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Assessment of polygenic character's association with yield in chickpea genotypes

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Abstract
Chickpea is one of the important pulse crop in Asia with special concern to India. Productivity of chickpea is low as compared to wheat in India. For this concern, the analysis of the relationships among yield attributing characters and their associations with seed yield is essential to establish selection criteria. The experimental material used in the present study comprised of forty genotypes including standard checks.

The characters *viz*., 100-seed weight, biological yield per plant, harvest index, number of pods per plant and number of seeds per plant recorded positive correlation coefficient with seed yield both at genotypic and phenotypic level. Path coefficient analysis revealed a higher and positive direct effect *viz*., number of seeds per plant, lowest branch height, number of primary branches per plant, harvest index and number of seeds per pod on seed yield per plant.

The result obtained from genotypic correlation coefficients and path analysis indicated that the characters namely; number of seeds per plant and harvest index exhibited strong positive correlation coefficient and high magnitude of positive direct effects on seed yield. Hence, it is suggested that while exercising selection index due weightage should be given to number of seeds per plant and harvest index as these were important components influencing seed yield of chickpea.

Keywords: Chick pea, correlation coefficient, path analysis

Introduction

Chickpea is one of the important pulse crop grown during *rabi* season in Asia. It is a self-fertilizing annual diploid grain legume of the family *Fabaceae*, sub family Faboideae. The scientific name *Cicer arietinum* (2n=2x=16) has been derived from the roman word '*Cicer'* owing to the resemblance of the head and the word '*arietinum'* derives its name from aries meaning ram. Hence it has resemblance to the head of ram. It is also known as Gram, Indian pea, Cecibean or Bengal gram, Garbanzo bean, and Egyptian pea. The cultivated chickpea are mainly divided into two groups based on plant characteristics, seed size, shape and colouration as *'kabuli'* and *'desi'*. The *'kabuli'* chickpea has relatively large creamy coloured seeds, white flowers and do not contain anthocyanin. In contrast, the *'desi'* chickpea has comparatively small seeds of various colours, purplish flowers and do contain anthocyanin pigmentation. Chickpea seeds contain on an average 23% protein, 64% total carbohydrates (47% starch, 6% soluble sugar), 5% fat, 6% crude fiber and 2% ash. It is also reported to contain high mineral content: phosphorus (340 mg/100 g), calcium (190 mg/100 g), magnesium (140 mg/100 g), iron (7 mg/100 g), zinc (3 mg/100 g) (Jukanti *et al*., 2012) [10].

Madhya Pradesh is also known as "Fort of Pulses" and chickpea is grown largely in rainfed and partial irrigated condition. Madhya Pradesh is the single largest producer of chickpea in the country accounting for over 40 per cent of the total national production. *Malwa* plateau, Vindhyan plateau, Bundelkhand, Narmada valley and Chambal valley regions of the state are the major chickpea producers. Production and price risks are more in chickpea compared to wheat in the state. That's why breeder has to concern on yield enhancement of chick pea for increasing production and productivity.

Breeding chickpea for various desirable traits is limited by the lack of adequate selection criteria (Meena and Kumar, 2014) [12]. Remembering above condition, the analysis of the relationships among yield attributing characters and their associations with seed yield is essential to establish selection criteria. But only using simple correlation coefficients between yield and yield components may not give satisfactory results.

Because, the components not only directly affect the yield, but they also affect the yield indirectly by affecting other yield components in negative or positive manner. Under such situations, the path coefficient analysis helps to determine the direct contribution of these characters and their indirect contributions *via* other characters (Singh, 1990) [19]. For this reason, in this study the correlation and path analyses have been conducted in chick pea to find out real contribution of characters among them to increase seed yield.

Material and Methods

Experimental material

The experimental material used in the present study comprised of forty genotypes including standard checks. The experiment was laid down in a Randomized Block Design (RBD) with three replications. Each entry was sown in four rows of 4 m length with a row spacing of 30 cm and plant to plant distances were maintained as 5 cm. The material was sown on November 26, 2016. All recommended package of practices were followed during the conduction of experiment to raise a good crop. The details are as under.

