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Correlation and path coefficient analysis in Desi Chickpea (*Cicer arietinum* L.)

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ABSTRACT

Correlation coefficient analysis ofvarious characters within F_5 generation in chickpea revealed that seed yield per plant exhibited significant and positive association at genotypic and phenotypic levels with number of pods per plant of all selection procedures [PS(EF), PS(HY), SSD and RBP] in GJG 0315 X ICCV 96029. Besides strong association of seed yield per plant with number of pods per plant, seed yield per plant exhibited significant and positive association with number of branches per plant in SSD and RBP at both levels; 100-seed weight in PS(HY) at genotypic level and in SSD at both levels; biological yield per plant in RBP at genotypic level; Harvest index in PS(EF) and RBP at phenotypic level and in SSD at both level. Phenotypic path coefficient analysis revealed that very high to high direct effects were exerted by biological yield per plant and harvest index towards seed yield per plant in all the selection procedures in this cross. Based on the genotypic and phenotypic correlations and path coefficient analysis, number of pods per plant, biological yield per plant and harvest index could be used as indirect selection criteria for improving seed yield in segregating generations of chickpea with irrespective of the breeding selection procedures.

Key words: Chickpea, Correlation coefficient, Path-analysis, Selection schemes

INTRODUCTION

Among the food crops, pulses are an important group which occupies a unique position in the world of agriculture by virtue of their high protein content. Pulses occupy a key position in Indian diet and meet about 30 per cent of the daily protein requirement[16]. Among the pulses, chickpea is the most important *rabi* crop with high acceptability and wider use. More availability of quality seed of improved varieties being made available to the famers and it is one of the factors contributing to better harvest of chickpea in recent years. Therefore, there is an argent need for developing high yielding varieties of chickpea employing a sound and effective breeding strategies. The study of correlation and path coefficient analysis of seed yield per plant with yield contributing characters is of immense importance to get information regarding exercising selection pressure in relation to yield attributes for genetic improvement of seed yield.

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MATERIALS AND METHODS

Four selection procedures *viz*., pedigree selection for early flowering [PS(EF)], pedigree selection for high yield [PS(HY)], single seed descent (SSD) and random bulk population (RBP) of GJG 0315 X ICCV 96029were evaluated in F_5 generations. A total of 80 progenies (20 progenies in each selection scheme of a cross) were evaluated in F_5 along with original F_2 and two parental lines in Compact Family Block Design (CFBD) with three replications at Instructional Farm, Junagadh Agricultural University, Junagadh, Gujarat during season of *Rabi* 2015-16.The row length 3.0 m was used to accommodate 20 plants per row at 45 x 15 cm spacing. All the recommended agronomical practices and necessary plant protection measures were followed timely to raise healthy crop. The observations were recorded on five randomly selected competitive plants in F_5 generation in each progenies of the PS(EF), PS(HY), SSD and RBP populations of a cross in each replication on 10 characters (Table 1) and the mean values were used for statistical analysis. The phenotypic and genotypic correlation coefficients of all the pair of characters were worked out as per Al-Jibouri*et al*.[2], while path coefficient analysis was carried out according to the method suggested by Dewey and Lu[5] in each selection schemes.

RESULT AND DISCUSSION

Seed yield per plant had significant and positive association at genotypic level as well as at phenotypic level with number of pods per plant in all the four selection procedures *viz*., PS(EF) (r_g = 0.786; r_p = 0.641); PS(HY) (r_g = 1.252; r_p = 0.527); SSD (r_g = 0.925; r_p = 0.815) and RBP (r_g = 1.146; r_p = 0.614). Gul *et al.* (2013) reported that seed yield per plant showed highly significant genotypic as well as phenotypic correlation with pods per plant in positive direction. Seed yield per plant exhibited very strong association at genotypic level as well as at phenotypic level with number of branches per plant (r_g = 0.764; r_p = 0.613) and 100-seed weight (r_g = 0.707; r_p = 0.472) in SSD and number of branches (r_g = 0.827; r_p = 0.542) in RBP population.Test weight was the only component, which showed significant and very strong to strong positive correlation with seed yield in SSD (r_g = 0.707; r_p = 0.472) as supported by Salimath and Bahl[14] and Shamsuzzaman*et al*[15].

