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Variability and correlation studies among yield and yield contributing characters in chickpea (*Cicer arietinum* L.) genotypes

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Abstract
The investigation on "Evaluation of chickpea (*Cicer arietinum* L.) genotypes for variability and correlation studies among yield and yield contributing characters" was conducted on 18 genotypes of chickpea during *rabi* 2019-20 at Pulses Improvement Project, M.P.K.V., Rahuri. Observations were recorded for the twelve characters. Number of pods per plant exhibited highest range of variability followed by plant height, seed yield per plant, 100 seed weight, days to maturity, wilt (%), days to 50% flowering, number of secondary branches per plant, iron content, zinc content and number of primary branches per plant. Whereas, number of seeds per pod showed lowest variability.

Genotypic and phenotypic coefficients of variation were highest for seed yield per plant followed by 100 seed weight and zinc content. The character days to maturity recorded lowest genotypic coefficient of variation. The maximum phenotypic coefficient of variation was recorded for seed yield per plant and 100 seed weight. High heritability coupled with high genetic advance as percent of mean was observed for all characters except days to 50% flowering, days to maturity, number of seeds per plant and 100 seed weight indicating that these traits were predominantly governed by additive gene action and suggesting that selection in these traits would be effectively made desired genetic improvement.

The significant positive correlation was observed between seed yield per plant with number of pods per plant, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, 100 seed weight and iron content at both genotypic and phenotypic level. While seed yield per plant exhibited negative and non significant correlation with the characters days to maturity and wilt% at both genotypic and phenotypic level. Other characters showed negligible amount of positive and non significant correlation with days to maturity, plant height and zinc content at both genotypic and phenotypic levels.

Keywords: Chickpea, genetic variability, heritability, GCV, PCV, genetic advance, correlation

Introduction
Pulses are one of the most important crop. They contribute for soil quality by fixing nitrogen in the soil. Though pulses are very popular crops in the developing world there is a massive gap in the productivity between pulse crops inside and outside the developing world. With the introduction of improved varieties and promotion of better management technique pulse crops can contribute to be an excellent choice for farmers in the developing world. As a steady source of nutrition, feed for animals and soil sustainability, pulse crops play a major role which will only grow in the future. The pulse crops are also called as grain legume and have been valued as nutritious and protein rich food, fodder and feed. They have a greater role in fixing atmospheric nitrogen by symbiotic association with *Rhizobium* spp.

During 2019-20, area under total pulses in India was 28.33 million ha, production was 23.15 million tonnes and productivity was 842 kg/ha. In Maharashtra, area under total pulses was 43.87 lakh ha, production was 40.27 lakh tonnes and productivity 918 kg/ha (Anonymous, 2019-20) [1]. India is the world's leading producer of chickpeas, accounting for 65.2 percent of total area and 65.4 percent of total production. In India, the area planted under chickpea was 10.78 million hectares, with a production of 11.35 million tonnes and a productivity of 1053 kg/ha, while, in Maharashtra, area under chickpea was 23.22 lakh ha, production was 25.97 lakh tonnes and productivity were 1118 kg/ha (Anonymous, 2019-20) [1].

Chickpeas are a preferred legume source of protein after milk because they are high in proteins and minerals. It is scientifically known as *Cicer arietinum* L. and is a rich source of soluble and insoluble fibre, complex carbohydrates, vitamins (specifically B vitamins) and minerals (particularly potassium, phosphorus, calcium, magnesium, copper, iron, and zinc), (Jukanti *et al.*, 2012) [5]. It is a self-pollinating crop belongs to the family Fabaceae of the Tribe Cicereae. It is a diploid species with 2n=2x=16 chromosome number.

As in all cultivated plants, the main objective of growing chickpea is for high yield and high-quality crops. Since genotypic and environmental factors are the main components for determining yield and quality in plants. The primary aim of this should be the determination of effects of genotypic and phenotypic factors for selection.

Because of the effect of the environment on plant yield and quality is not heritable, plant breeding researchers must investigate the effect of genotypic factors on yield and quality. The complex relationships between the many features associated to the dependent variables are not taken into account by simple correlation (Garcia de Moral *et al.*, 2003) [3]. The correlation coefficient represents the association between independent variables. But it is not sufficient to describe this relationship when the causal relationship among variables is needed.

