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Assessment of Genetic Variability and Correlation of Yield Related Traits in Chickpea (*Cicer arietinum L.*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was undertaken with 21 genotypes of Chickpea, (including one check) during Rabi 2020-21 in a randomized block design with three replications at field experimentation centre of Department of Genetics and Plant Breeding. Sam Higginbottom University of Agriculture, Technology and Sciences. The data were recorded for 13 characters to study genetic variability, correlation and path analysis. Analysis of variance among 21 genotypes showed highly significant differences for all the characters indicated the presence of substantial amount of genetic variability. On the basis of mean performance, the highest seed yield was observed in genotype NBEG-1121 and RVS-5949. The estimates of GCV and PCV were moderate for plant height, number of primary branches. Low GCV and PCV was recorded for days to 50% flowering. The difference between PCV and GCV was very low for all 13 yield contributing characters. This indicates that the influence of environment factor was low on these characters. High heritability estimate was recorded for number of seeds per plant, number of secondary branches per plant. A high magnitude of genetic advance expressed as a percent of mean was observed in respect of number of seeds per plant, number of secondary branches per plant. Seed yield per plant exhibited positive and highly significant correlations with days to 50% Flowering, no of secondary branches at both genotypic and phenotypic level. The positive non-significant correlations of seed yield per plant were found

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with number of secondary branches and days to maturity. Negative non- significant correlation was being observed with the plant height, number of primary branches per plant and number of pods per plant. Path analysis at both genotypic and phenotypic level showed positive direct effects by days to 50% flowering, number of secondary branches per plant. The characters identified above as important components merit due to consideration in the formulation of effective selection strategy in chickpea for developing high yielding varieties.

Keywords: Chickpea; variability; heritability; genetic advance; phenotypic coefficient of variation and genotypic coefficient of variation; correlation; path coefficient analysis.

1. INTRODUCTION

Chickpea (*Cicer arietinum*, L.) is a requisite part of Indian agriculture since decades, because of its intrinsic value in terms of high protein, carbohydrates, minerals, nitrogen fixing ability and indispensability as alternative crop for crop diversification (K Desai et al.,2015). Chickpea occupies a prime position among the pulses in the country with a maximum hectarage, production and its high nutritive value. Chickpea *(Cicer arietinum* L.) is a self - pollinated diploid (2n= 2x=16) with genome size of 732 Mbp (K Desai et al.,2015).It is known to have originated in Western Asia. It belongs to Order Fabales, Family Fabaceae, Genus Cicer, species *Cicer arietinum*. Two are found to be cultivated in India, viz: *Cicer arietinum* (2n- 14) which is most widely cultivated and Cicer soongaricum (2n = 16) cultivated in Western temperate and Alpine regions (9000-15000 ft) in altitude of Himalaya. India is largest producer (25%), importer (20%) and consumer (27%) of Pulses in the world. In Pulses, chickpea occupies third position in the world (Anonymous,2020).

In India the area under chickpea was 9.539 million ha with a production of 90.75 million tons while the productivity was 951kg/ha. In Utter Pradesh, it is grown on 5.89 lakh ha area with total production of 5.967 lakh tons and average productivity of 1013 kg/ha during 2018-19. It occupies 61 per cent of total area under pulses producing about 65 per cent of total production in Uttar Pradesh. Though India is the largest producer of this crop, it imports 25% chickpea because its productivity is low as compared to countries like Italy, Turkey, Iron, etc,(Shaflque et al.,2016). There is a good scope to improve the productivity of this crop by varietal improvement and adopting the improved production technology on larger areas of the country. The variability observed is the sum total of hereditary effects of concerned genes as well as the environmental influence (Renukdevi, P et al.,2006*)*. Hence the variability partitioned into heritable and non-heritable components with suitable genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance (GA). The variability was highest for number of pods/plant in chickpea obtained by Malik et al. [1]. The estimation of this genetic variability parameter helps breeder in achieving the required crop improvement by selection. The basic objective of most of the crop improvement programs is to realize a marked improvement programs is to realize a marked improvement in crop yield.

Seed yield, an extremely complex trait, is an example of integration of component factors. The direct selection of plant on the basis of seed yield may be misleading. Therefore, characters association and path analysis must be studied to understand the contribution of genotype and environment towards the final yield before selection of plant. Path coefficient analysis helps in partitioning the correlation coefficient into direct and indirect effects, thereby providing relative importance of each of causal factors.

