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Character Association and Path Analysis in Desi Chickpea (*Cicer arietinum* L.) Genotypes for Yield and Traits Related to Mechanical Harvesting

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Abstract

The experiment was conducted to assess character association and path analysis desi chickpea (*Cicer arietinum* L.) genotypes suitable for machine harvestduring Rabi 2019-20grown in a Randomized Block Design with three replications. The data were recorded on 11 quantitative traits with two morphological traits. Analysis of variance reveled significant difference for all character studied suggesting the availability of sufficient genetic variability among the genetic material tested in the present experiment. High PCV and GCV was observed for characters like seed yield per plant, number of pods per plant, number of branches per plant and 100-seed weight. High heritability coupled with high genetic advance as per cent of mean was observed for number of pods per plant, number of branches per plant, 100-seed weight, height of first fruiting node, stem thickness and seed yield per plant which may be contributed to the preponderance of additive gene action and selection pressure could profitably be applied on this character for improving the seed yield. Seed yield per plant exhibited highly significant and positive correlation at genotypic and phenotypic levels with number of pods per plant, number of branches per plant and stem thickness. 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, days to 50% flowering and reproductive phase duration exhibited very high to high and positive direct effects on seed yield per plant. Seed yield per plant could be improved by selection based on these characters. Genotypes identified for mechanical harvesting were F6-2018-08, ICCV 181607, BG 3062 and CSJ 515. These superior genotypes can be utilized in further breeding programme.

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

Introduction

Chickpea [Cicer arietinum (L.) 2n=2x=16] popularly called Gram, Bengal gram, Chhola and Garbanzo bean. This is an annual, self-pollinating, diploid pulse crop. The origin of the crop is considered to be Western Asia from wherein it unfolds in India and different components of the world (1). In India**,** the region under chickpea was 95.5 lakh hectares with a production of 99.4 lakh tonnes and productivity of 1041 kg ha^{-1} during 2018-19. In Gujarat, an area under chickpea was 1.73 lakh hectares with a total production of 2.35 lakh tonnes and productivity of 1358 kg ha^{-1} during 2018-19 (2). The chickpea is harvested with the aid of using hand in India due to the fact that the available chickpea cultivars aren't perfect to machine harvest. With constantly growing labour costs, manual harvesting has end up an expensive field operation for any crop and farmers are increasingly choosing machine harvesting, wherein it's far feasible. The availability of chickpea cultivars that are machine harvestable will lower production costs and encourage farmers to grow chickpeas. Chickpea cultivars with tall and non-spreading erect plant type are needed for mechanical harvesting. Development of cultivars with 30 to 40% more height than the prevailing cultivars and semi-erect to erect growth habit will make those cultivars perfect to mechanical harvesting (3). Such plant types can accommodate more number of plants per unit area and also can give better yield. Chickpea has high variation for different qualitative and quantitative traits. Genetic variation among traits is crucial for breeding and in choosing proper genotypes. Characterization of genotypes is a prerequisite for usage in crop improvement (4). Phenotypic characterization involves recording characters that are highly heritable, easily visible by the eye and are expressed in all environments. To enhance the production ability of chickpea, breeding programme must be aimed toward developing high yielding varieties that's perfect for machine harvesting. It requires precise information on the nature and extent of genetic variability present in the crop plants. Breeding techniques can be effective if there may be adequate information on genetic variability for numerous quantitative traits found appropriate for mechanical harvesting.

Materials and Methods

The present investigation was carried out with 44 chickpea genotypes were sown in a Randomized Block Design

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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)	100-SW (g)	SYP (g)
Replications	2	5.371	6.598	22.454	13.205	25.035	0.033	5.196	0.007	0.381	4.694	3.766
Genotypes	43	49.76*	118.19**	106.37**	57.30**	96.78**	0.84**	450.76**	0.04**	1.72**	48.25**	74.09**
Error	86	4.231	19.234	16.586	6.121	9.707	0.034	5.632	0.003	0.198	2.007	1.667

*,** Significant at 5% and 1% levels, respectively
DF = Days to 50% 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, 100-SW = 100-Seed weight, SYP = Seed yield per plant.