Observations recorded

Observations were recorded on plot as well as single plant basis. Observations were recorded plot basis for days to 50% flowering, days to maturity. The data were recorded on the five competitive plants selected randomly from each plots. Average of these five plants in respect of plant height (cm), lowest branch height (cm), number of primary branches per plant, number of pods per plant, number of seeds per plant, number of seeds per pod, 100-seed weight (g), biological yield per plant (g), harvest index, seed yield per plant (g) was used for statistical analysis.

Table 1: List of Chickpea genotypes

S. No.	Name of Genotypes	S. No.	Name of Genotypes	S. No.	Name of Genotypes
1	IG-2015-1	15	IG-2015-15	29	IG-2015-29
2	IG-2015-2	16	IG-2015-16	30	IG-2015-30
3	IG-2015-3	17	IG-2015-17	31	IG-2015-31
4	IG-2015-4	18	IG-2015-18	32	JG-16
5	IG-2015-5	19	IG-2015-19	33	JG-130
6	IG-2015-6	20	IG-2015-20	34	JAKI-9218
7	IG-2015-7	21	IG-2015-21	35	RVG-201
8	IG-2015-8	22	IG-2015-22	36	RVG-202
9	IG-2015-9	23	IG-2015-23	37	JG-412
10	IG-2015-10	24	IG-2015-24	38	JG-218
11	IG-2015-11	25	IG-2015-25	39	JG-226
12	IG-2015-12	26	IG-2015-26	40	JG-11
13	IG-2015-13	27	IG-2015-27		
14	IG-2015-14	28	IG-2015-28		

Statistical analysis

Correlation coefficient analysis

Phenotypic, genotypic and environmental correlation coefficient between characters were computed utilizing respective components of variance and co-variance, by following formula suggested by Miller *et al.* (1958) [14].

To test the significance of phenotypic and environmental correlation coefficient, the estimated values were compared with the tabulated values of Fisher and Yates (1938) [6] at t-2 d.f. at two levels of probability, *viz.*, 5% and 1%.

Path coefficient analysis

The proportion of direct and indirect contributions of various characteristics to the total correlation coefficient with seed yield was estimated through path coefficient analysis as suggested by Wright (1921, 1934) [20, 21] and elaborated by Dewey and Lu (1959) [5]. Residual effect, which measures the contribution of the characters not considered in the causal scheme, was also obtained.

Experimental Results

Correlation coefficient analysis

Significant and positive association at phenotypic level was observed between seed yield with number of pods per plant (0.682), number of seeds per plant (0.670), harvest index (0.611), 100-seed weight (0.601) and biological yield per plant (0.597). Other yield components, *viz.*, lowest branch height (-0.377) showed significant negative association with yield. While plant height (0.152) showed non-significant positive association with seed yield. However, number of primary branches per plant (-0.230), number of seeds per pod (-0.230) and days to maturity (-0.023) reported non-significant negative association with yield at phenotypic level. Positive association at genotypic level was observed between seed yield with 100-seed weight (0.753), biological yield per plant (0.753), harvest index (0.704), number of pods per plant (0.532), number of seeds per plant (0.466) and plant height (0.071). However, rest of yield components, *viz.*, days to 50% flowering (-0.813), lowest branch height (-0.486), number of seeds per pod (-0.460), number of primary branches per plant (-0.410) and days to maturity (-0.049) exhibited non-significant and negative association with yield at genotypic level.

Path coefficient analysis

The estimate of path coefficient has been furnished in the Table 3 (phenotypic) and Table 4 (genotypic). In general the genotypic direct effects as well as indirect effects were slightly higher in magnitude as compared to corresponding phenotypic direct indirect effects. The measurement of the direct and indirect effects were characterize as negligible (0.00 to 0.09), low (0.10 to 0.19), moderate (0.20 to 0.29), high (0.30 to 0.99) and very high (> 1.00) as suggested by Lenka and Mishra (1973).

Phenotypic path analysis (Table 3) exhibited that number of seeds per plant (0.757) registered the high positive direct effect, followed by, 100-seed weight (0.685). While, other characters recorded negligible direct effect on seed yield per plant.