2. MATERIALS AND METHODS

The experimental materials comprising of 21 genotypes including one check were grown under Randomized Block Design (RBD) with three replications. The row to row and plant to plant distance was kept at spacing of 30×10 cm^2. The nitrogen was applied in two splits, one at the time of sowing and other at 25 days after sowing. Entire Phosphorus was applied as basal dose. All recommended practices were followed and timely plant protection measures were taken to avoid damage through insect-pests and diseases. List of Genotypes (Table 1) and observations for different quantitative traits were recorded on five randomly selected competitive plants for each treatment in three replications, except days to 50% flowering, days to 50% pod setting and days to maturity which was recorded on a plot basis and remaining was taken on plant basis. The observations were made 40 days after planting. Analysis of variance was worked out to

Table 1. List of Chickpea Genotypes/Germplasm

Genotypes	Genotypes	Genotypes
ICC-4968	IPC-05-62	RVS-5949
JG-16	DCP-92-3	ICCV-16317
KING GANESH	CSQ-89-62	IPC-21107
GG-2	CSJ-512	IPC-97-29
IPC-57-29	IPC-2K-2000-25	RSG-963
EC-556270	ICC-5439	NBEG-1121
ILC-0	ILC-10768	PUSA-362 (Check)

test the significance of F and T-tests. It was carried out according to procedure of RBD analysis for each character as per methodology suggested by Panse and Sukhatme [2]. The phenotypic and genotypic correlation coefficients were computed from the phenotypic and genotypic variance and co-variances. The direct and indirect effects were estimated through path coefficient analysis as suggested by Wright [3] and elaborated by Dewey and Lu [4].

3. RESULTS AND DISCUSSION

The genetic improvement in a crop species is inevitable and continuous process to meet the future challenges. For this the strengths of available germplasm has to be evaluated to identify potential genotypes which ultimately leads to food and nutritional security of the country. Success of the breeding programme largely depends upon the knowledge of genetic variability present in a given crop species for the characters under improvement. As such, before launching any breeding programme it is necessary to have thorough knowledge on variability present in the available genetic material.Analysis of variance showed there is significant difference among the genotypes for thirteen characters under the study (Table 2). This indicated that there is ample scope for selection of genotypes for yield and its components.

Although range can provide a preliminary idea about the variability, it has to be confirmed by the magnitude of variance. Further, for comparing variation of one character with another, the coefficient of variation which was independent unit of measurement is preferred. Moderate PCV and GCV were recorded for plant height, number of primary branches, number of secondary branches, number of pods per plant, Number of seeds per plant, biological yield, seed index, harvest index and seed yield per plant indicating that there is great scope for selection of this character (Table 3). Results were in accordance with the findings of Jeena et al. [5], Thakur and Sirohi et al. [6], Kishore et al. [7], Tsehaye et al. [8] and Shivashish et al. [9] in chickpea. Characters showing high heritability

Table 2. ANOVA for thirteen characters in chickpea *(Cicer arietinum* L.)

S. No.	Characters	Mean Sum of Squares		
		Replication (d.f=2)	Treatments (d.f=20)	Error (d.f=40)
1	Days to 50% Flowering	0.683	2.816**	1.066
2	Days to 50% pod setting	1.778	5.797**	0.794
3	Plant height	1.362	92.437**	1.991
4	Number of primary branches/plants	0.009	0.623**	0.039
5	Number of secondary branches/plants	0.138	4.478**	0.051
6	Days to maturity	0.333	12.643**	3.283
7	Number of pods per plant	0.388	67.433**	2.238
8	Number of seeds per plant	2.676	357.533**	2.747
9	Number of seeds per pod	0.062	0.077**	0.03
10	Seed index	0.023	31.615**	0.848
11	Biological yield per plant	0.225	31.71**	0.901
12	Harvest index	12.222	69.581**	7.143
13	Seed yield per plant	0.133	6.669**	0.197

****Indicates significant at 5 and 1 % level of significance*

Table 3. Estimation of Genetic parameters for 13 characters of Chick pea (*Cicer arietinum* L.) genotypes