The statistical analysis of one or more characters influenced by a large number of genes is accomplished by estimating correlation coefficients. The genotypic correlation coefficient is a unit of measurement for character genotypic recombination. Hence, the present investigation was undertaken for evaluation of variability and correlation studies in chickpea genotypes.

Materials and Methods

The present investigation on "Variability and correlation studies in chickpea" was conducted out during *rabi* 2019-20 at Pulses Improvement Project, M. P. K. V., Rahuri comprised of eighteen chickpea genotypes in RBD design with three replications. Observations were recorded on five randomly selected plants for twelve characters *viz*., days to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight (g), seed yield per plant (g) and wilt (%). Also two quality parameters were estimated which are zinc content and iron content in mg/100g.

Heritability in broad sense and expected genetic advance were estimated as suggested by Burton (1952) [2] & Johnson *et al*. (1955) [4] respectively. Genotypic and phenotypic coefficients of variability were estimated as suggested by Burton and De Vane (1952) [2] and Johnson *et al*. (1955) [4]. Genotypic and phenotypic correlation coefficients were calculated as suggested by Johnson *et al*. (1955) [4].

Results and Discussion

For all the yield and yield contributing characters, phenotypic variance was higher than the genotypic variance and it is an indicator of influence of environmental factors on these traits (Table 1). Estimation of phenotypic variance (σ^2p) and genotypic variance (σ^2g) were obtained for different traits (Table 1). A wide range of variance was observed for all the traits. The highest variances (V_p) and (V_g) were recorded for number of pods per plant (112.18 and 105.65) followed by plant height (42.55 and 39.99) and 100 seed weight (31.80 and 31.19).

The result on mean, range, PCV, GCV, heritability and genetic advance as per cent of mean for seed yield and yield contributing characters are presented in Table 2. Genotypic coefficient variation was highest for seed yield per plant (37.07%) followed by 100 seed weight (23.00%) and zinc content (22.38%). The character days to maturity (3.72%) recorded lowest GCV. The maximum phenotypic coefficient of variation was recorded for seed yield per plant (38.59%) followed by 100 seed weight (23.22%). However, moderate GCV was recorded for the characters like number pf seeds per pod (9.66%), iron content (10.88%), plant height (14.85%) and number of secondary branches per plant (16.55%) and moderate PCV was recorded for the characters iron content (10.89%), number of primary branches per plant (13.39%), number of seeds per pod (15.06%), plant height (15.32%), number of secondary branches per plant (17.20%) and zinc content (22.79%).

The character 100 seed weight and seed yield per plant exhibited highest estimates of genotypic (GCV) and phenotypic coefficients of variation (PCV) indicating good scope for their improvement through selection. The result obtained was in the conformity with the results of Kishor *et al.* (2018) [10], studied genetic diversity of 25 chickpea genotypes, the phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for seed yield, days to flowering, flowering period, canopy height, number of pods per plant.

High estimates of heritability (>60%) was observed for all the studied characters except number of primary branches and number of seeds per pod. The highest estimates of heritability exhibited in both zinc content and iron content (99.86%) followed by 100 seed weight (98.08%), days to 50% flowering (95.98%), number of pods per plant (94.18%), days to maturity (94.08%), plant height (94.00%) and number of secondary branches per plant (92.54%) and seed yield per plant (92.24%).

While moderate estimates of heritability were recorded in number of seeds per pod (41.14%) followed by number of primary branches (44.97%). Similar results were reported by Bhanu *et al*. (2017) [11] showing high heritability for the characters 100 seed weight, days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, 100 seed weight and seed yield per plant.

In the present investigation, range of genetic advance observed from 0.15 to 20.55. The highest estimate of GA for number of pods per plant (20.55) followed by plant height (12.63), 100 seed weight (11.39) and seed yield per plant (10.69). While, the moderate genetic advance was observed for days to maturity (6.85), days to 50% flowering (6.33) and number of secondary branches per plant (3.96). Whereas, the least value for genetic advance was recorded for the character number of seeds per pod (0.15) which was followed by number of primary branches per plant (0.33), zinc content (1.26) and iron content (1.64).