Study of genotypic path analysis (Table 4) recorded that number of seeds per plant (4.211) registered very high positive direct effect, followed by, lowest branch height (2.112) and number of primary branches per plant (1.876). High positive direct effect was observed for the characters *viz*., harvest index (0.544), number of seeds per pod (0.525) on seed yield per plant. While days to maturity (0.266) showed moderate positive direct effect. Least positive direct effect was recorded in days to maturity. Whereas, days to 50% flowering (-3.850) recorded very high negative direct effect on seed yield per plant, followed by, number of pods per plant (-2.948). High negative direct effect was observed for the characters *viz.*, biological yield per plant (-0.791) and plant height (-0.400). While, 100-seed weight (-0.229) recorded moderate negative direct effect on seed yield per plant.

Table 2: Estimates of Phenotypic and Genotypic coefficient of correlation for yield and its attributing characters in chickpea genotypes

S. No	Characters		Days to maturity	No. of pods per plant	No. of seed per plant	Plant Height (cm)	Lowest branch Height (cm)	No of primary branches	No of seed per pod	Biological yield (g)	Harvest index	100-seed weight	Seed yield per plant (g)
1	Days to 50% flowering	P	0.236	-0.241	-0.149	0.023	0.467**	0.323*	0.270	-0.190	-0.581**	-0.679**	-0.617**
		G	0.504	-0.313	-0.151	0.023	0.613	0.592	0.553	-0.245	-0.810	-0.782	-0.813
2	Days to maturity	P		0.171	0.242	0.156	0.162	0.115	0.087	0.205	-0.203	-0.284	-0.023
		G		0.232	0.394	0.252	0.248	0.197	0.327	0.290	-0.298	-0.350	-0.049
3	No of pods/plant	P			0.941**	0.077	-0.284	-0.075	-0.435**	0.601**	0.199	-0.093	0.682**
		G			0.953	-0.051	-0.381	-0.100	-0.608	0.743	0.106	-0.103	0.532
4	No. of seeds/plant	P				0.056	-0.262	-0.025	-0.136	0.606**	0.182	-0.175	0.670**
		G				-0.100	-0.350	-0.120	-0.341	0.739	0.024	-0.224	0.466
5	Plant Height(cm)	P					0.688**	-0.099	-0.088	0.214	-0.042	0.161	0.152
		G					0.733	-0.193	-0.171	0.270	-0.134	-0.187	0.071
6	Lowest Branch Height(cm)	P						0.184	0.098	-0.047	-0.426**	-0.227	-0.377*
		G						0.221	0.203	-0.081	-0.567	-0.266	-0.486
7	No of primary Branches/plant	P							0.106	0.185	-0.446**	-0.280	-0.230
		G							-0.093	0.098	-0.644	-0.377	-0.410
8	No of Seeds/ pod	P								-0.189	-0.096	-0.168	-0.230
		G								-0.520	-0.192	-0.305	-0.460
9	Biological yield(g)	P									-0.218	0.147	0.597**
		G									0.057	0.265	0.753
10	Harvest index	P										0.624**	0.611**
		G										0.769	0.704
11	100-seed weight (g)	P											0.601**
		G											0.753

Table 3: Phenotypic Path analysis for yield and its component characters in chickpea genotypes

S. No	Characters	Days to 50% flowering	Days to maturity	No. of pods/ plant	No. of seed/ plant	Plant Height (cm)	Lowest branch Height (cm)	No of primary branches/ plant	No of seed per pod	Biological yield/ plant (g)	Harvest index	100 seed weight	Phenotypic correlation coefficient with Seed yield/plant (g)
1	Days to 50% flowering	0.011	-0.00 2	0.004	-0.113	-0.001	0.013	-0.004	-0.001	-0.015	-0.044	-0.466	-0.617**
2	Days to maturity	0.003	-0.010	-0.003	0.183	-0.005	0.004	-0.001	0.000	0.016	-0.015	-0.194	-0.023
3	No. of pods/ plant	-0.003	-0.002	-0.016	0.712	-0.002	-0.008	0.001	0.002	0.047	0.015	-0.064	0.682
4	No. of seeds/plant	-0.002	-0.002	-0.015	0.757	-0.002	-0.007	0.000	0.000	0.047	0.014	-0.120	0.670
5	Plant Height	0.000	-0.002	-0.001	0.042	-0 .031	0.019	0.001	0.000	0.017	-0.003	0.110	0.152
6	Lowest Branch Height	0.005	-0.002	0.005	-0.198	-0.022	0.028	-0.002	0.000	-0.004	-0.032	-0.155	-0.377
7	No of primary Branches/plant	0.003	-0.001	0.001	-0.019	0.003	0.005	-0.011	0.000	0.014	-0.034	-0.192	-0.230
8	No of Seeds/pod	0.003	-0.001	0.007	-0.103	0.003	0.003	-0.001	-0.004	-0.015	-0.007	-0.115	-0.230
9	Biological yield/ plant	-0.002	-0.002	-0.010	0.458	-0.007	-0.001	-0.002	0.001	0.078	-0.016	0.101	0.597
10	Harvest index	-0.006	0.002	-0.003	0.138	0.001	-0.012	0.005	0.000	-0.017	0.075	0.428	0.611
11	100-seed weight	-0.007	0.003	0.001	-0.133	-0.005	-0.006	0.003	0.001	0.011	0.047	0.685	0.601

