mildew : Sulphur dusting @ 6-12 kg/ha

Downy mildew : Spray 1% BM

Disorders

Flower-bud : Flower and berry-drop This problem has been reported from the states of Punjab, Haryana and Rajasthan in North India. The malady has been investigated and the association of a number of factors such as, improper nitrogen application, improper fertilization, ambient temperature, heavy crop load, uneven ripening and endogenous auxin deficiency at a particular stage of berry development are reported to cause the malady. To control bud, flower and berry drop, the following measures are suggested; making 0.5 cm wide girdle from the trunk about 10 days before full bloom which results in better berry set; judicious application of fertilizers under a given set of conditions, particularly N fertilizers, for 'even' ripening; 500 ppm ethrel at veraison stage should be applied; dipping of bunches in NAA 100ppm 10 days before ripening reduces berry drop, heavy irrigation at bloom should be avoided.

Blossom-end rot : A black sunken spot develops at the blossom-end of the berry which later on spreads with water-soaked region around it. Defective calcium nutrition and assimilation appear to be the cause for it. Spray of 1.0 per cent calcium nitrate may correct it.

Boron deficiency : The presence of small sized fruits and large sized fruits in the same bunch is known as hen and chicken disorder. The fruits are sour in taste. The symptoms include death of growing tips, leaf fall and brittleness of young shoots. The leaves may be deformed with interveinal chlorosis spreading from margins to inwards and this is particularly evident after the fruiting. Spraying of 0.2% boric acid a week before bloom and another at full bloom control the disorder effectively.

Iron deficiency : The leaves turn yellow (chlorosis) during iron deficiency and the entire shoot become yellow to yellowish green under extreme conditions. Iron deficiency may occur due to the presence of excess calcium in the soil (lime induced chlorosis). The corrective measure is two sprays of 0.2% ferrous sulphate, one before bloom and the second after fruit set

Ripening

To get uniform ripening bunches are sprayed with 0.2% K chloride at 20th and 40th day after berry set and clusters of seedless varieties are diped in 25 ppm GA (25 mg/lit) at calyptras fall stage and repeated again at pepper stage to increase the size of berries.

Harvesting and Yield

Seed less : 15 t/ha/yr

Muscat : 30 t/ha/yr

Pachadroksha: 40 t/ha/yr

Anab-e-shahi and Arka hybrids : 20 t/ha/yr

Grapes should be harvested only after ripening. The heat requirement of most of varieties ranges from 2900 to 3600 units. The grape berries can be kept without spoilage for 7 days at room temperature. Grapes can economically be stored upto 40-45 days in cold storage. The optimum storage temperature recommended is -2 to -1.5°C. Raisins from grapes form an important by product industry in several grape growing countries in the world. Grapes of 17° brix and above are used for raisin making while 20-23° brix is the standard.

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Chapter 19

Green Roof as an Energy Saver and Environment Conservator

Heera Lal Atal, Mahendra Meena, Kunal Debbarma, Lopamudra Jena, Kommu Pavan Kumar and Narendra Kumar Bharati
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, West Bengal

Introduction

Planting of green vegetation on roof of a building is called green roofs. In green roofs plants are grown in growing media prior to place on the roof of building and can consist of diverse vegetation, mosses to small trees, growing substrate, drainage and filter material, root barrier and insulation (Vijayaraghavan, 2016). Green roofs are classified into 3 groups, extensive, intensive and semi intensive (Berardi *et al.*, 2014; Vijayaraghavan, 2016). Mainly the location of green roofs measure suggest that it reduce pollutant concentration from local emission source as well as background contribution and improve air quality. Due to low capital cost, light weight and minimum maintenance extensive method of green roofs commonly adopted which has a thin layer of substrate with (smaller plants) mosses and grasses. While because of thick layer of substrate intensive method require high maintenance, in this methods small trees are used, so its require more investment. But semi-intensive method is a combination (hybrid) of both intensive and extensive method with medium substrate, capital cost and maintenance. Green roof infrastructure is helpful for reduce energy consumption and urban heat island effect, manage runoff water, improve ecological balance and reduce air and noise pollution (Berardi *et al.*, 2014; Castleton *et al.,* 2010; Czemiel Berndtsson, 2010; Oberndorfer *et al.,* 2007; Saadatian *et al.,* 2013; Vijayaraghavan, 2016).