Seed yield per plant was found to be highly significant and positively correlated with harvest index in PS(EF) (r_p = 0.565) and RBP (r_p = 0.480) at phenotypic level indicating that this trait had good association with seed yield in chickpea and therefore, was important trait for bringing genetic improvement in seed yield. Johanson *et al.*[7] emphasized that these correlated yield attributes can serve as indicator characters for improving seed yield. Breeders can also concentrate their attention either on number of branches or number of pods to achieve higher seed yield while practicing selection of individual plant in segregating materials of chickpea. Vaghela *et al*.[18] and Meena[9] also reported the similar results in fixed homozygous material. This indicated that functionally related traits tend to be highly integrated morphologically, and their phenotypic correlation structure confirms to the functional relationship structure[3]. It is evident from the results of genotypic and phenotypic correlations of various yield attributing and developmental characters with seed yield per plant that relationship between pairs of characters did not vary up to large extent under different selection schemes practiced in the present investigation. These results are in agreement with those of Mehta[10] and Millawithanachchi*et al.*[11] in cowpea and Meena and Kumar[8] in chickpea. While contrast result was also reported by Ahmed *et al*.[1] in faba bean.

In general, most of the character pairs had higher values of genotypic correlations than their corresponding phenotypic correlations. These results was in agreement with the findings of Meena and Kumar[8] and Raval[12].

In case of PS(EF), pair of characters that showed significant and positive correlations were between days to first flowering and plant height (r_g = 0.896); days to maturity and reproductive phase duration (r_g = 0.665 and r_p = 0.633); reproductive phase duration and number of pods per plant (r_g = 0.538); plant height and number of branches per plant (r_g = 0.490), biological yield per plant (r_g = 0.726); number of branches per plantand 100-seed weight (r_g = 0.572). PS(HY) showed significant and positive association between reproductive phase duration and days to maturity (r_g = 0.628 and r_p = 0.661); 100-seed weight and plant height (r_g = 0.616); biological

yield per plant and number of branches per plant (r_g = 0.714), number of pods per plant (r_g = 0.555), 100-seed weight (r_g = 0.454); harvest index and days to first flowering (r_g = 0.642)(Table 1). Deshmukh and Patil (1995) reported that significant and positive associations of biological yield per plant with number of pods per plant and 100-seed weight were observed in both the F_1 and F_2generations.

In case of SSD population, significant and positive correlation were observed between days to maturity and reproductive phase duration (r_g = 0.645 andr_p = 0.560); number of branches per plant and number of pods per plant (r_g = 0.639 and r_p = 0.565); 100-seed weight (r_g = 0.686 andr_p = 0.494); harvest index (r_g = 0.748 and r_p = 0.624); number of pods per plant and 100-seed weight (r_g = 0.677); harvest index (r_g = 0.597 and r_p= 0.532) and 100-seed weight and harvest index (r_g = 0.711). Saki *et al*.[13], observed that number of branches per plant were positively correlated with number of pods per plant.While in case of RBP, significant and positive correlations were recorded between days to first flowering and days to maturity (r_g = 0.790 and r_p = 0.490), days to maturity and reproductive phase duration (r_g = 0.620); plant height and number of branches per plant (r_g = 1.379),number of pods per plant (r_g = 1.218),biological yield per plant (r_g = 1.475 and r_p = 0.503); number of branches per plant and number of pods per plant (r_g = 0.741 and r_p = 0.564), biological yield per plant (r_g = 0.593) and number of pods per plant and biological yield per plant (r_g = 0.591). (Table 2).

The results thus, revealed that the days to maturity, reproductive phase duration, plant height, number of branches per plant, number of pods per plant, 100-seed weight per plant biological yield per plant and harvest index were the most important attributes which contributed towards higher seed yield per plant. Therefore, more emphasis should be given to these components during selection leading to higher seed yield per plant. The interrelationships among yield components would help in increasing the seed yield level.