These results also supported by Neelu kumari *et al.* (2013) [6] high expected genetic advance coupled with high heritability estimate was obtained for plant height, number of secondary branches per plant, number of pods per plant and seed yield per plant.

The range of genetic advance as per cent of mean is classified as suggested by Johanson *et al.* (1955) [4]. High estimates of genetic advance as per cent of mean observed for seed yield per plant (73.33%) followed by 100 seed weight (46.91%) and zinc content (46.06%). While, days to maturity (7.44%) recorded the lowest performance in genetic advance as per cent of mean.

The results of genetic advance as percent of mean were in accordance with Singh *et al.* (2014) [9], Shengu *et al*. (2018) [8] which have shown the value of genetic advance as percent of mean was recorded highest for 100 seed weight which was followed by seed yield per plant and number of primary branches per plant.

High heritability coupled with high genetic advance as percent of mean was observed for all characters except number of primary branches, No. of seeds per pod indicating that these traits were predominantly governed by additive gene action in the inheritance of these traits and scope for direct selection of these characters in early generation served to be effective for desired genetic improvement. The results were in accordance with the findings of Padmavati *et al.* (2013) [7] showing that the high heritability coupled with high genetic advance for the characters like number of primary branches per plant, biological yield per plant and seed yield per plant.

The correlation coefficient between seed yield and its components were estimated at both genotypic and phenotypic level. The genotypic (rg) and phenotypic (rp) correlations for twelve characters studied are presented in Table 2. In general, genotypic correlation coefficients were higher than their corresponding phenotypic correlations.

It is revealed from Table 2 that, significant positive correlation was reported between seed yield per plant with number of pods per plant, number of primary branches/plants, number of secondary branches per plant and 100 seed weight, number of seeds per pod and iron content. Non-significant positive correlation was reported between seed yield per plant with days to maturity and plant height and zinc content. However, no any significant negative correlation was reported between seed yield per plant with any of the character at genotypic level. While, non-significant negative correlation recorded with days to 50 per cent flowering and wilt%.

Table 1: Estimates of variability parameters for seed yield and its contributing characters in eighteen chickpea genotypes

Sr. No.	Character	Mean	Range	Genotypic variance	Phenotypic variance	GCV (%)	PCV (%)	ECV (%)	Heritability h² (bs)	Genetic Advance	Genetic Advance as% of Mean
1	Days to 50% flowering	53.84	50.00-58.33	9.84	10.25	5.82	5.95	1.19	95.98	6.33	11.76
2	Days to maturity	92.13	88.00-98.67	11.77	12.51	3.72	3.84	0.93	94.08	6.85	7.44
3	Plant height (cm)	42.59	35.11-54.55	39.99	42.55	14.85	15.32	3.75	94.00	12.63	29.66
4	No. of pods per plant	51.34	35.77-67.44	105.65	112.18	20.02	20.63	4.98	94.18	20.55	40.03
5	No. of primary branches per plant	2.69	2.24-3.14	0.06	0.13	8.98	13.39	9.93	44.97	0.33	12.40
6	No. of secondary branches per plant	12.08	9.33-14.78	4.00	4.32	16.55	17.20	4.70	92.54	3.96	32.80
7	100 seed weight (g)	24.29	18.23-35.75	31.19	31.80	23.00	23.22	3.21	98.08	11.39	46.91
8	No. of seeds per pod	1.16	1.00-1.44	0.01	0.03	9.66	15.06	11.56	41.14	0.15	12.77
9	Zinc content (mg/100g)	2.74	2.04-3.65	0.38	0.38	22.38	22.39	0.83	99.86	1.26	46.06
10	Iron content (mg/100g)	7.33	6.15-8.20	0.64	0.64	10.88	10.89	0.40	99.86	1.64	22.40
11	seed yield/plant (g)	14.58	6.93-25.92	29.20	31.66	37.07	38.59	10.75	92.24	10.69	73.33

Note: The character wilt (%) is not considered for estimation of variability parameters for seed yield and its contributing characters

Table 2: Estimates of genotypic (above diagonal) and phenotype correlation coefficients (below diagonal) among seed yield and twelve yield contributing characters in eighteen chickpea genotypes.