S. No.	Characters	GCV	PCV	h^2 (%)	GA (5%)	GA as % of mean (5%)
1	Days to 50% flowering	0.924	1.554	35.4	0.936	1.132
2	Days to 50% pods setting	1.262	1.534	67.7	2.189	2.14
3	Plant height	10.048	10.374	93.8	10.955	20.047
4	Number of primary branches per plant	16.141	17.674	83.4	0.83	30.368
5	Number of secondary branches per plant	16.746	17.035	96.6	2.46	33.91
6	Number of days to maturity	1.425	2.041	48.7	2.54	2.049
7	Number of pods per plant	15.269	16.035	90.7	9.144	29.949
8	Number of seeds per plant	18.449	18.662	97.7	22.146	37.571
9	Number of seeds per pod	6.759	11.576	34.1	0.15	8.13
10	100 seed weight	16.74	17.418	92.4	6.34	33.141
11	Biological yield per plant	15.636	16.307	91.9	6.33	30.884
12	Harvest index	10.087	11.69	74.4	8.109	17.928
13	Seed yield per plant	15.836	16.544	91.6	2.896	31.227

coupled with high genetic advance as percent of mean was recorded for number of seeds per plant and harvest index. Such results indicated, predominantly the presence of additive gene action in the expression of these characters and consequently chance of improving these characters through simple selection procedures. These findings were in agreement with Thakur and Sirohi [6], Dwivedi et al. (2009), Borate et al. [10], Khan et al. [11], Yucel et al. [12] and Anush et al. (2020). It can be concluded that high PCV, GCV, heritability and genetic advance as percent of mean were observed for number of seeds per plant and harvest index indicating the prevalence of additive gene action was playing major role for expression of these characters and simple selection may be effective for improvement of these traits the findings were agreement in Thakur and Sirohi [6] Tsehaye et al. [8] and Shivashish et al. [9]

Seed yield per plant, the most important economic character, exhibit highly significant positive correlation with days to 50% Flowering, no of secondary branches, days to maturity, no of seeds per plant, biological yield, harvest index, both at phenotypic and genotypic level (Table 4). Similar results were in accordance with the findings of Babbar et al. [13], Renukadevi and Subbalakshmi [14], Meena et al. [15], Ali et al. [16], Malik et al. [1], Babbar et al. [13], Gul et al. [17], Kuldeep et al. [18], Dehal et al. [19], Tadesse et al. [20], Tiwari et al. (2016), Vartika singh et al. (2017), Singh et al. [21] and Manasa et al. [22].

The estimates of genotypic correlation coefficient with yield showed similar trend to those of phenotypic correlation coefficient in direction. However, these were higher in magnitude. It suggests that these correlation coefficients were due to breeding values and therefore, more dependable. Hence, on the basis of correlation coefficient studies, it is obvious, that the characters *viz*, days to 50% Flowering, no of secondary branches, days to maturity, no of seeds per plant, biological yield , harvest index were positively correlated with seed yield and also with one another indicating their utility in selection program for improving yield potential of population.

Path Coefficient analysis was suggested by Dewey and Lu [4] and it is standardized regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects. It measures the direct and indirect contribution of various independent characters on the dependent characters like seed yield per plant. Path coefficient analysis was carried out using phenotypic correlation coefficient and taking seed yield per plant as the dependent variable in order to see the causal factor(s) and to identify the best components which were responsible for producing high seed yield. Thus, the information obtained from this technique, also helps in making selection based on component characters of yield.

The results of this study revealed that no of days to 50% flowering, number of secondary branches per plant, days to maturity, and number of seeds per plant, biological yield and harvest index showed high positive direct effect on seed yield per plant (Table 5 and 6). While the correlation coefficient of these two traits with seed yield per plant was also positive. Therefore, a true

Table 4. Phenotypic Correlation coefficient between yield and its related traits in 21 chickpea genotypes

Character	DF50%	DP50%	PH	NPBP	NSBP	DM	NPPL	NSPL	NSP	BYP	SI	HI	SYP
DF50%	1	0.3951 **	-0.3699 **	-0.0132	-0.047	0.1131	0.0908	-0.1525	-0.1742	-0.3709 **	-0.3665 **	0.246	-0.153
DP50%		1	-0.0954	0.069	0.0191	0.0398	-0.0301	-0.4090 **	0.1232	-0.3452 **	-0.4769 **	-0.0751	-0.4075**
PH			1	-0.4009 **	-0.1543	0.2151	0.0794	-0.2685 *	0.0074	-0.0547	0.2954 *	-0.0999	-0.1277
NPBP				1	0.4094 **	-0.3016 *	-0.1092	-0.0347	0.0541	-0.2027	-0.2409	-0.0277	-0.2032
NSBP					1	-0.141	0.2197	0.1009	0.0632	0.3371 **	0.2242	-0.3014 *	0.1283
DM						1	0.0802	-0.0559	0.0003	-0.079	-0.1334	0.1928	0.072
NPPL							1	-0.1754	-0.2484 *	0.0352	-0.1199	-0.3028 *	-0.1608
NSPL								1	0.2547 *	0.6703 **	0.3010 *	0.3888 **	0.9087**
NSP									1	0.1943	-0.0373	0.1362	0.2528*
BYP										1	0.6128 **	-0.2942 *	0.7251**
SI											1	-0.2315	0.4148**
HI												1	0.4279**

