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Genetical Variability, Correlation and Path Analysis in Chickpea (*Cicer arietinum* L.) for Mechanical Harvesting

K. Durga Prasad[1], R.M. Javia[1] and L.K. Sharma[1] and S.P. Singh[2]
Department of Genetics and Plant Breeding, Junagadh Agriculture University, Junagadh-362001, Gujarat
CSAUAT-Agriculture Research Station, Kalai, Aligarh, Uttar Pradesh
Email : dprasadrr@gmail.com

Abstract

The experiment was conducted to assess genetic variability, correlation and path analysis and suitability to mechanical harvesting in chickpea (*Cicer arietinum* L.) genotypes during Rabi 2021-22 grown in a Randomized Block Design with three replications. The data were recorded on 11 quantitative traits with two morphological traits. A Randomized Block Design (RBD) analysis revealed that mean square due to genotypes were found highly significant for all the characters included in this study suggesting the availability of sufficient genetic variability among the genetic material tested in the present experiment. However, narrow differences observed between the PCV and GCV in certain cases indicated that these characters were less influenced by the environment. High to moderate magnitude of genotypic coefficient of variation and phenotypic coefficient of variation was observed for characters like seed yield per plant, number of pods per plant, height of first fruiting node, number of branches per plant and plant height. High heritability coupled with high genetic advance as per cent of mean was observed for seed yield per plant, number of pods per plant, height of first fruiting node, number of branches per plant and plant height which may be contributed to the preponderance of additive gene action and selection pressure could profitably be applied on these character for improving the seed yield. The seed yield per plant exhibited highly significant and positive correlation at genotypic and phenotypic levels with number of pods per plant and number of branches per plant. Hence, improvement of seed yield per plant can be achieved by improvement of these characters. Among the various traits studied number of pods per plant and plant height exhibited high and positive direct effects on seed yield per plant. Seed yield per plant could be improved by selection based on these characters. The study revealed that the genotypes viz., GJG 1916, ICCV 201107, ICCV 201112, ICCV 201114, IG 2020-2 and PG 191618 were identified to be high yielders and also suitable for mechanical harvesting.

Key words *: Chickpea, genetical variability correlation, path analysis and mechanical harvesting.*

Introduction

Chickpea [*Cicer arietinum* L.) 2n=2x=16] popularly known as Gram, Bengal gram, Chhola and Garbanzo bean is one of the first seed legumes to be domesticated by humans in old world (1). The genus Cicer belongs to the sub-family Papilionaceae of the family Leguminoceae (2) now popularly known as Fabaceae. It is an annual, self-pollinating, diploid pulse crop. The origin of the crop is considered to be Western Asia from where it spread in India and other parts of the world. Chickpea has it an important contributor to soil fertility as it provides nitrogen to soil through fixation of atmospheric nitrogen. It also helps in enhancing the soil quality for subsequent cereal crop cultivation by adding organic matter for the maintenance of soil health and ecosystem. Deep and tap root system of chickpea is known to help in opening up of the soil to the deeper strata, ensuring better texture and aeration of the soil for next crop. In India, the area under chickpea was 96.8 lakh hectares with a production of 110.8 lakh tonnes and productivity of 1142 kg ha^{-1} during 2020-21. In Gujarat, an area under chickpea was 7.8 lakh hectares with a total production of 13.0 lakh tonnes and productivity of 1662 kg ha^{-1} during 2020-21. (Anon., 2020). Over a 90% of the chickpea area is in developing countries, such as India, Pakistan, Iran, Myanmar, Ethiopia, Tanzania and Malawi, where chickpea is largely harvested manually. On the other hand, in the developed countries, such as Australia, Canada, USA and Spain chickpea is harvested by machine. The traits required for the suitability to machine harvesting include tall, erect or semi-erect growth habit and lodging tolerance. Manual harvesting of chickpea is becoming increasingly expensive because of the rising labour cost and shortage of labour at the peak time of requirement. Delay in harvests leads to significant losses of grains and their quality. Chickpea is harvested by hand in India because the available chickpea cultivars are not suited to machine harvest. With continuously increasing labour costs, manual harvesting has become an expensive field operation for any crop and farmers are increasingly opting for machine harvesting, where it is feasible. Availability of chickpea cultivars suited to machine harvesting will reduce production cost and attract farmers to chickpea cultivation (3). Chickpea cultivars with tall and non-spreading erect plant type are needed for mechanical

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harvesting. Development of cultivars with 30 to 40 per cent more height than the existing cultivars and semi-erect to erect growth habit will make these cultivars suited to mechanical harvesting. Such plant types can accommodate more number of plants per unit area and can also give higher yield.