Despite a number of studies evaluating various objectives of green roofs, but limited research has been focused on green roofs air quality improvement ability (Baik *et al.*, 2012; Berardi *et al*., 2014; Currie and Bass, 2008; Li *et al.,* 2010; Rowe, 2011). In most of the studies investigated the significant removal capability of green roofs, despite being inferior to trees at both cities and local scale (Currie and Bass, 2008). The Effect of green roofs on air quality and its cooling effect in street canyons demonstrated a potential 32 percent decrease in pollutant matter concentration and 2ºC reduction in temperature at breathing level (Baik *et al.,* 2012). In comparison, without recognition of the associated cooling effect marginal pollutant removal by a green roof structure was recorded by Pugh *et al.,* (2012). Speak *et al.,* (2012) studied that green roofs in traffic area shown a significant improvement in air quality and reduction in the quantity of fine pollutant particles (less than 0.56 µm) released from motor vehicles source was noticed by Tan and Sia, (2005). The pollutant removal rate air quality improvement by green roofs are depending on the wind condition, seasonal variation, plant species and characters and location of green roofs (Currie and Bass, 2008; Li *et al.,* 2010; Speak *et al.*, 2012).

Functions of Green Roofs

Storm water attenuation : Green roof structure lowering the risk of flooding by hold rainwater and delay peak flow of water (Chen *et al.,* 2015). When rain water enters in the green roofs, a portion of water absorbed by growing substance and hold in pore spaces. Rain water also can absorb by roof vegetation and either stored in plant tissues after than transpired back into the atmosphere (Nagase and Dunnett 2012), and the remaining water passes through filter fabrics of

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green roof and then exhaust through drainage. Water will be detained because of due to potential to store water between compartment (in the case of drainage modules) or pores (in the case of granules). The overflow will drain, when drainage space completely utilised. The remaining water in roofs will evaporate or will be used by plant or it will transpire by plants. The evaporated or transpired water explain the role of green roofs in retention potential of runoff water. Any green roof retention potential strongly depends on the thickness and type of growing media, type of vegetation and its coverage area, type of drainage element and its storage capacity, time period between last rain and present rain, volume of rainfall and sloop of green roof structure. Among different factors, growing media play a significant role in water holding. The substrate which are used for green roofs are light weight and volcanic material, which are having high water holding capacity. An investigation was carried out by Vijayaraghavan and Joshi 2014 on substrate of green roofs and identify delay in runoff releasing from green roofs is mainly due to high water holding capacity of growing media. During that time a simulated study was carried out on green roofs by Graceson et al., 2013 and found that higher water holding capacity result in higher runoff retention. Plants significantly reduce the runoff and its mainly depending on each plant water interception capacity, water retention capacity and transpiration (Nagase and Dunnett 2012). A study was done by Speak *et al.*, (2012) and indicated that 65.7% retention of runoff water can be achieved by an intensive green roof, as compare to 33.6% on an adjacent paved roof. A significant difference in quantity of water runoff between plant types was done by Nagase and Dunnett (2012) on the various plant species which are commonly used in intensive green roofs. In the sense reduction of runoff production grasses are more effective followed by forbs and sedum. By the use of plant species those are having taller height, larger diameter, larger shoot biomass and root biomass can achieve more control on runoff (Vijayaraghavan, 2016). (VanWoert *et al.,* 2005) suggest that where perception that runoff generation is high from green roofs using minimal water required succulents than from other plant species with higher transpiration rate which dry out substrate between two rainfall periods. Available water can rapidly have transpired by sedum species and it can share up to 40% of a green roofs ability to retain rain water, it is depending on size and time between two rain events. Rain water storage by green roofs also affected by type of drainage elements. In recent years' plastic drainage modules were used to supply water to plants during dry periods. Storage potential of drainage module plays significant role to decrease runoff volume. Many studies correlated water retention capacity of green roofs with rainfall intensity, size of rainfall and time of dry period (Berndtsson, 2010). Water storage capacity of green roofs is mainly depending on the sloop of green roof and rain event. For a rainfall with an intensity of 0.4 mm/min, 62%, 43% and 39% of the total precipitation were retained in the green-roof having slopes of 2°, 8° and 14°, respectively. For rain intensity 0.8mm/min at slopes of 2°, 8° and 14°, the retentions were 54%, 30% and 21%, respectively (Vijayaraghavan 2016).