DF50%: Days to 50% flowering, **DP50%: Days to pod setting, **PH:** Plant Height, **NPBP**: No of primary branches/plant, **NSBP**: No of secondary branches/plant, **DM**: Days to maturity, **NPPL**: No of pods/plant, **NSPL**: No of seeds//plant, **NSP:** No of seeds per pod, **BYP**: Biological yield/ plant ,**SI:** Seedindex ,**HI:** Harvest Index, **SYP:** Seed yield/plant*

Table 5. Phenotypic direct (in bold) and indirect effects of 13 traits on grain yield in Chickpea evaluated during *Rabi* 2020-2021

Traits	DF50%	DP50%	PH	NPBP	NSBP	DM	NPPL	NSPL	NSP	BYP	SI	HI
DF50%	0.0342	0.0135	-0.0127	-0.0005	-0.0016	0.0039	0.0031	-0.0052	-0.006	-0.0127	-0.0126	0.0084
DP50%	-0.0196	-0.0495	0.0047	-0.0034	-0.0009	-0.002	0.0015	0.0203	-0.0061	0.0171	0.0236	0.0037
PH	-0.0038	-0.001	0.0104	-0.0042	-0.0016	0.0022	0.0008	-0.0028	0.0001	-0.0006	0.0031	-0.001
NPBP	0.0002	-0.0013	0.0074	-0.0185	-0.0076	0.0056	0.002	0.0006	-0.001	0.0037	0.0044	0.0005
NSBP	-0.0022	0.0009	-0.0071	0.0189	0.0461	-0.0065	0.0101	0.0047	0.0029	0.0156	0.0103	-0.0139
DM	0.0017	0.0006	0.0032	-0.0045	-0.0021	0.015	0.0012	-0.0008	0	-0.0012	-0.002	0.0029
NPPL	-0.0003	0.0001	-0.0003	0.0004	-0.0008	-0.0003	-0.0037	0.0007	0.0009	-0.0001	0.0004	0.0011
NSPL	-0.0117	-0.0313	-0.0205	-0.0027	0.0077	-0.0043	-0.0134	0.0765	0.0195	0.0513	0.023	0.0297
NSPP	0.0018	-0.0013	-0.0001	-0.0006	-0.0007	0	0.0026	-0.0027	-0.0104	-0.002	0.0004	-0.0014
BYP	-0.3144	-0.2926	-0.0464	-0.1718	0.2858	-0.0669	0.0298	0.5683	0.1647	0.8477	0.5195	-0.2494
SI	0.0022	0.0028	-0.0018	0.0014	-0.0013	0.0008	0.0007	-0.0018	0.0002	-0.0037	-0.006	0.0014
HI	0.1589	-0.0485	-0.0645	-0.0179	-0.1947	0.1246	-0.1956	0.2511	0.088	-0.19	-0.1495	0.6459
SYP	**-0.153**	**-0.4075****	**-0.1277**	**-0.2032**	**0.1283**	**0.072**	**-0.1608**	**0.9087****	**0.2528***	**0.7251****	**0.4148****	**0.4279****

DF50%: Days to 50% flowering, **DP50%: Days to pod setting, **PH:** Plant Height, **NPBP**: No of primary branches/plant, **NSBP**: No of secondary branches/plant, **DM**: Days to maturity, **NPPL**: No of pods/plant, **NSPL**: No of seeds//plant, **NSP:** No of seeds per pod, **BYP**: Biological yield/ plant, **SI:** Seedindex ,**HI:** Harvest Index, **SYP:** Seed yield/plant*

Table 6. Genotypic direct (in bold) and indirect effects of 13 traits on grain yield in Chickpea evaluated during *Rabi* 2020-2021