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

Character	Mean	Range	Coefficient of range (%)	Phenotypic coefficient of variation (%)	Genotypic coefficient of variation (%)	Heritability (Broad Sense) (%)	Genetic advance (GA)	GA expressed as % of mean
Days to 50% flowering	45.94	39.00 - 54.67	16.72	8.86	8.47	91.50	7.67	16.70
Days to maturity	112.60	101.66 - 126	10.72	5.57	5.10	83.73	10.82	9.61
Reproductive phase duration	66.65	55.33 - 77.66	16.81	8.93	8.20	84.41	10.35	15.53
Height of first fruiting node (cm)	31.79	22.39 - 42.60	31.09	13.74	12.99	89.32	8.04	25.29
Plant height (cm)	55.24	42.42 - 65.00	21.02	10.28	9.75	89.97	10.52	19.05
Number of branches per plant	2.25	1.33 - 3.13	40.35	23.52	23.03	95.92	1.05	46.48
Number of pods per plant	41.33	21.25 - 75.93	56.26	29.65	29.47	98.75	24.93	60.33
Number of seeds per pod	1.41	1.11 - 1.75	22.37	9.09	8.81	93.96	0.24	17.60
Stem thickness (mm)	5.94	04.84 - 08.39	26.83	12.74	11.99	88.48	1.38	23.23
100-seed weight (g)	24.58	12.05 - 34.17	47.85	20.21	19.98	97.75	10.00	40.71
Seed yield per plant	10.40	4.93 - 27.41	69.51	38.52	37.71	95.84	7.91	76.06

(RBD) with three replications during *Rabi* 2019-20 at Pulses Research Station, J.A.U., Junagadh. Each genotype was accommodated in 1 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 5 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% 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, 100-seed weight (g) and seed yield per plant and qualitative traits such as plant growth habits and lodging resistance. 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 (5), phenotypic co-efficient of variation and genotypic co-efficient of variation was calculated as per the formula suggested by (6) and heritability and genetic advance was estimated using the formula suggested by (7). 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, genotypes were identified for their *per se* performance which were erect, tall (>50 cm), height of first fruiting node (>25 cm), lodging resistance (scale 1) and seed yield per plant (>15 g).

Results and Discussion

Analysis of variance result 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).

Experimental material showed wide range of phenotypic variation for seed yield per plant, number of pods per plant, 100-seed weight, number of branches per plant and height of first fruiting node as revealed by high values of coefficient of range.

The estimate 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, number of pods per plant, number of branches per plant and 100-seed weight.

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

Correlated Traits		DF	DM	RPD	HFN	PH	NBP	NPP	NSP	ST	100-SW
SYP	r_p	-0.0146	0.3167*	0.3438*	-0.1863	0.1782	0.7769**	0.8755**	0.2452	0.6375**	0.2750
	r_g	-0.0137	0.3492*	0.3763*	-0.1904	0.1793	0.7801**	0.8830**	0.2422	0.6681**	0.2827
DF	r_p		0.4014**	-0.2608	0.3379*	0.2444	0.0027	-0.0753	-0.1307	0.2212	-0.1024
	r_g		0.4074**	-0.2844	0.3856**	0.2454	0.0015	-0.0798	-0.1418	0.2278	-0.1054
DM	r_p			0.7795**	0.3319*	0.3065*	0.2870	0.2931	-0.0787	0.3510*	0.1062
	r_g			0.7597**	0.3753*	0.2988*	0.3289*	0.3180*	-0.0979	0.3975**	0.1140
RPD	r_p				0.1187	0.1559	0.3007*	0.3604*	0.0065	0.2187	0.1820
	r_g				0.1193	0.1389	0.3442*	0.3907**	-0.0018	0.2551	0.1947
HFN	r_p					0.7934**	0.0066	-0.0841	0.0951	0.1928	-0.0578
	r_g					0.8928**	0.0207	-0.0756	0.0935	0.2357	-0.0593
PH	r_p						0.2421	0.2370	0.1158	0.3873**	0.2030
	r_g						0.2508	0.2478	0.1089	0.4050**	0.2165
NBP	r_p							0.8568**	0.3678*	0.5260**	0.2602
	r_g							0.8667**	0.3830**	0.5454**	0.2671
NPP	r_p								0.3521*	0.6603**	0.2159
	r_g								0.3624*	0.6964**	0.2184
NSP	r_p									0.0332	0.0192
	r_g									0.0305	0.0157
ST	r_p										0.3044*
	r_g										0.325*