Materials and Methods

Investigation was carried out with 52 chickpea genotypes were sown in a Randomized Block Design (RBD) with three replications during *Rabi* 2021-22 at Pulses Research Station, JAU, Junagadh. Each population was accommodated in one row of 4 m length with a spacing of 45 cm. The recommended agronomical and plant protection practices were followed for the successful raising of the crop. The observations were recorded on five randomly selected and tagged plants from each entry and average values were used for the statistical analysis. The data were recorded on quantitative traits such as days to 50 per cent flowering, days to maturity, reproductive phase duration, height of first fruiting node (cm), plant height (cm), number of branches per plant, number of pods per plant, number of seeds per pod, stem thickness, seed yield per plant and 100-seed weight (g). The replication wise mean values of randomly selected plants were used for statistical analysis for different characters. Analysis of variance for randomized block design (RBD) was done as per (4), phenotypic co-efficient of variation and genotypic coefficient of variation was calculated as per the formula suggested by (5), heritability and genetic advance was estimated using the formula suggested by (6), correlation coefficients worked out as (7) and path analysis as suggested by (8). The traits considered for evolution for mechanical harvesting were plant growth habit, plant height, height of first fruiting node, lodging resistance and seed yield per plant. Therefore, the genotypes were identified based on their *per se* performance having the characters erect, tall (>50 cm), height of the first fruiting node (>25 cm), resistance to lodging and high yielding (>15 g).

Results and Discussion

Results for analysis of variance revealed that mean square due to genotypes were found highly significant for the all the character included in this study suggesting the availability of sufficient genetic variability among the genetic material tested in the present experiment (Table-1).

The estimates of genotypic and phenotypic coefficient of variation in present study indicated that the values of phenotypic coefficient of variation were higher than that of genotypic coefficient of variation in most of the cases, indicating more influence of environmental factors (Table-2). However, narrow differences observed between the PCV and GCV in certain cases indicated that these characters were less influenced by the environment. High PCV and GCV was observed for characters like seed yield per plant and number of pods per plant. This indicates substantial phenotypic variation in respect of these traits. Selection of such traits may be effective for the improvement of chickpea. These results are similar to (9). With the help of genotypic coefficient of variation alone, it is not possible to determine the extent of variation which is heritable. Thus, the knowledge of heritability of a character helps the plant breeders in predicting the genetic advance for any quantitative characters and aids in exercising necessary selection procedure. (5) suggested that genotypic coefficient of variation together with heritability estimate would give the best picture for selection. High heritability (bs) was observed for almost all the characters studied. Seed yield per plant exhibited maximum heritability followed by number of pods per plant, days to 50 per cent flowering, height of first fruiting node, number of branches per plant, 100-seed weight, reproductive phase duration, plant height, number of seeds per pod, stem thickness and days to maturity. High heritability for the above traits which were controlled by polygenes might be useful to the plant breeders for making effective selection. Suggested that the heritability estimate along with genetic advance is more useful than the heritability alone in predicting the resultant effect of selection. In the present study, the estimates of high heritability coupled with high genetic advance as per cent of mean was observed for seed yield per plant, number of pods per plant, height of first fruiting node, number of branches per plant and plant height. This result is in agreement with (10). This may be contributed to the preponderance of additive gene action and selection pressure could profitably be applied on these characters for improving the seed yield.

In present investigation, genotypic correlation coefficient values were higher than the phenotypic values. This indicated that strong intrinsic associations were somewhat masked at phenotypic level due to environmental effects. Seed yield per plant exhibited highly significant and positive correlation at genotypic and phenotypic levels with number of pods per plant and number of branches per plant. These similar findings are in accordance with (11). This indicating the character seed yield was more influenced by these attributes in chickpea and therefore, were important for bringing improvement in seed yield.