Very high to moderatepositive direct effect on seed yield was revealed by biological yield per plant and harvest index in all four selection procedures*viz*., PS(EF) (1.0095, 1.0753); PS(HY) (1.7221, 1.8091); SSD (0.6620, 1.0753) and RBP (1.1446, 1.2140)respectively, which depicted a true relationship and selection based on both these characters would be highly desirable. These both characters also had either significant and positive correlation or only positive correlation with seed yield per plant in most of the cases. Thus, both these characters turned to be major components of seed yield. Besides above two traits, high direct effect was also exterted by days to maturity in case of PS(HY) (0.7244) and SSD (0.3874) population. The maximum and positive direct effects of biological yield per plant and harvest index was observed by Thakur and Sirohi[17], Vaghela *et al*.[18], and Meena[9] in homogenous experimental materials. On contrary, Vekariya[19] observed high to moderate positive direct effects on seed yield per plant by number of seeds per plant, number of pods per plant and 100-seed weight in F_2 generation.

The results exhibited low to moderate residual effects in all selection procedures, which indicated that seed yield were contributed by the characters included in the present investigation.

The significant and positive correlation between number of pods per plant and seed yield per plant might be due to considerable indirect effect of number of pods per plant via biological yield per plant and harvest index in all the four selection schemes in the cross except PS(HY) in the cross. Likewise, number of branches per plant had considerable indirect effects *via* harvest index and biological yield per plant in SSD and RBP, respectively in cross.

Based on the genotypic and phenotypic correlations, number of pods per plant, biological yield per plant and harvest index could be used as indirect selection criteria for improving seed yield in segregating generations of chickpea with irrespective of the breeding selection procedures. Path coefficient analysis revealed similar trend of association analysis in that sense biological yield per plant and harvest index were exhibited very high to high direct effect along with high indirect effect of number of pods per plant *via* biological yield per plant and harvest index in most of the selection procedures in the cross.

Table 1: Genotypic (r_g) and phenotypic (r_p) correlation coefficients of pedigree selection for early flowering (above diagonal) and pedigree selection for high yield (below diagonal) among various characters in F_5 generation of GJG 0315 x ICCV 96029 of chickpea

Characters		Seed yield / plant	Days to first flowering	Days to maturity	Reproductive phase duration	Plant height (cm)	No. of branches / plant	No. of pods / plant	100 seed weight (g)	Biological yield / plant (g)	Harvest index (%)
Seed yield / plant	r_g	**1.000**	-0.065	-0.110	-0.042	0.113	-0.092	0.786**	-0.340	0.421	0.391
	r_p	**1.000**	-0.046	-0.022	0.018	0.009	0.085	0.641**	-0.147	0.082	0.565**
Days to first flowering	r_g	0.342	**1.000**	0.214	-0.587**	0.896**	-0.279	-0.319	0.250	0.173	-0.331
	r_p	0.141	**1.000**	0.369	-0.487*	0.337	-0.005	-0.122	-0.030	0.104	-0.151
Days to maturity	r_g	-0.746**	0.164	**1.000**	0.665**	-0.027	-0.618**	0.355	-0.618**	0.000	-0.082
	r_p	-0.110	0.312	**1.000**	0.633**	0.010	-0.171	0.274	-0.282	0.125	-0.138
Reproductive phase duration	r_g	-0.834**	-0.665**	0.628**	**1.000**	-0.707**	-0.298	0.538**	-0.703**	-0.132	0.185
	r_p	-0.211	-0.507*	0.661**	**1.000**	-0.272	-0.157	0.359	-0.240	0.030	-0.003
Plant height (cm)	r_g	0.239	-0.963**	-0.475*	0.399	**1.000**	0.490**	-0.241	0.150	0.726**	-0.797**
	r_p	0.098	-0.255	-0.040	0.166	**1.000**	0.044	-0.093	0.135	0.233	-0.209
No. of branches / plant	r_g	0.053	-0.261	0.152	0.321	0.102	**1.000**	-0.186	0.572**	-0.269	0.115
	r_p	0.138	-0.175	0.040	0.175	0.135	**1.000**	0.154	-0.039	0.038	0.030
No. of pods / plant	r_g	1.252**	0.358	-0.408	-0.591**	-0.164	0.256	**1.000**	-0.457**	0.378	0.238
	r_p	0.527*	0.237	-0.088	-0.267	0.113	0.210	**1.000**	-0.349	0.282	0.156
100 seed weight (g)	r_g	0.500*	-0.136	0.148	0.219	0.616**	0.143	0.541*	**1.000**	-0.256	-0.024
	r_p	0.283	-0.148	0.041	0.154	0.175	0.041	0.259	**1.000**	-0.107	-0.033
Biological yield / plant (g)	r_g	0.441	-0.412	0.035	0.351	0.141	0.714**	0.555*	0.454*	**1.000**	-0.660**
	r_p	0.178	-0.232	-0.063	0.126	0.246	0.395	0.364	0.238	**1.000**	-0.753**
Harvest index (%)	r_g	-0.003	0.642**	-0.413	-0.819**	-0.045	-0.740**	-0.007	-0.198	-0.899**	**1.000**
	r_p	0.302	0.290	0.060	-0.175	-0.206	-0.303	-0.105	-0.063	-0.869**	**1.000**