Green roof as an energy saver : For energy saving green roof is an attractive option in building sector. Green roofs help to reduce energy demand in building through improvement in thermal performance of building. A study was conducted on green roofs by (Niachou *et al.*, 2001) and found that green roof decreases the energy demand for cooling between 2% and 48% its depending on covered area by green roof, and it is also decrease the building temperature up to 4 K. Building thermal performance improvement is basically due to increment of shading, better insulation and higher thermal mass of the green roof system. Added insulation to roof given by growing media and the thermal inertia of the structure improved by water. Thermal performance improvement ability of green roofs also reported by Ekaterini and Dimitris (1998). According to them, 27% radiation was reflected, 60% radiation absorbed by growing media and plants and up to 13% was transmitted into substrate medium of the total solar radiation absorbed by planted roofs. An investigation was conducted on green roofs in Singapore on five commercial building and found that it is helpful to 1-15% energy saving annually, saved 17-79% in the space cooling load and 17-79% in the peak space load in that study also reported that maximum energy saving is mainly depend on the type and thickness of the growing media and plant species. Green roof act as insulator and decrease heat flow during winter. However, this advantage of green roof often under debate as some studies claimed green roof worked as an energy saver medium, in other studies shown that green roofs not influence during winter, and some viewed it as a cause of high energy consumption. Green roof can also be used to reduce urban heat island effect for example to reduce air temperature in cities. High population density and intensely urbanised area highly affected by urban heat island effect and worst urban eco-environment. Green roofs act as a tool which combat the urban heat island effect and increase the albedo in urban areas (Saadatian *et al*., 2013). Berardi *et al.,* (2014) indicated that albedo of green roofs ranges from 0.7 to 0.85, which is much higher than the albedo (0.1–0.2) of bitumen, tar, and gravel roofs. In his review article, Santamouris (2014) com-pared several mitigation technologies to minimise urban heat island effect and recommended that large-scale application of green roofs could reduce the ambient temperature from 0.3 to 3°C.

Water quality improvement : Green roof produces good quality storm water runoff by remove the pollutants from water and it is also buffer acidic rain water (Vijayaraghavan and Joshi 2012). However, there exist a difference in research studies opinion for runoff quality from green roofs (Berndtsson, 2010; Vijayaraghavan and Joshi 2014). Green roof can improve storm water in a number of ways. There is possibility for both cleaning and contamination of rain water during percolation of rain water through the vegetation and substrate. Both substrate and vegetation help to remove dust and air born particulates from rain water, so both are act as particle trap. The substrate medium of green roof also acts as an ion exchange filter for nutrients and metals in rain water. If high concentration of an ion available in rain, the green roof worked as a sink and it will reduce the ion concentration in runoff. If ion concentration in substrate medium is higher as compare to runoff water, then some of the ions leached out from substrate medium and runoff water will have higher concentration of ions than the incoming rain water.

