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CORRELATION AND PATH COEFFICIENT ANALYSIS FOR YIELD AND ITS CONTRIBUTING CHARACTERS UNDER DIFFERENT SOWING DATES IN CHICKPEA (*CICER ARIENTINUM* L.)

P.P. Desai[1]*, N.S. Kute[1], A.S. Totre[2], V.R. Awari[3], M.R. Pati[1], G.C. Shinde[1], S.B. Narale[1] and S.S. Gawade[1]

[1]Post Graduate Institute, MPKV, Rahuri - 413 722, Maharashtra, India.
[2]Pulses Improvement Project, MPKV, Rahuri - 413 722, Maharashtra, India.
[3]Sorghum Improvement Project, MPKV, Rahuri - 413 722, Maharashtra, India.
*Corresponding author E-mail : pratikshadesai112@gmail.com
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ABSTRACT

The present investigation was layout in a Randomized Block Design with twenty-one genotypes of chickpea with three replications for three different sowing dates. Observations on nine characters were recorded *viz*., days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, seeds per pod, pods per plant, 100 seed weight and yield per plant. The significant positive genotypic correlation was observed among yield per plant with days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod and 100 seed weight under all three environments. This shows that simultaneous improvement of these characters through selection. Path analysis revealed that days to maturity, number of primary branches per plant, number of secondary branches per plant, number of pods per plant and 100 seed weight had positive direct effect on yield per plant for all the three environments. Which will be useful in Chickpea improvements.

Key words : Chickpea, Correlation, Path analysis.

Introduction

Chickpea *Cicer arietinum* L. is one of the important pulse crop worldwide, known for both its nutritional value and its contribution to sustainable agriculture. It is an annual species with the haploid genome size of 738 Mb. It belongs to the Fabaceae family and has a diploid chromosome number of 2n = 16. Its wild ancestor is *Cicer reticulatum*. Chickpea is cultivated in two primary forms first one is *desi*, which has smaller, darker seeds and is mainly grown in India and second is *kabuli*, which features larger, white coloured seeds and it has demand in market.

Yield is a complex trait associated by multiple agronomic characteristics and their interactions with the environment. Genotypic and phenotypic correlation analyses are valuable tools for revealing the degree and nature of associations between traits providing insights into how they collectively impact yield performance. These correlations helps identify traits with both direct and indirect effects on yield, enabling more effective selection strategies for improving yield and related traits. Path coefficient analysis partitioning the observed correlation coefficients into their respective direct and indirect effects, thereby offering a better understanding of the interrelationships among traits.

Materials and Methods

The experiment was conducted at Pulses Improvement Project, MPKV, Rahuri during the *Rabi* 2023-24. Twenty-one chickpea genotypes were assessed using a Randomized Block Design (RBD) with three replications for each sowing date. The gross plot size measured 4.00 × 1.80 m^2, consisting of six rows. The row to row spacing was 30 cm apart and plant to plant spacing of 10 cm. A basal dose of 25:50:30 NPK kg/ha

Table 1 : Analysis of variance for nine characters of chickpea in Environment I, II and III.

S. no.	Characters	Mean Sum of Squares 1st SD: 5 Oct. 2023			Mean Sum of Squares 2nd SD: 31 Oct. 2023			Mean Sum of Squares 3rd SD: 22 Dec. 2023		
		Replications	Genotypes	Error	Replications	Genotypes	Error	Replications	Genotypes	Error
		d.f.=2	d.f. = 20	d.f. = 40	d.f. = 2	d.f. = 20	d.f. = 40	d.f. = 2	d.f. = 20	d.f. = 40
1	**Days to 50% flowering**	0.11	33.5**	1.09	3.19	33.01**	0.91	0.30	57.95**	1.22
2	**Days to maturity**	0.33	105.4**	1.17	0.44	35.68**	0.98	3.06	59.98**	0.88
3	**Plant height (cm)**	3.26	60.37**	4.37	1.17	20.10**	2.90	5.87	21.91**	3.14
4	**Number of Primary branches/plant**	0.08	0.52**	0.07	0.005	0.20	0.14	0.10	0.50**	0.16
5	**Number of secondary branches/plant**	0.8	22.20**	0.55	0.16	11.32**	1.73	1.62	18.44**	0.31
6	**Number of pods/plant**	5.98	314.97**	3.79	142.66	300.97**	24.09	34.59	196.25**	9.57
7	**Number of seeds/pod**	0.004	0.01	0.01	0.03	0.02	0.02	0.09	0.05**	0.02
8	**100 seed weight (g)**	0.97	18.81**	1.64	6.16	22.16**	3.46	2.48	22.62**	2.51
9	**Yield/plant (g)**	0.66	9.31**	0.36	0.61	6.12**	0.68	0.004	5.47**	0.14

SD: Sowing Date * and ** indicate significant at 5 % and 1% level, respectively.

was applied at the time of sowing. Field operations *viz.*, gap filling, thinning and inter culturing were carried out as and when required so that the field was kept free from weeds. Recommended plant protection measures were adopted for control of pests and diseases.