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

Table 2: Genotypic (rg) and phenotypic (rp) correlation coefficients of single seed descent (above diagonal) and random bulk population (below diagonal) among various characters in F_5 generation of GJG 0315 x ICCV 96029 of chickpea

Characters		Seed yield / plant	Days to first flowering	Days to maturity	Reproductive phase duration	Plant height (cm)	No. of branches / plant	No. of pods / plant	100 seed weight (g)	Biological yield / plant (g)	Harvest index (%)
Seed yield / plant	r_g	**1.000**	-0.013	-0.280	-0.260	-0.540*	0.764**	0.925**	0.707**	0.112	0.821**
	r_p	**1.000**	0.001	0.022	0.021	0.080	0.613**	0.815**	0.472*	0.110	0.771**
Days to first flowering	r_g	-0.012	**1.000**	0.388	-0.454*	0.031	0.106	-0.189	0.123	-0.283	0.128
	r_p	-0.038	**1.000**	0.458*	-0.480*	-0.108	-0.071	-0.048	0.068	0.014	-0.021
Days to maturity	r_g	0.032	0.790**	**1.000**	0.645**	0.258	-0.168	-0.539*	0.085	-0.807**	0.274
	r_p	0.013	0.490*	**1.000**	0.560*	-0.011	-0.103	-0.141	0.053	-0.166	0.135
Reproductive phase duration	r_g	0.068	-0.276	0.372	**1.000**	0.224	-0.250	-0.365	-0.020	-0.546*	0.159
	r_p	0.048	-0.380	0.620**	**1.000**	0.090	-0.035	-0.094	-0.011	-0.177	0.153
Plant height (cm)	r_g	1.392**	-0.117	-0.423	-0.485*	**1.000**	-0.326	-0.613**	-0.856**	-0.745**	-0.084
	r_p	0.173	-0.104	-0.155	-0.071	**1.000**	0.228	0.167	0.245	0.054	0.028
No. of branches / plant	r_g	0.827**	-0.044	-0.090	-0.074	1.379**	**1.000**	0.639**	0.686**	-0.096	0.748**
	r_p	0.542*	-0.038	-0.011	0.022	0.371	**1.000**	0.565**	0.494*	-0.170	0.624**
No. of pods / plant	r_g	1.146**	-0.201	-0.116	0.122	1.218**	0.741**	**1.000**	0.677**	0.381	0.597**
	r_p	0.614**	-0.014	0.058	0.074	0.171	0.564**	**1.000**	0.420	0.221	0.532*
100 seed weight (g)	r_g	0.013	-0.203	-0.196	0.000	0.187	0.119	-0.321	**1.000**	-0.158	0.711**
	r_p	0.133	-0.231	-0.109	0.092	-0.033	0.085	-0.039	**1.000**	-0.055	0.432
Biological yield / plant (g)	r_g	0.550*	0.059	-0.111	-0.264	1.475**	0.593**	0.591**	-0.069	**1.000**	-0.475*
	r_p	0.316	-0.060	-0.034	0.018	0.503*	0.420	0.224	-0.015	**1.000**	-0.534*
Harvest index (%)	r_g	0.195	-0.124	0.125	0.385	-0.856**	-0.034	0.254	0.088	-0.715**	**1.000**
	r_p	0.480*	0.001	0.014	0.014	-0.287	0.053	0.285	0.088	-0.664**	**1.000**