An experiment was done by Van Steres et al., (2009) for examined runoff some from an extensive green roof for total suspended solids, metals, nutrients, PH, bacteria and polycyclic aromatic hydrocarbons (PAH) and noticed that the concentration of most pollutant materials lower in green roof sample relative to the conventional roof with the exception of total phosphorus, calcium and magnesium. However, water quality data of those studies proved that higher nutrient concentration were present in green roof runoff that others. Berndtsoon *et al*., (Berndtsson *et al*., 2006) noticed that while in lower concentration than normally found in urban runoff, from green roof some metals appear in runoff in concentration that would correspond to moderately polluted natural water. An another study was conducted by Vijayaraghavan et al., (2012) under real rain event with the help of pilot-scale green roof assemblies and the result were that runoff comprise significant quantities of sodium, potassium, calcium, magnesium, nitrogen, phosphorus and traces of ferrous, copper and aluminium. In several studies it was reported that this difference in opinion runoff quality is mainly due to large variation in substrate composition, construction, age and maintenance of green roof. Many authors told that the quality of runoff in the first year of a recently developed green roof may not be representative of the runoff from a well-established and mature green roof (Vijayaraghavan and Joshi 2014; Rowe, 2011), because of in mature green roof structure, continues rainfall, plant uptake and other biological activities were expected to remove the pollutants out from the green roof. Nutrients discharge from green roof can also be directly related to use of fertilizer.

Effect on air pollution : To mitigate air pollution in urban environment green roofs structure is a popular approach. Urban air is very harmful for human health and environment, because of due to availability of elevated level of pollutants. Among various mitigation techniques, the ability of plants to remove pollutants from air is considered practical and eco-friendly technique (Rowe, 2011). Commonly plants reduce air pollution through direct or indirect process i.e. gaseous pollutants directly consumed by plant stomata or indirectly be modifying in microclimate. A study was carried out and found that 1.67 tan (O_3 52%, NO_2 27%, PM10 14% and SO_2 7%) of pollutant from air was removed in one year by 19.8 hectare of green roof (Yang *et al.,* 2008). Jonson and Newton (1996) found in another study that 2000 m^2 of green roof with uncut grass can remove 4 tan pollutant matters. Rowe, (2011) told that one square meter of green roof can solve annual particulate matter emission of one car. The authors investigated that the performance of green roof structure was depended on the condition of plants, position and location of green roof and ambient airflow condition. It was reported that in a sunny day, green roof system may decrease the CO_2 concentration in the nearby area as much as 2% planting tree in cities has been shown to excess better benefits in reduction of air pollution (Akbari *et al.,* 2001). But due to limited available space in cities development of forest is very difficult, so in general conclusion is that intensive type of roof garden is more favourable for minimising the air pollution than extensive type, owing to the possibility of installing small trees and shrubs (Rowe, 2011).

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Our Conference Memory

About the Chief Editor

Chief Editor

Dr. S.P. Singh, born in Village Jevri, Post Rajbun, District Meerut (U.P.), in 1970 and Graduated in Agriculture with Honors from G.M.V., Rampur Maniharan, Saharanpur (U.P.). He did his Post Graduation in Agricultural Botany, Institute of Advance Studies, Meerut University Campus, Meerut and Doctorate in the same discipline (Ag. Bot.) from C.S.J.M. University, Kanpur. Presently, he is working as Scientist (Plant Breeding) at C.S.A. University of Agriculture and Technology, Zonal Agriculture Research Station, Kalai, Aligarh (U.P.). Dr. Singh is a fellow of SRDA, and member of many other professional Societies, having **25** years of experience in Research and Extension Education Works. **He authored many books** such as Plant Breeding, Agriculture at a Glance, Hand Book of Agricultural Sciences (Hindi & English), Crop Physiology (Hindi & English), College Botany, Environmental Science & Agroecology, Concepts of Ecology etc. He is well recognized Scientist and having more than **300** publications in reputed National and International Journals. Dr. S.P. Singh is also **Editor-in-Chief, Progressive Research-An International Journal & Frontiers in Crop Improvement Journal** (both Journals are NAAS recognized), **Secretary,** Society for Scientific Development in Agriculture & Technology and also **President,** Astha Foundation, Meerut, working in the field of Science & Education.