The phenotypic path coefficient analysis revealed that the traits like number of pods per plant, plant height exhibited high and positive direct effects on seed yield per plant. While days to 50 per cent flowering, reproductive

Table-1 : Analysis of variance for different characters in chickpea genotypes.

Source	d.f.	Mean squares										
		DF	DM	RPD	HFN (cm)	PH (cm)	NBP	NPP	NSS	ST (mm)	SYP (g)	100-SW (g)
Replications	2	1.391	7.352	11.198	9.777	5.202	0.834	20.680**	0.011	0.442	5.580	1.612
Genotypes	51	86.77**	13.36**	64.26**	80.95**	142.85**	3.99**	551.94**	0.02**	1.80**	41.02**	15.68**
Error	102	5.567	5.038	9.878	6.891	25.88	0.425	32.205	0.005	0.459	1.747	2.371

*, ** Significant at 5% and 1% levels, respectively.

Here : DF = Days to 50 per cent flowering, DM = Days to maturity, RPD = Reproductive phase duration, HFN = Height of first fruiting node (cm), PH = Plant height, NBP = Number of branches per plant, NPP = Number of pods per plant, NSP = Number of seeds per pod, ST = Stem thickness, SYP = Seed yield per plant, 100-SW = 100-Seed weight.

Table-2 : Genetic parameters of variability for yield and its components in chickpea genotypes.

Character	Mean	Range	Coefficient of range (%)	Phenotypic coefficientof variation (%)	Genotypic coefficient of variation (%)	Heritability (Broad Sense) (%)	Genetic advance (GA)	GA expressed as percentage of mean
Days to 50 per cent flowering	58.57	45.00-67.33	19.87	9.18	8.88	93.60	10.37	17.70
Days to maturity	103.26	100.00-108.00	3.84	2.04	1.61	62.30	2.71	2.62
Reproductive phase duration	44.74	36.00-54.67	20.60	10.35	9.51	84.60	8.07	18.03
Height of first fruiting node (cm)	29.31	18.73-40.67	36.94	17.72	16.95	91.50	9.79	33.40
Plant height (cm)	56.22	42.00-73.20	27.08	12.27	11.11	81.90	11.64	20.70
Number of branches per plant	7.04	3.93-9.87	43.04	16.40	15.50	89.40	2.13	30.19
Number of pods per plant	43.67	20.33-78.00	58.64	31.06	30.14	94.20	26.31	60.25
Number of seeds per pod	1.17	1.08-1.48	15.62	7.67	6.79	78.30	0.15	12.37
Stem thickness (mm)	7.30	5.96-8.95	20.05	10.62	9.17	74.50	1.19	16.31
Seed yield per plant	11.75	6.40-21.17	53.57	31.49	30.81	95.70	7.29	62.10
100-seed weight (g)	20.38	17.13-25.02	18.72	11.22	10.34	84.90	4.00	19.62

Table-3 : Phenotypic (rp) and genotypic (rg) correlation coefficients among 11 characters in chickpea genotypes.

Correlated Traits		DF	DM	RPD	HFN	PH	NBP	NPP	NSP	ST	100-SW
SYP	r_p	0.1107	0.1240	-0.0969	-0.0721	0.1479	0.3819**	0.6378**	0.2806*	0.0776	0.0191
	r_g	0.1181	0.1202	-0.1199	-0.0794	0.1720	0.4010**	0.6645**	0.3049*	0.0628	0.0053
DF	r_p		0.5593**	-0.9246**	0.3781**	0.2414	0.0665	0.0518	-0.1631	0.2283	0.0353
	r_g		0.6845**	-0.9786**	0.4048**	0.2487	0.0683	0.0458	-0.1664	0.2595	0.0497
DM	r_p			-0.2164	0.2691	0.1420	-0.0041	0.1124	-0.0464	0.1863	-0.0100
	r_g			-0.4753**	0.3152*	0.0973	-0.0258	0.1142	-0.0199	0.1292	-0.0263
RPD	r_p				-0.3039*	-0.2019	-0.0914	-0.0450	0.1520	-0.1540	-0.0280
	r_g				-0.3533*	-0.2590	-0.1053	-0.0505	0.1758	-0.2288	-0.0531
HFN	r_p					0.7901**	0.0341	-0.2171	-0.1101	0.3250*	0.0803
	r_g					0.8819**	0.0338	-0.2400	-0.1092	0.4078**	0.0610
PH	r_p						0.0950	-0.0788	0.0464	0.3529**	0.0038
	r_g						0.1117	-0.1029	0.0957	0.4396**	-0.0054
NBP	r_p							0.5387**	0.2318	0.1369	-0.3075*
	r_g							0.5876**	0.2446	0.1402	-0.3502*
NPP	r_p								0.3745**	-0.0679	-0.3059*
	r_g								0.4260**	-0.0836	-0.3504*
NSP	r_p									-0.0948	-0.1166
	r_g									-0.1164	-0.1530
ST	r_p										0.0977
	r_g										0.1125