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

Table 3: Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of pedigree selection for early flowering for different characters on seed yield per plant in F_5 generation of GJG 0315 x ICCV 96029 of chickpea

Characters	Days to first flowering	Days to maturity	Reproductive phase duration	Plant height (cm)	No. of branches / plant	No. of pods / plant	100 seed weight (g)	Biological yield / plant (g)	Harvest index (%)	Correlation coefficient with Seed yield / plant
Days to first flowering	**0.1866**	-0.0602	-0.0647	0.0115	0.0001	-0.0242	-0.0018	0.1052	-0.0230	-0.046
Days to maturity	0.0688	**-0.1633**	0.0841	0.0003	0.0047	0.0545	-0.0166	0.1259	0.1452	-0.022
Reproductive phase duration	-0.0908	-0.1033	**0.1330**	-0.0093	0.0043	0.0713	-0.0141	0.0306	0.1648	0.018
Plant height (cm)	0.0629	-0.0016	-0.0362	**0.0342**	-0.0012	-0.0184	0.0079	0.2348	0.0300	0.009
No. of branches / plant	-0.0008	0.0279	-0.0208	0.0015	**-0.0277**	0.0306	-0.0023	0.0383	0.6709	0.085
No. of pods / plant	-0.0227	-0.0448	0.0478	-0.0032	-0.0043	**0.1985**	-0.0205	0.2851	0.5717	0.641**
100 seed weight(g)	-0.0056	0.0461	-0.0319	0.0046	0.0011	-0.0692	**0.0589**	-0.1077	0.4641	-0.147
Biological yield / plant (g)	0.0194	-0.0204	0.0040	0.0080	-0.0011	0.0561	-0.0063	**1.0095**	-0.5747	0.082
Harvest index (%)	-0.0282	0.0225	-0.0004	-0.0071	-0.0008	0.0310	-0.0019	-0.7604	**1.0753**	0.565**

*, ** Significant at 5% and 1% level, respectively, Residual effect, R = 0.2500

Table 4: Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of pedigree selection for high yield for different characters on seed yield per plant in F_5 generation of GJG 0315 x ICCV 96029 of chickpea

Characters	Days to first flowering	Days to maturity	Reproductive phase duration	Plant height (cm)	No. of branches / plant	No. of pods / plant	100 seed weight (g)	Biological yield / plant (g)	Harvest index (%)	Correlation coefficient with Seed yield / plant
Days to first flowering	**-0.6873**	0.2257	0.4672	-0.0128	0.0005	0.0178	0.0045	-0.3992	0.5243	0.141
Days to maturity	-0.2142	**0.7244**	-0.6093	-0.002	-0.0001	-0.0066	-0.0012	-0.1088	0.1076	-0.110
Reproductive phase duration	0.3484	0.4789	**-0.9216**	0.0083	-0.0005	-0.0200	-0.0046	0.2165	-0.3164	-0.211
Plant height (cm)	0.1755	-0.0288	-0.1526	**0.0501**	-0.0004	0.0085	-0.0053	0.4234	-0.372	0.098
No. of branches / plant	0.1206	0.0288	-0.1609	0.0067	**-0.0028**	0.0157	-0.0012	0.6796	-0.5487	0.138
No. of pods / plant	-0.1631	-0.0637	0.2462	0.0057	-0.0006	**0.0748**	-0.0078	0.6259	-0.1901	0.527*
100 seed weight(g)	0.1019	0.0298	-0.1423	0.0088	-0.0001	0.0193	**-0.0301**	0.4102	-0.1142	0.283
Biological yield / plant (g)	0.1593	-0.0458	-0.1159	0.0123	-0.0011	0.0272	-0.0072	**1.7221**	-1.5728	0.178
Harvest index (%)	-0.1992	0.0431	0.1612	-0.0103	0.0009	-0.0079	0.0019	-1.4972	**1.8091**	0.302