*,** significant at 5% and 1% levels, respectively,

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	2.5237	-1.4986	-0.9579	-0.1571	0.0685	0.0005	-0.0321	-0.0052	0.0412	0.0025	-0.0146
DM	1.0131	-3.7331	2.8627	-0.1543	0.0859	0.0575	0.1251	-0.0031	0.0654	-0.0025	0.3167*
RPD	-0.6582	-2.9098	3.6726	-0.0552	0.0437	0.0602	0.1539	0.0003	0.0407	-0.0044	0.3438*
HFN	0.8528	-1.2389	0.4359	-0.4649	0.2224	0.0013	-0.0359	0.0038	0.0359	0.0014	-0.1863
PH	0.6169	-1.1443	0.5726	-0.3689	0.2803	0.0485	0.1012	0.0046	0.0722	-0.0049	0.1782
NBP	0.0068	-1.0715	1.1043	-0.0031	0.0679	0.2003	0.3658	0.0146	0.0980	-0.0062	0.7769**
NPP	-0.1900	-1.0941	1.3236	0.0391	0.0664	0.1717	0.4269	0.0140	0.1230	-0.0052	0.8755**
NSP	-0.3299	0.2938	0.0237	-0.0442	0.0324	0.0737	0.1503	0.0397	0.0062	-0.0005	0.2452
ST	0.5581	-1.3103	0.8032	-0.0897	0.1086	0.1054	0.2819	0.0013	0.1863	-0.0073	0.6375**
100-SW	0.2584	-0.3965	0.6684	0.0269	0.0569	0.0521	0.0922	0.0008	0.0567	-0.0239	0.2750

*,** significant at 5% and 1% levels, respectively, (Residual effect 0.4102)

This indicates substantial phenotypic variation in respect of these traits. Selection of such traits may be effective for the improvement of chickpea. This result are similar to (8,9). Moderate PCV and GCV was observed for characters like height of first fruiting node, stem thickness and plant height. Similar results were observed by (8) for plant height. 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.

(6) 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. Number of pods per plant exhibited maximum heritability followed by 100-seed weight, number of branches per plant, seed yield per plant, number of seeds per pod, days to 50% flowering, plant height, height of first fruiting node, stem thickness, reproductive phase duration 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. Similar result of high heritability (bs) for number of pods per plant and

Table-5 : Top performing genotypes for traits related to mechanical harvesting.

Sr. No.	Characters	No. of genotypes	Top performing genotypes
1.	Erect growth habit	36	GJG 1902, GJG 1914, F6-2018-08, ICCV 181601, ICCV 181607, JG 24, NBeG 47, BG 3062, DBGV 221, CSJ 515
2.	Plant height (>50 cm)	35	F6-2018-08, ICCV 181607, NBeG 47, BG 3062, ICCV 181664, JG 24, ICCV 181613, ICCV 181604, BG 4003, CSJ 515
3.	Height of the first fruiting node (>25 cm)	42	F6-2018-08, ICCV 181664, ICCV 181613, NBeG 47, JG 24, ICCV 181601. ICCV 181607, BG 3062, CSJ 515, BG 4003
4.	Seed yield per plant (>15 g)	6	F6-2018-08, ICCV 181607, BG 3062, DBGV 221, CSJ 515, BG 4003
5.	Lodging resistance (Scale 1)	27	GJG 1607, F6-2018-08, ICCV 181601, ICCV 181604, ICCV 181607, ICCV 181608, JG 24, NBeG 47, BG 3062, CSJ 515

seed yield per plant were observed by (10,11). (12) observed same result for characters like number of pods per plant, days to 50% flowering, days to maturity, 100-seed weight, plant height, seed yield per plant, number of primary branches per plant and number of seeds per pod.

