International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 1750-1754

Received: 07-07-2019
Accepted: 09-08-2019

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Path analysis and correlation response in chickpea

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Abstract
60 chickpea genotypes were evaluated to study the nature and magnitude of relationship of important agronomic traits with seed yield along with their direct and indirect effects. Days to maturity, number of primary branches per plant, number of secondary branches per plant, pods per plant, plant height and height at first pod had highly significant and positive association with seed yield per plant. While, pods per plant, plant height, number of primary branches/plant, days to maturity and seed volume/weight showed the positive direct effect in determining yield in chickpea. Hence due emphasis should be given to number of pods per plant, number of primary branches and harvest index for improvement of seed yield in chickpea.

Keywords: Correlation, direct and indirect effect, chickpea

Introduction
Pulses are an important group of food crops which occupies a unique position in the world of agriculture by virtue of their high protein content. It is grown on more than 10 million ha in 45 countries FAOSTAT (2017)[1]. In India chickpea (*Cicer arietinum* L.) is an important winter pulse crop of India and significantly contributing in pulse economy. It is a self-fertilizing annual grain legume of the family Fabaceae, subfamily Faboideae. This crop occupies an indispensable place in our daily diet by contributing 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]. It also plays important role in low input and rainfed agriculture by fixing atmospheric nitrogen. It has a status of an important winter seed legume crop grown in Indian sub-continent, fits well in cropping systems and tolerates drought. But due to lack of high yielding varieties, it is not competing well with another *rabi* season crops. Therefore, there is an urgent need for developing high yielding varieties of chickpea using a sound and effective breeding tactics. Seed yield being the most important and polygenically controlled complex character, is also governed by many physiological changes within the plant and influenced by many environmental factors when cultivated, hence it is not an efficient character for selection. Association studies give an idea about the contribution of different characters towards seed yield and it reveals the type, nature and magnitude of correlation between yield components with yield and among themselves. Path analysis identifies the yield components which directly and indirectly influence the yield. Hence, the present research work was carried out to study the correlation coefficients and path coefficients in order to formulate selection criteria for evolving high yielding genotypes of chickpea.

Materials and Methods
Description of the study area
The field experiment was conducted at Pulses and Castor Research Station, Navsari Agricultural University, Navsari during *rabi* season of the year 2018. The place is located 12 km away in the east from the great historical place "Dandi" on the Arabian seashore. Geographically, it is situated at 20°-57′N latitude and 72°-54'E longitude with an elevation of 10.0 meter above mean sea level on the western coastal belt of India. For this study, sixty genotypes of chickpea obtained from Pulses and Castor Research Station, NAU, Navsari

(Table 1.) were used. The experiment was laid out in Randomized Block Design (RBD) with three replications. A spacing of 45 cm between rows and 10 cm between plants within the row was maintained. For each genotype five randomly taken plants in each replication were used to record data on number of primary branches per plant, number of secondary branches per plant, pods per plant, plant height (cm), height at first pod (cm), seed yield per plant (g), 100-seed weight (g), seed volume per weight (ml/g), harvest index (%), protein content (%). Days to flowering and days to maturity were recorded on plot basis.

Table 1: List of Chickpea genotypes

1	NGD-1651	11	NGDE-1665	21	NGDE-1677	31	GG-6	41	NG-66	51	NG-230
2	NGD-1652	12	NGDE-1666	22	NGDE-1678	32	Dahod Yellow	42	NG-71	52	NG-305
3	NGD-1654	13	NGDE-1667	23	NGDE-1680	33	NG-139	43	NG-72	53	NG-323
4	NGD-1655	14	NGDE-1668	24	NGDE-1681	34	NG-367	44	NG-73	54	NG-365
5	NGD-1656	15	NGDE-1669	25	NGDE-1682	35	NG-461	45	NG-74	55	NG-366
6	NGD-1657	16	NGDE-1670	26	NGDE-1684	36	NG-9	46	NG-113	56	NG-493
7	NGD-1658	17	NGDE-1673	27	GG-1	37	NG-22	47	NG-165	57	NG-495
8	NGD-1661	18	NGDE-1674	28	GG-2 **(C)**	38	NG-24	48	NG-191	58	NG-496
9	NGD-1663	19	NGDE-1675	29	GG-3	39	NG-52	49	NG-206	59	NG-94
10	NGD-1664	20	NGDE-1676	30	GG-5 **(C)**	40	NG-55	50	NG-223	60	NG-96

Data analysis

Analysis of covariance for all possible pairs of twelve characters was carried out using the procedure of Panse and Sukhatme (1985) [12] for each family. Prior to calculating the correlation coefficients, the analysis of co-variance for all the possible pairs of the characters under investigation was carried out using the procedure described by Panse and Sukhatme (1985) [12]. The cause and effect relationship between two variables cannot be known by a simple correlation coefficient. Therefore, path analysis suggested by Wright (1921) [18] and Dewey and Lu (1959) [5] was adopted in order to partition the genotypic correlation between variables with seed yield into direct and indirect effects of those variables on yield. Genotypic correlation coefficients of sixty variables with yield were used to estimate the path coefficients for the direct effect of various.