Residual effect = 0.0185

Table 4: Genotypic path analysis for yield and its component characters in chickpea genotypes

S. No	Characters	Days to 50% flowering	Days to maturity	No. of pods/ plant	No. of seed/ plant	Plant Height (cm)	Lowest branch Height (cm)	No of primary branches/ plant	No of seed/ pod	Biological yield/ plant (g)	Harvest index	100 seed weight	Genotypic correlation with Seed yield/plant (g)
1	Days to 50% flowering	-3.850	0.134	0.923	-0.638	-0.009	1.294	1.110	0.290	0.194	-0.441	0.179	-0.813
2	Days to maturity	-1.942	0.266	-0.683	1.658	-0.101	0.523	0.369	0.172	-0.229	-0.162	0.080	-0.049
3	No. of pods/plant	1.205	0.062	-2.948	4.012	0.020	-0.806	-0.187	-0.320	-0.588	0.057	0.024	0.532
4	No. of seeds/ plant	0.583	0.105	-2.808	4.211	0.040	-0.740	-0.225	-0.179	-0.585	0.013	0.051	0.466
5	Plant Height	-0.090	0.067	0.151	-0.423	-0.400	1.548	-0.362	-0.090	-0.214	-0.073	-0.043	0.071
6	Lowest Branch Height	-2.356	0.066	1.124	-1.475	-0.293	2.112	0.415	0.107	0.064	-0.308	0.061	-0.486
7	No. of primary Branches/plant	-2.280	0.052	0.294	-0.506	0.077	0.467	1.876	-0.049	-0.078	-0.350	0.086	-0.410
8	No. of Seeds/pod	-2.128	0.087	1.794	-1.436	0.068	0.429	-0.175	0.525	0.412	-0.105	0.070	-0.460
9	Biological yield	0.944	0.077	-2.191	3.113	-0.108	-0.172	0.184	-0.273	-0.791	0.031	-0.061	0.753
10	Harvest index	3.120	-0.079	-0.311	0.103	0.054	-1.197	-1.208	-0.101	-0.045	0.544	-0.176	0.704
11	100-seed weight	3.011	-0.093	0.303	-0.945	-0.075	-0.561	-0.707	0.160	-0.209	0.418	-0.229	0.753

Residual effect: (-0.0626)

Discussion

In the present investigation attempt has been made with the objective to get the information about the nature, extent and direction of relationship and selection pressure practice to achieve practical and usable results. High magnitude of positive correlation coefficient at genotypic level indicates strong linkage at genetic level, but high values of correlation coefficient at phenotypic levels may not always show strong association and it may be broken up with the change. When the characters having direct bearing on the yield were selected, their association with other characters was to be simultaneously considered as it would directly affect the yield. Path coefficient analysis was carried out using genotypic and phenotypic correlation coefficients 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.