He has been awarded as Best Editor and Writer Award-**2006**, Young Scientist Award-**2007**, Dr. M.S. Swaminathan Young Scientist Award-**2009**, Distinguished Scientist Award-**2014**, Scientific Initiator Award-**2014** from Directorate of Rice Research, Hyderabad, Science Leader Award-**2015** From RVSKVV, Gwalior, Outstanding Scientist in Agriculture Award-**2016,** Outstanding Achievement Award-**2016,** Excellence in Research Award-**2017,** Innovative Scientist of the Year Award-**2017** Outstanding Scientist in Agriculture Award-**2018** Before this International conference, Dr. S.P. Singh has already organized five conference at different corner of country, first conference was National symposium on **"Achieving Millennium Development Goal : Problems & Prospects"** at Bundelkhand University, Jhansi (UP) during October 25-26, **2009** under the umbrella of SSDAT, Meerut, Dr. Singh has been acted as an Organizing Secretary. The second was National conference on Emerging Problems and Recent Advances in Applied Sciences : Basic to molecular Approaches **(EPRAAS-2014)** during February 08-09, 2014 at Ch. Charan Singh University, Meerut (UP) again by SSDAT, Meerut in which Dr. S.P. Singh has played his role as an Organizing Chairman. The Third, Conference was Organized by SSDAT, Meerut and Astha Foundation, Meerut at Directorate of Rice Research, Hyderabad on Emerging Challenges and opportunities in Biotic and Abiotic Stress Management **(ECOBASM-2014)** during December 13-14, **2014**. Fourth Conference organized by Astha Foundation, Meerut & SSDAT, Meerut at RVSKVV, Gwalior on Global Research Initiatives for Sustainable Agriculture & Allied Sciences **(GRISAAS-2015)**. Fifth Conference was jointly organized by SSDAT, Meerut & Astha Foundation, Meerut at PJTSAU, Rajendranagar, Hyderabad, Telangana State on Innovative and Current Advances in Agriculture & Allied Sciences **(ICAAAS-2016)** during December 10-11, 2016. Sixth Conference organized by Astha Foundation, Meerut in collaboration with SSDAT, Meerut, MPUAT, Udaipur; CSAUAT, Kanpur; UAS, Raichur at MPUAT, Udaipur, Rajasthan on Global Research Initiatives for Sustainable Agriculture & Allied Sciences **(GRISAAS-2017)**. Seventh Conference organized by Astha Foundation, Meerut in collaboration with SSDAT, Meerut, CSAUAT, Kanpur; IGKV, Raipur; BAU, Sabour; MPKV, Rahuri; RARI, Durgapura, Jaipur; Global Research Initiatives for Sustainable Agriculture & Allied Sciences **(GRISAAS-2018)**. Eight Conference organized by Astha Foundation, Meerut in collaboration with SSDAT, Meerut, CSAUAT, Kanpur; IGKV, Raipur; BAU, Sabour; MPKV, Rahuri; UAHS, Shivamogga, Global Research Initiatives for Sustainable Agriculture & Allied Sciences **(GRISAAS-2019)**. Ninth Conference organized by SSDAT, Meerut in collaboration with Astha Foundation, Meerut, Innovative and Current Advances in Agriculture & Allied Sciences **(ICAAAS-2020)** at Bangkok, Thailand. Tenth International Web Conference organized by Astha Foundation, Meerut in collaboration with SSDAT, Meerut, CSAUAT, Kanpur; IGKV, Raipur; BAU, Sabour; MPKV, Rahuri; BAU Rachi and UAHS, Shivamogga on Global Research Initiatives for Sustainable Agriculture & Allied Sciences **(GRISAAS-2020)**. Eleventh International Web Conference organized by SSDAT, Meerut in collaboration with Astha Foundation, Meerut, CSAUAT, Kanpur; IGKV, Raipur; MPKV, Rahuri; BAU Rachi and UAHS, Shivamogga on Innovative and Current Advances in Agriculture & Allied Sciences **(ICAAAS-2021)**.

Glimpse of SSDAT & Astha Foundation's Conferences

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