Traits	DF50%	DP50%	PH	NPBP	NSBP	DM	NPPL	NSPL	NSP	BYP	SI	HI
DF50%	0.0205	0.0113	-0.0118	-0.0004	-0.0021	0.0068	0.001	-0.0062	-0.0035	-0.0135	-0.0137	0.0105
DP50%	-0.0301	-0.0547	0.0055	-0.0098	-0.0017	-0.004	0.001	0.0269	-0.0034	0.0242	0.0311	0.0059
PH	0.0064	0.0011	-0.011	0.0049	0.0018	-0.0022	-0.0011	0.003	-0.0004	0.0005	-0.0037	0.0018
NPBP	0.0019	-0.0194	0.0483	-0.1082	-0.0493	0.0522	0.0161	0.0057	-0.0304	0.0245	0.0326	0.004
NSBP	-0.0108	0.0032	-0.0165	0.0468	0.1027	-0.024	0.0241	0.0108	0.0114	0.0368	0.0248	-0.0366
DM	0.0163	0.0036	0.0097	-0.0237	-0.0115	0.0491	0.0085	-0.0041	0.0068	-0.002	-0.0067	0.009
NPPL	-0.0016	0.0006	-0.0033	0.005	-0.0079	-0.0059	-0.0337	0.0065	0.0136	-0.0012	0.0046	0.0119
NSPL	-0.1011	-0.1646	-0.0921	-0.0176	0.0353	-0.0281	-0.0649	0.3348	0.1474	0.2363	0.1058	0.1525
NSP	-0.007	0.0026	0.0015	0.0115	0.0045	0.0056	-0.0165	0.018	0.0409	0.0147	-0.0017	0.0056
BYP	-0.3538	-0.2388	-0.0266	-0.122	0.1931	-0.0224	0.0184	0.3806	0.1938	0.5393	0.3546	-0.1331
SI	-0.0193	-0.0164	0.0096	-0.0087	0.007	-0.004	-0.004	0.0091	-0.0012	0.019	0.0289	-0.0072
HI	0.1933	-0.0407	-0.0598	-0.0138	-0.1343	0.0687	-0.1328	0.1717	0.052	-0.093	-0.0939	0.3768
SYP	**-0.2853***	**-0.5122****	**-0.1466**	**-0.2359**	**0.1375**	**0.0919**	**-0.1839**	**0.9568****	**0.4268****	**0.7855****	**0.4628****	**0.401****

DF50%: Days to 50% flowering, **DP50%: Days to pod setting, **PH:** Plant Height, **NPBP**: No of primary branches/plant, **NSBP**: No of secondary branches/plant, **DM**: Days to maturity, **NPPL**: No of pods/plant, **NSPL**: No of seeds//plant, **NSP:** No of seeds per pod, **BYP**: Biological yield/ plant ,**SI:** Seedindex ,**HI:** Harvest Index, **SYP:** Seed yield/plant*

relationship exists between pods per plant, number of primary branches, seed index. These characters have shown indirect negative effect also but were of very negligible magnitude. The results obtained from path analysis indicated that the characters namely biological yield per plant and number of seeds per plant exhibited strong positive correlation and high magnitude of positive direct effect on seed yield.

Hence, it is suggested that while exercising selection index due weightage should be given to biological yield per plant and number of seeds per plant as these were important components influencing seed yield of chickpea. Correlation coefficient analysis at both phenotypic and genotypic levels indicated that apart from biological yield per plant and number of seeds per plant, other characters like number of pods per plant, number of primary branches per plant, number of secondary branches per plant and plant height were positively correlated with seed yield per plant. It is therefore suggested that preference should be given to these characters in selection program to isolate superior strains with genetic potentiality for higher yield.These results were in confirmations with the findings of Renukadevi and Subbalakshmi [14], Naveed et al. (2012), Dehal et al. [19], and Tadesse et al. [20]

4. CONCLUSION

From present investigation, it is concluded that among 21 genotypes of chickpea on the basis of mean performance NBEG1121and ICC4968 genotypes were found to be superior grain yield over check variety. Genotypic and phenotypic variation was moderate for plant height, number of primary branches, number of secondary branches, number of pods per plant, Number of seeds per plant, biological yield, seed index, harvest index and seed yield per plant. Genetic parameters revealed that heritability and genetic advance as percent mean values were high for number of seeds per plant , number of secondary branches, seed index , biological yield per plant , seed yield per plant and no of pods per plant and no of primary branches per plant. correlation coefficient analysis revealed seed yield per plant exhibited positive and significant association with days to 50% flowering , no. of secondary branches, days to maturity no of seeds per plant biological yield and harvest index at genotypic and phenotypic level, path coefficient analysis revealed that characters days to 50% flowering, number of secondary branches per plant, days to maturity, number of seeds per plant, biological yield and harvest index at genotypic and phenotypic level. Hence at most important should be given to these characters during selection of improvement yield in chickpea.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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