Correlation coefficient analysis at phenotypic and genotypic levels indicated that apart from number of seeds per plant and harvest index other characters like biological yield per plant (g), 100-seed weight, number of pods per plant, number of seeds per plant and plant height were positive correlated with seed yield per plant. It is therefore suggested that preference should also be given to these characters in selection programme to isolate superior strains with genetic potentiality for higher seed yield. These results were in confirmation with the findings of Ali *et al*. (2010) [1], Gohil and Patel (2010) [7], Borate and Dalvi (2010) [2], Shrivastav *et al*. (2012) [18], Padmavathi *et al*. (2013) [15], Jadhav *et al*. (2014) [8], Kuldeep *et al*. (2014) [11], Johnson *et al*. (2015) [9], Mehta *et al*. (2015) [13], Salgotra (2016) [16], Shafique *et al*. (2016) [16] and Dev *et al*. (2017) [4].

The result of this study revealed that number of seeds per plant registered the very high positive and direct effect, followed by, lowest branch height and number of primary branches per plant on seed yield. High positive and direct effect was observed for the characters *viz.*, harvest index, number of seeds per pod and days to maturity, while, the correlation coefficient only two characters *viz.*, number of seeds per plant and harvest index with seed yield per plant was also positive relation. Therefore, a true relationship exists between seed yield per plant with number of seeds per plant and harvest index.

Number of pods per plant showed positive correlation coefficient with seed yield per plant; exhibited considerable negative direct contribution towards seed yield. This negative direct contribution was converted into positive correlation coefficient mainly due to its positive indirect effects *via* number of seeds per plant, days to 50% flowering, days to maturity, harvest index (%) and 100-seed weight. Biological yield per plant showed positive correlation coefficient with seed yield per plant; and exhibited considerable negative direct contribution. This negative direct contribution was converted into positive correlation coefficient mainly due to its positive indirect effects *via* number of seeds per plant, days to 50% flowering, number of primary branches per plant, days to maturity and harvest index (%). Lowest branch height per plant showed negative correlation coefficient with seed yield per plant; but exhibited positive direct contribution. This positive direct contribution was converted into negative correlation coefficient mainly due to its negative indirect effects *via* days to 50% flowering, number of seeds per plant, harvest index (%) and plant height (cm).

Number of seeds per pod showed negative correlation coefficient with seed yield per plant; but exhibited positive direct contribution. This positive direct contribution was converted into negative correlation coefficient mainly due to its negative indirect effects *via* days to 50% flowering, number of seeds per plant, harvest index (%) and number of primary branches per plant. Number of primary branches per plant showed negative correlation coefficient with seed yield per plant; and exhibited positive direct contribution. This positive direct contribution was converted into negative correlation coefficient mainly due to its negative indirect effects *via* days to 50% flowering, number of seeds per plant, harvest index (%) and number of seeds per pod. 100-seed weight had positive correlation coefficient with seed yield per plant; but exhibited negative direct contribution. This negative direct contribution was converted into positive correlation coefficient mainly due to its positive indirect effects *via* days to 50% flowering, harvest index (%), number of pods per plant and number of seeds per pod. These results are similar

with the findings of Shrivastav *et al*. (2012) [18], Padmavathi *et al*. (2013) [15], Mehta *et al*. (2015) [13] and Dev *et al*. (2017) [4].

The result obtained from genotypic correlation coefficients and path analysis indicated that the characters namely; number of seeds per plant and harvest index exhibited strong positive correlation coefficient and high magnitude of positive direct effects on seed yield. Hence, it is suggested that while exercising selection index due weightage should be given to number of seeds per plant and harvest index as these were important components influencing seed yield of chickpea.

The component of phenotypic (0.0185) and genotypic (-0.0626) residual effects of path analysis were very low indicating that characters for path analysis were adequate and appropriate. These findings were in consonance to the results obtained by Chopdar *et al*. (2016) and Dev. *et al*. (2017) [4].

Conclusions

The characters *viz*., 100-seed weight, biological yield per plant, harvest index, number of pods per plant and number of seeds per plant recorded positive correlation coefficient with seed yield both at genotypic and phenotypic level. Path coefficient analysis revealed a higher and positive direct effect *viz*., number of seeds per plant, lowest branch height, number of primary branches per plant, harvest index and number of seeds per pod on seed yield per plant.

The result obtained from genotypic correlation coefficients and path analysis indicated that the characters namely; number of seeds per plant and harvest index exhibited strong positive correlation coefficient and high magnitude of positive direct effects on seed yield. Hence, it is suggested that while exercising selection index due weightage should be given to number of seeds per plant and harvest index as these were important components influencing seed yield of chickpea.

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