Observations recorded on Days to 50% Flowering, Days to maturity, Plant height (cm), Number of primary branches per plant (No.), Number of secondary branches per plant (No.), Number of Pods per plant (No), Number of Seeds per pod (No.) 100 seed weight (g) and Yield per plant (g).

Analysis of covariance was calculated as suggested by Singh and Chaudhary (1977) and Johnson *et al*. (1955). The significance of correlation coefficients was evaluated form the statistical table of correlation coefficient at 1 and 5 per cent level of significance (Snedecor and Cochran, 1967).

Dewey and Lu (1959) introduced this technique to quantify how independent variables (predictor traits) influence a dependent variable (such as yield) directly and indirectly through other correlated traits. As proposed by Dewey and Lu (1959) and developed by Wright (1921), the first step in establishing a cause-and-effect link was to divide the genotypic and phenotypic correlation coefficient into direct and indirect effects using path analysis.

Results and Discussion

The analysis of variance among the genotypes for all nine characters in all three environments was observed. This suggests that a significant amount of variation persists for all the characters in all three environments among the genotypes under study. Above results were acquainted with the Ali *et al.* (2009), Bhanu *et al.* (2017), Kumar *et al.* (2019), Thombre *et al*. (2019), Kiran *et al.* (2023), Bharath *et al.* (2024), Kamble *et al.* (2024) and Pravalika *et al.* (2024).

Correlation coefficient analysis

The correlation between seed yield and its component were studied at genotypic level. The association study interprets relation of component traits with yield which provide basis of selection. The genotypic correlation coefficient analysis for nine characters for three different sowing dates were presented in Tables 2, 3 and 4.

In Environment I, the characters *viz.* days to 50% flowering (rg = 0.632), days to maturity (rg = 0.706), plant height (rg = 0.617), number of primary branches

Table 2 : Estimates of genotypic correlation coefficients among seed yield and yield contributing characters in twenty one chickpea genotypes in Environment I (Sowing date - 05 Oct. 2023).

S. no.	Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches/plant	Number of secondary branches/plant	Number of pods/plant	Numbers of seeds/pod	100 seed weight (g)	Yield/plant (g)
1	**Days to 50% flowering**	**1.000**	0.535**	0.559**	0.865**	0.468**	0.541**	0.162	-0.080	0.632**
2	**Days to maturity**		**1.000**	0.829**	0.788**	0.418**	0.328**	0.632**	0.455**	0.706**
3	**Plant height (cm)**			**1.000**	0.719**	0.380*	0.276*	0.677**	0.405**	0.617**
4	**Number of primary branches/plant**				**1.000**	0.781**	0.821**	0.267**	-0.031	0.897**
5	**Number of secondary branches/plant**					**1.000**	0.851**	0.274*	0.058	0.874**
6	**Number of pods/plant**						**1.000**	-0.101	-0.051	0.808**
7	**Number of seeds/pod**							**1.000**	0.584**	0.386**
8	**100 seed weight (g)**								**1.000**	0.297*
9	**Yield/plant (g)**									**1.000**

Table 3 : Estimates of genotypic correlation coefficients among seed yield and yield contributing characters in twenty one chickpea genotypes in in Environment II (Sowing date: 31Oct. 2023).

S. no.	Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches/plant	Number of secondary branches/plant	Number of pods/plant	Numbers of seeds/pod	100 seed weight (g)	Yield/plant (g)
1	**Days to 50% flowering**	**1.000**	0.465**	0.669**	0.769**	0.089	0.108	-0.141	0.168	0.229
2	**Days to maturity**		**1.000**	0.170	0.237	0.238	0.280**	0.918**	0.130	0.247*
3	**Plant height (cm)**			**1.000**	0.831**	0.338**	0.487**	-0.208	0.250*	0.438**
4	**Number of primary branches/plant**				**1.000**	0.562**	0.976**	0.095	0.628**	0.765**
5	**Number of secondary branches/plant**					**1.000**	0.724**	0.964**	0.847**	0.803**
6	**Number of pods/plant**						**1.000**	0.897**	0.592**	0.898**
7	**Number of seeds/pod**							**1.000**	0.954**	0.801**
8	**100 seed weight (g)**								**1.000**	0.814**
9	**Yield/plant (g)**									**1.000**