(13) 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 number of pods per plant, number of branches per plant, 100-seed weight, height of first fruiting node, stem thickness and seed yield per plant. (14,15) obtained same result for total number of pods per plant. (16) also observed same for number of pods per plant, number of branches per plant, 100-seed weight and seed yield per plant. This may be contributed to the preponderance of additive gene action and selection pressure could profitably be applied on this character for improving the seed yield.

Correlation coefficients at genotypic and phenotypic level among the seed yield and its component characters have been worked out in study (Table-3). In general, the 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. In the present study, seed yield per plant exhibited highly significant and positive correlation at genotypic and phenotypic levels with number of pods per plant, number of branches per plant and stem thickness. These similar findings are in accordance with (17). While significant and positive correlation at genotypic and phenotypic levels with reproductive phase duration and days to maturity, this findings are in accordance with (18), which indicating that these attributes were more influencing the seed yield in chickpea and therefore, were important for bringing improvement in seed yield. Thus, the results revealed that the number of branches per plant, number of pods per plant and stem thickness were the most important attributes which contributed towards higher yield. Therefore, more emphasis should be given to these components during selection for higher yield.

The phenotypic path coefficient analysis (Table-4) revealed that the traits like number of pods per plant (17), days to 50% flowering (19) and reproductive phase duration (20) exhibited very high to high and positive direct effects on seed yield per plant. While days to maturity and height of first fruiting node exhibited high and negative direct effect on seed yield per plant. Plant height and number of branches per plant exhibited positive and moderate direct effect on seed yield per plant, while this finding are opposed with (17). Stem thickness exhibited low and positive direct effect, while negligible and positive effect was observed in number of seeds per pod with seed yield per plant also negligible and negative effect was observed in 100-seed weight (19). It was apparent from the path analysis that higher direct effects were exerted by number of pods per plant, days to 50% flowering and reproductive phase duration. While, moderate direct effects were exerted by plant height and number of branches per plant. Stem thickness exhibited low direct effect. Days to maturity exhibited positive and high indirect effect on seed yield per plant through days to 50% flowering and reproductive phase duration. Height of first fruiting node exhibited positive and moderate indirect effect on seed yield per plant through plant height. Number of branches per plant exhibited positive and high indirect effect on seed yield per plant through reproductive phase duration and number of pods per plant. Out of these characters, number of branches per plant, number of pods per plant, stem thickness and reproductive phase duration also exhibited significant and positive association with seed yield per plant and hence, they may be considered as most important yield contributing characters and due emphasis should be placed on these components while breeding for high seed yield in chickpea. A moderate residual effect suggests that some attributes of yield were not taken into account 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 (>50cm), height of the first fruiting node (>25cm), resistance to lodging and high yielding (>15g). Based on these traits, genotypes F6-2018-08, ICCV 181607, BG 3062 and CSJ 515 were identified for mechanical harvesting. The details of top performing genotypes are presented in the Table-5.

Conclusions

It can be concluded from variability parameters that additive gene action was operating for seed yield per plant, number of pods per plant, number of branches per plant, 100-seed weight, height of first fruiting node and stem thickness. Correlation study revealed that number of pods per plant, number of branches per plant and stem thickness were 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 in chickpea. Genotypes *viz*., F6-2018-08, ICCV 181607, BG 3062 and CSJ 515 were found most suitable and promising for mechanical harvesting.

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