Results and Discussion

Correlation coefficient analysis

The analysis of variance indicated significant differences among genotypes for all the characters. The correlation coefficient between seed yield and its components and among the component characters were estimated at genotypic and phenotypic levels. The genotypic (rg) and phenotypic (rp) correlation coefficients of twelve characters studied are presented in Table 2.

Table 2. Genotypic (r_g) and phenotypic (r_p) correlation coefficients among twelve characters in chickpea

Characters		Days to 50 % flowering	Days to maturity	No. of primary branches/ plant	No. of secondary branches/ plant	Pods/ plant	Plant height (cm)	Height at first pod (cm)	100-seed weight (g)	Seed volume/ weight (ml/g)	Harvest index (%)	Protein content (%)
Days to 50 % flowering	r_g	1.000										
	r_p	1.000										
Days to maturity	r_g	-0.89**	1.000									
	r_p	-0.33**	1.000									
No. of primary branches/ plant	r_g	-0.35**	0.36**	1.000								
	r_p	-0.12	0.10	1.000								
No. of secondary branches/ plant	r_g	-0.40**	0.60**	0.47**	1.000							
	r_p	-0.23**	0.19**	0.36**	1.000							
Pods/ plant	r_g	-0.85**	0.90**	0.38**	0.50**	1.000						
	r_p	-0.46**	0.30**	0.15*	0.37**	1.000						
Plant height (cm)	r_g	-0.54**	0.87**	0.27**	0.75**	0.68**	1.000					
	r_p	-0.28**	0.24**	0.27**	0.48**	0.38**	1.000					
Height at first pod (cm)	r_g	-0.29**	0.35**	0.52**	0.57**	0.33**	0.91**	1.000				
	r_p	-0.17*	0.13	0.20**	0.48**	0.21**	0.52**	1.000				
100-seed weight (g)	r_g	-0.08	0.27**	0.25**	-0.34**	0.04	-0.09	0.01	1.000			
	r_p	-0.06	0.10	0.15*	-0.26**	0.06	0.001	0.02	1.000			
Seed volume/ weight (ml/g)	r_g	-0.06	-0.17*	0.16*	0.02	0.04	-0.11	0.03	0.37**	1.000		
	r_p	0.03	-0.07	0.12	0.04	0.09	0.01	0.01	0.32**	1.000		
Harvest index (%)	r_g	0.09	-0.75**	0.30**	-0.36**	0.07	-0.19**	-0.13	0.30**	0.49**	1.000	
	r_p	-0.01	0.01	0.02	-0.16*	-0.02	-0.03	-0.05	0.10	0.09	1.000	
Protein content (%)	r_g	-0.14*	0.10	-0.04	-0.01	0.06	0.06	0.04	0.08	0.14	-0.50	1.000
	r_p	-0.10	0.03	0.03	-0.02	0.08	0.10	0.009	0.06	0.06	-0.16*	1.000
Seed yield/ plant (g)	r_g	-0.91**	0.87**	0.36**	0.50**	0.70**	0.57**	0.30**	0.11	0.02	-0.04	0.10
	r_p	-0.66**	0.42**	0.25**	0.46**	0.70**	0.40**	0.23**	0.10	0.06	-0.02	0.10

Seed yield per plant had recorded a highly significant and positive correlation with days to maturity (0.87), number of primary branches per plant (0.36), number of secondary branches per plant (0.50), pods per plant (0.70), plant height (0.57) and height at first pod (0.30). Seed yield per plant showed a highly significant but negative correlation with days

to flowering (-0.91). The result of the present study was in agreement with the finding of Gohil and Patel (2010) [6], Jivani *et al.* (2013) [9], Jain *et al.* (2014) [7], Kumar *et al.* (2014) [11], Parhe *et al.* (2014) [13, Attri and Jamwal (2015) [3], Petrova and Desheva (2016) [14], Astereki *et al.* (2017) [2], Chopdar *et al.* (2017) [4] and Singh *et al.* (2017) [16].