*, ** Significant at 5% and 1% level, respectively, Residual effect, R = 0.3070

Table 5: Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of single seed descent for different characters on seed yield per plant in F_5 generation of GJG 0315 x ICCV 96029 (cross-1) of chickpea

Characters	Days to first flowering	Days to maturity	Reproductive phase duration	Plant height (cm)	No. of branches / plant	No. of pods / plant	100 seed weight (g)	Biological yield / plant (g)	Harvest index (%)	Correlation coefficient with Seed yield / plant
Days to first flowering	**-0.3516**	0.1775	0.1934	-0.0001	0.0001	-0.0046	0.0001	0.0090	-0.0230	0.001
Days to maturity	-0.1611	**0.3874**	-0.2257	0.0001	0.0001	-0.0134	0.0001	-0.1101	0.1452	0.022
Reproductive phase duration	0.1687	0.2169	**-0.4030**	0.0001	0.0001	-0.0090	0.0001	-0.1170	0.1648	0.021
Plant height (cm)	0.0380	-0.0041	-0.0363	**0.0008**	0.0001	0.0159	0.0005	0.0356	0.0300	0.080
No. of branches / plant	0.0248	-0.0397	0.0142	0.0002	**0.0001**	0.0540	0.0011	-0.1126	0.6709	0.613**
No. of pods / plant	0.0169	-0.0545	0.0379	0.0001	0.0001	**0.0954**	0.0009	0.1460	0.5717	0.815**
100 seed weight(g)	-0.0238	0.0206	0.0043	0.0002	0.0001	0.0401	**0.0022**	-0.0362	0.4641	0.472*
Biological yield / plant (g)	-0.0048	-0.0644	0.0712	0.0001	0.0001	0.0210	-0.0001	**0.6620**	-0.5747	0.110
Harvest index (%)	0.0075	0.0523	-0.0618	0.0001	0.0001	0.0507	0.0009	-0.3538	**1.0753**	0.771**

*, ** Significant at 5% and 1% level, respectively, Residual effect, R = 0.1371

Table 6: Phenotypic path coefficient analysis showing direct (diagonal and bold) and indirect effects of random bulk population for different characters on seed yield per plant in F_5 generation of GJG 0315 x ICCV 96029 (cross-1) of chickpea

Characters	Days to first flowering	Days to maturity	Reproductive phase duration	Plant height (cm)	No. of branches / plant	No. of pods / plant	100 seed weight (g)	Biological yield / plant (g)	Harvest index (%)	Correlation coefficient with Seed yield / plant
Days to first flowering	**-0.0573**	0.0573	0.0353	0.0053	0.0001	-0.0003	-0.0116	-0.0682	0.0012	-0.038
Days to maturity	-0.0281	**0.1167**	-0.0574	0.0079	0.0001	0.0013	-0.0055	-0.0387	0.0167	0.013
Reproductive phase duration	0.0218	0.0723	**-0.0927**	0.0036	0.0001	0.0016	0.0046	0.0204	0.0166	0.048
Plant height (cm)	0.0060	-0.0181	0.0066	**-0.0511**	0.0002	0.0038	-0.0017	0.5755	-0.3479	0.173
No. of branches / plant	0.0022	-0.0013	-0.0020	-0.0189	**0.0006**	0.0125	0.0043	0.4805	0.0648	0.542*
No. of pods / plant	0.0008	0.0068	-0.0068	-0.0087	0.0003	**0.0221**	-0.0019	0.2563	0.3455	0.614**
100 seed weight(g)	0.0132	-0.0128	-0.0086	0.0017	0.0001	-0.0009	**0.0503**	-0.0175	0.1069	0.133
Biological yield / plant (g)	0.0034	-0.0039	-0.0017	-0.0257	0.0003	0.0049	-0.0008	**1.1446**	-0.8056	0.316
Harvest index (%)	-0.0001	0.0016	-0.0013	0.0146	0.0001	0.0063	0.0044	-0.7596	**1.2140**	0.480*

*, ** Significant at 5% and 1% level, respectively, Residual effect, R = 0.212

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