*, ** Significant at 5% and 1% levels, respectively.

phase duration and height of first fruiting node exhibited high and negative direct effect on seed yield per plant. Stem thickness and number of seeds per pod recorded positive and negligible direct effect on seed yield per plant. Days to 50 per cent flowering exerted positive and high indirect effect through reproductive phase duration on seed yield per plant *via* each other. Height of first fruiting node exhibited positive and high indirect effect on seed yield per plant through plant height. Number of branches per plant exhibited positive and high indirect

Table-4 : Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effect of different characters on seed yield per plant in chickpea genotypes.

Characters	DF	DM	RPD	HFN	PH	NBP	NPP	NSP	ST	100-SW	Phenotypic correlation with SYP
DF	-0.5237	0.1517	0.4559	-0.1303	0.1052	0.0063	0.0310	-0.0020	0.0074	0.0093	0.1107
DM	-0.2929	0.2713	0.1067	-0.0927	0.0618	-0.0004	0.0673	-0.0006	0.0060	-0.0026	0.1240
RPD	0.4842	-0.0587	-0.4931	0.1047	-0.0880	-0.0086	-0.0270	0.0018	-0.0050	-0.0073	-0.0969
HFN	-0.1980	0.0730	0.1498	-0.3445	0.3442	0.0032	-0.1301	-0.0013	0.0105	0.0211	-0.0721
PH	-0.1264	0.0385	0.0996	-0.2722	0.4357	0.0089	-0.0472	0.0006	0.0114	0.0010	0.1497
NBP	-0.0348	-0.0011	0.0451	-0.0117	0.0414	0.0940	0.3227	0.0028	0.0044	-0.0808	0.3819**
NPP	-0.0271	0.0305	0.0222	0.0748	-0.0344	0.0506	0.5991	0.0045	-0.0022	-0.0803	0.6378**
NSP	0.0854	-0.0126	-0.0750	0.0379	0.0202	0.0218	0.2243	0.0121	-0.0031	-0.0306	0.2806*
ST	-0.1196	0.0506	0.0759	-0.1120	0.1538	0.0129	-0.0407	-0.0011	0.0322	0.0257	0.0776
100-SW	-0.0185	-0.0027	0.0138	-0.0277	0.0016	-0.0289	-0.1830	-0.0014	0.0031	0.2627	0.0191

*, ** Significant at 5% and 1% levels, respectively. (Residual effect 0.6765).

effect on seed yield per plant through number of pods per plant. The residual effect was high suggesting that the some of the yield attributes had not been included in the path analysis. The traits consider for evaluation of genotypes suitable for machine harvest were growth habit, plant height, height of the first fruiting node, lodging resistance and seed yield per plant. Therefore, the genotypes identified for their *per se* performance of the characters which were erect, tall (>50 cm), height of the first fruiting node (>25 cm), resistance to lodging and high yielding (>15 g). Based on these traits, genotypes GJG 1916, ICCV 201107, ICCV 201112, ICCV 201114, IG 2020-2 and PG 191618 were identified for mechanical harvesting.

Conclusions

It can be concluded from variability parameters that additive gene action was operating for seed yield per plant, number of pods per plant, height of first fruiting node, number of branches per plant and plant height. Correlation study revealed that number of pods per plant and number of branches per plant were positive and highly significantly correlated with seed yield and path coefficient analysis also revealed high direct and indirect effect of these characters therefore, due weightage should be given to these traits for selection. Genotypes *viz.,* GJG 1916, ICCV 201107, ICCV 201112, ICCV 201114, IG 2020-2 and PG 191618 were found most suitable and promising for mechanical harvesting.

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