Pods per plant exhibited highly significant and positive correlation with seed yield per plant (0.70), plant height (0.68) and height at first pod (0.33). Similar observations were reported by Gohil and Patel (2010) [6], Chopdar *et al.* (2017) [40] for harvest index; Parhe *et al.* (2014) [13], Chopdar *et al.* (2017) [4 and Singh *et al.* (2017) [16] for seed yield per plant; Jain *et al.* (2014) [7], Kumar *et al.* (2014) [11] and Chopdar *et al.* (2017) [4] for 100-seed weight.

Days to 50% flowering showed highly significant and negative correlation with seed yield per plant (-0.91), days to maturity (-0.89), number of primary branches per plant (-0.35), number of secondary branches per plant (-0.40), pods per plant (-0.90), plant height (-0.54) and height at first pod (-0.29), while non-significant and negative correlation was recorded with 100-seed weight (-0.08) and seed volume per weight (-0.06).

Days to maturity showed a highly significant and positive correlation with seed yield per plant (0.87), number of primary branches per plant (0.36), number of secondary branches per plant (0.60), pods per plant (0.90), plant height (0.87), height at first pod (0.35) and 100-seed weight (0.27).

Number of primary branches per plant depicted highly significant and positive correlation with seed yield per plant (0.36), number of secondary branches per plant (0.47), pods per plant (0.38), plant height (0.27), height at first pod (0.52), 100-seed weight (0.25) and harvest index (0.30). It also exhibited a significant and positive correlation with seed volume per weight (0.16) and exhibited a non-significant and negative correlation with protein content (-0.04).

Number of secondary branches per plant showed a highly significant and positive correlation with seed yield per plant (0.50), pods per plant (0.50), plant height (0.75) and height at first pod (0.57). It also depicted a highly significant and negative correlation with 100-seed weight (-0.34) and harvest index (-0.36). Rest of the traits had a non-significant association.

Plant height exhibited a highly significant and positive correlation with seed yield per plant (0.57) and height at first pod (0.91). 100-seed weight had a highly significant and positive correlation with seed volume per weight (0.37) and harvest index (0.30). Seed volume per weight exhibited a highly significant and positive correlation with harvest index (0.49). Whereas, protein content (0.14) and seed yield per plant (0.02) had positive and non-significant association. Harvest index had a non-significant and negative correlation with protein content (-0.50) and seed yield per plant (-0.04). Protein content had non-significant and positive correlation with seed yield per plant (0.10).

The result of present study, which revealed comparatively higher degree of genotypic correlation coefficient than their phenotypic counterparts in most of the characters, indicated that there was a high degree of association between two characters at genotypic level, their phenotypic association was lessened due to the influence of environment. A significant and positive genotypic association among days to maturity, number of primary branches per plant, number of secondary branches per plant, pods per plant, plant height and height at first pod and their positive association with seed yield indicated that these are major yield contributing traits in chickpea. Therefore, selection for any of these traits would offer the scope for simultaneous improvement of contributing characters in addition would be helpful in improving the yield potetnial in chickpea.

Path coefficient analysis

In order to achieve a clear picture of inter relationship of various component characters with yield, direct and indirect effects were calculated using path coefficient analysis at genotypic level. The results of path coefficients were partitioned into direct and indirect effects through various yield contributing characters as given in Table 3 and figure 1.

Genotypic path analysis revealed that number of pods per plant had the high positive direct effect (0.67) on seed yield followed by plant height (0.60), number of primary branches/plant (0.50), days to maturity (0.49) seed volume/weight (0.33) and days to 50% flowering (0.32). Remaining traits recorded negative direct effect on seed yield. It revealed that direct selection of such traits will be rewarding to increase grain yield. Pods per plant exhibited positive indirect effects via days to maturity, number of primary branches per plant, plant height and seed volume per weight.

The number of secondary branches per plant showed a negative direct effect on seed yield per plant (-0.59) but indirect effects through days to maturity, number of primary branches per plant, pods per plant, plant height, 100-seed weight, seed volume per weight, harvest index and protein content are positive. The indirect effects of most of the characters under study via number of pods, plant height were observed to be high. Similar results were reported by Gohil and Patel (2010) [6], Jivani *et al.* (2013) [9], Parhe *et al.* (2014) [13], Jan *et al.* (2015) [8], Shafique *et al.* (2016) [15], Astereki *et al.* (2017) [2], Singh *et al.* (2017) [16] and Sozen and Karadavut (2018) [17] for a positive direct effect of pods per plant.

In the present study, the residual effect at genotypic level was 0.31 which suggested that there might be few more component traits responsible to influence the seed yield per plant than those studied. For the improvement of seed yield per plant, emphasis should be made on all yield contributing characters which are influencing it directly or indirectly. In the present study, the overall picture of path analysis revealed that for improving yield in chickpea, selection advantage should be given to pods per plant, plant height, number of primary branches per plant, days to maturity, seed volume per weight and days to 50 % flowering. However, consumer preference must be taken into consideration while the selection of the trait.