Sr. No.	Name of character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of pods / plant	No. of primary branches /plant	No. of secondary branches / plant	100 seed weight (g)	No. of seeds/ pod	Wilt (%)	Zinc (mg/100g)	Iron (mg/100g)	Seed yield/ plant (g)
1.	Days to 50% flowering	1.000	0.779**	-0.336*	-0.395**	-0.530**	-0.265*	-0.019	0.132	-0.251	-0.075	-0.196	-0.198
2.	Days to maturity	0.766**	1.000	-0.266*	-0.012	-0.152	-0.077	0.256*	-0.224*	-0.288*	0.038	0.211	0.106
3.	Plant height (cm)	-0.331*	-0.266*	1.000	0.092	0.550**	-0.204	0.196	-0.233*	0.088	0.126	0.231*	0.104
4.	No. of pods / plant	-0.385**	-0.012	0.088	1.000	0.874**	0.684**	0.320*	0.203	0.234	0.372**	0.182	0.788**
5.	No. of primary branches /plant	-0.397**	-0.090	0.403**	0.691**	1.000	0.564**	0.424*	-0.362*	0.160	0.566**	0.549**	0.599**
6.	No. of secondary branches / plant	-0.261*	-0.078	-0.196	0.656**	0.454**	1.000	0.310*	-0.078	0.280	0.052	-0.175	0.544**
7.	100 seed weight (g)	-0.016	0.254*	0.193	0.312*	0.351**	0.300*	1.000	-0.147	-0.298	-0.250*	0.426**	0.784**
8.	No. of seeds / pod	0.111	-0.149	-0.196	0.124	-0.074	-0.055	-0.125	1.000	-0.208	0.467**	-0.346**	0.233*
9.	Wilt (%)	-0.244*	-0.282*	0.093	0.228	0.108	0.269*	-0.296*	-0.160	1.000	-0.129	-0.472**	-0.158
10.	Zn (mg/100g)	-0.074	0.037	0.125	0.365**	0.447**	0.051	-0.248*	0.360*	-0.128	1.000	0.180	0.122
11.	Fe (mg/100g)	-0.193	0.208	0.227*	0.179	0.431**	-0.172	0.424**	-0.262*	-0.469	0.180	1.000	0.313*
12.	Seed yield/plant (g)	-0.185	0.109	0.093	0.765**	0.529**	0.524**	0.765**	0.286*	-0.156	0.120	0.307*	1.000

*and ** significant at P= 5 and P = 1 level of significance, respectively

Conclusion

In the present investigation, analysis of variance revealed highly significant differences among the 18 genotypes for all the traits studied in chickpea indicating good amount of variability for all the characters studied and therefore these traits are applicable to exploitation. Genotypes like Phule G 15109, Phule G 1131-4, BDNG 2017-49, AKG 1702, AKG 1706, BDNG 797, Vijay, Phule Vikrant and Phule Vikram were found superior for most of the characters based on mean performance. While the moderate magnitudinal differences between GCV and PCV were found for number of primary branches per plant, number of seeds per pod, wilt% and seed yield per plant indicating the role of environment in phenotypic expression of these traits which shows good scope for their improvement through selection. High heritability (b.s.) coupled with high genetic advance as precent mean was recorded for all the characters except days to 50% flowering, days to maturity and number of pods per plant indicated that these traits were predominantly governed by additive gene action and selection of these traits would be more effective for desired genetic improvement.

Seed yield per plant found to be positively and significantly correlated with number of pods per plant, number of primary branches per plant, number of secondary branches per plant, 100 seed weight, number of seeds per pod and Fe content at both genotypic and phenotypic levels. This indicate simultaneous improvement of these characters through selection. While seed yield per plant exhibited negative and non significant correlation with days to maturity and wilt% at both genotypic and phenotypic levels. Other characters showed negligible amount of positive and non significant correlation with days to maturity, plant height and Zn content at both genotypic and phenotypic levels. This proves that these characters do not have any inherent association of these characters with seed yield.

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