Table 3: Direct and indirect effects of eleven causal variables on seed yield per plant in chickpea.

Sr. No.	Days to 50 % flowering	Days to maturity	Number of primary branches/ plant	Number of secondary branches/ plant	Pods/ plant	Plant height (cm)	Height at first pod (cm)	100-seed weight (g)	Seed volume/ weight (ml/g)	Harvest index (%)	Protein content (%)
Days to 50 % flowering	0.32	-0.28	-0.11	-0.12	-0.32	-0.17	-0.09	-0.02	-0.01	0.02	-0.04
Days to maturity	-0.44	0.49	0.18	0.29	0.63	0.43	0.17	0.13	-0.08	-0.03	0.05
Number of primary branches/ plant	-0.17	0.18	0.50	0.23	0.19	0.13	0.26	0.12	0.08	0.15	-0.02
Number of secondary branches/ plant	0.23	-0.36	-0.28	-0.59	-0.30	-0.45	-0.34	0.20	-0.01	0.22	0.005
Pods/plant	-0.67	0.86	0.26	0.34	0.67	0.46	0.22	0.02	0.01	0.04	0.04
Plant height (cm)	-0.32	0.53	0.16	0.45	0.41	0.60	0.55	-0.05	0.03	-0.11	0.04
Height at first pod (cm)	0.14	-0.17	-0.26	-0.28	-0.16	-0.45	-0.50	-0.008	-0.06	0.06	-0.02
100-seed weight (g)	0.03	-0.10	-0.09	0.12	-0.01	0.03	-0.006	-0.37	-0.01	-0.11	-0.03
Seed volume/ weight (ml/g)	-0.019	-0.057	0.05	0.009	0.01	-0.03	0.01	0.12	0.33	0.16	0.04
Harvest index (%)	-0.012	0.10	-0.04	0.04	-0.009	0.02	0.01	-0.04	-0.06	-0.13	0.06
Protein content (%)	0.005	-0.003	0.001	0.0003	-0.002	-0.002	-0.001	-0.002	-0.05	0.017	-0.03
Correlation Coefficient with seed yield/ plant	-0.91**	0.87**	0.36**	0.50**	0.70**	0.57**	0.30**	0.11	0.02	-0.04	-0.10

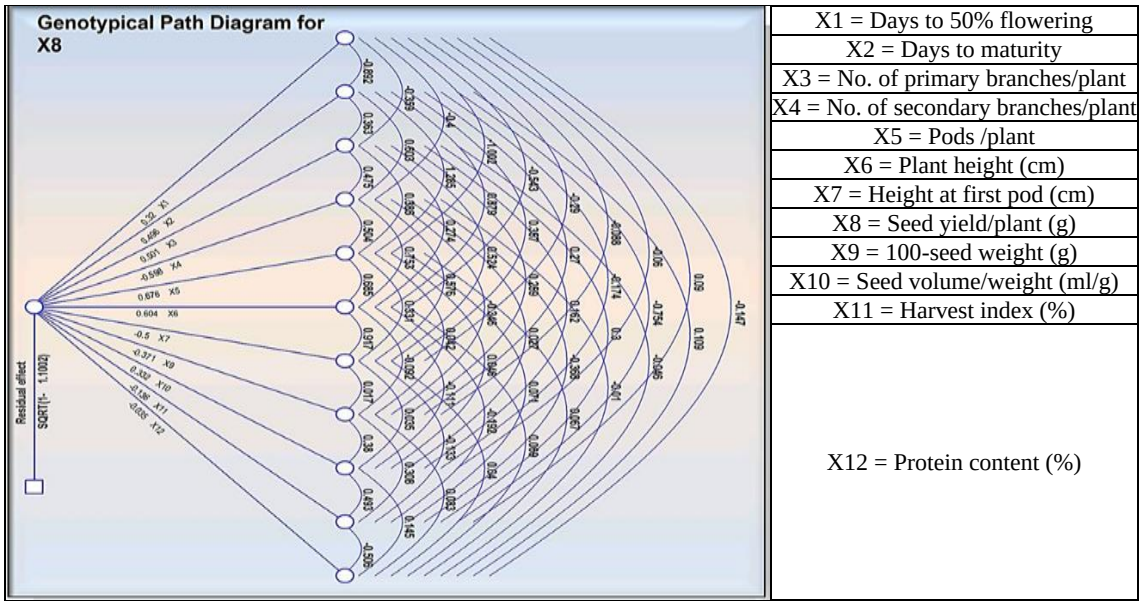

Fig 1: Genotypic path diagram in chickpea

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