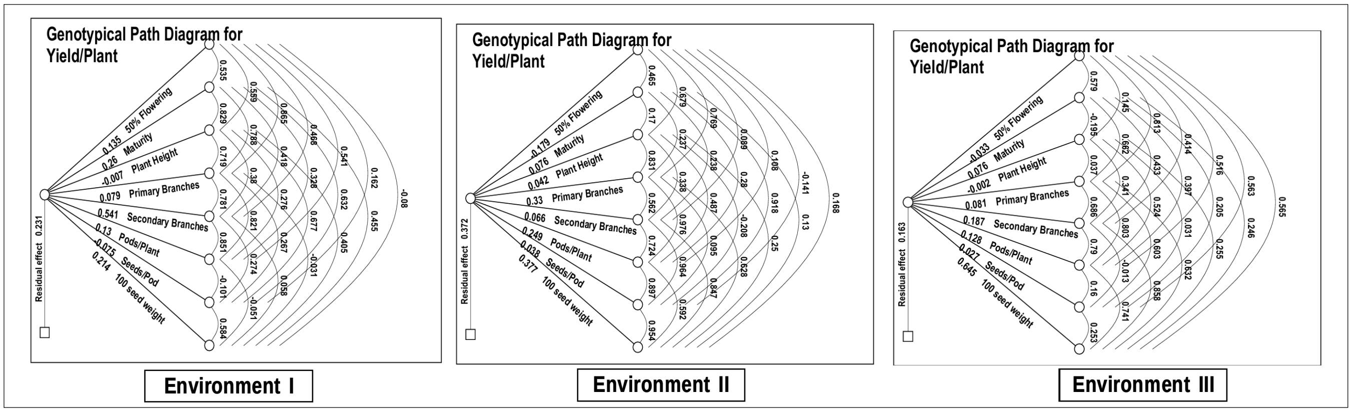

Fig. 1 : Genotypic path diagram for yield/ plant in different environments.

per plant (rg = 0.897), number of secondary branches per plant (rg = 0.874), number of pods per plant (rg = 0.808), number of seeds per pod (rg = 0.386) and 100 seed weight (rg = 0.297) showed significant positive association with yield per plant at genotypic level.

The Environment II, the characters *viz.* days to maturity (rg = 0.247), plant height (rg = 0.438), number of primary branches per plant (rg =0.765), number of secondary branches per plant (rg = 0.803), number of pods per plant (rg = 0.898) number of seeds per pod (rg = 0.801) and 100 seed weight (rg = 0.814) showed significant positive association with yield per plant at genotypic level. While days to 50% flowering (rg = 0.229) relieved non-significant positive correlation with yield per plant at genotypic level.

Environment III, indicated that the characters *viz.* days to 50% flowering, (rg = 0.599), days to maturity (rg = 0.407), plant height (rg = 0.277), number of primary branches per plant (rg = 0.759), number of secondary branches per plant (rg = 0.914), number of pods per plant (rg = 0.834), number of seeds per pod (rg = 0.254) and 100 seed weight (rg = 0.957) has a significant positive correlation with yield per plant at genotypic level.

From the above, it was indicated that the significant positive correlation was found for days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of pods per plant, number of seeds per pod and 100 seed weight under all three environments hence selection based on these traits will be effective in order to increase yield. Similar results were also obtained by Raval and Dobariya (2003), Singh (2007), Padmavathi *et al.* (2013), Kuldeep *et al.* (2014).

Path coefficient analysis

The estimates of path coefficient analysis have been given in Tables 5, 6 and 7.

Days to 50% flowering

For Environment I, days to 50% flowering showed high positive direct effect on yield per plant (0.135). Its genotypic correlation with yield per plant was also positive and highly significant (0.632). For Environment II, days to 50% flowering showed negative direct effect on yield per plant (-0.179) (Table 5, 6). For Environment III, negative direct effect was shown by days to 50% flowering (-0.033) on yield per plant. Its genotypic correlation with yield per plant was positive and significant (0.599) due to high positive indirect effect observed through all the characters (Table 7). Similar results recorded by Raval and Dobariya 2003 and Bharat *et al.* (2024).

Days to maturity

The Environment I, II and III, days to maturity has a positive direct effect on seed yield (0.260), (0.076) and (0.076). The genotypic correlation with yield per plant was also was also positive and significant (0.706) (0.247) (0.407) for the environment I, II and III, respectively (Tables 5, 6, 7). Similar findings reported by Raval and Dobariya (2003), Bharat *et al.* (2024) and Kiran *et al.* (2023).

Plant height

In Environment I and III, for plant height has a negligible negative direct effect on yield per plant (-0.007) and (-0.002). Its genotypic correlation with yield per plant was positive and significant (0.617) due to highly positive indirect effect observed through characters such as days to maturity (0.215), number of secondary branches per plant (0.205), 100 seed weight (0.087), days to 50% flowering (0.075) number of primary branches per plant (0.057) and number of pods per plant (0.036). In Environment II, plant height has a positive direct effect on yield per plant (0.042). Its genotypic correlation with yield per plant was also positive and significant (0.437). Similar results observed by Kiran *et al.* (2023) and

Table 4 : Estimates of genotypic correlation coefficients among seed yield and yield contributing characters in twenty one chickpea genotypes in Environment III (Sowing date - 22 Dec. 2023).

S. no.	Characters	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of primary branches/plant	Number of secondary branches/plant	Number of pods/plant	Numbers of seeds/pod	100 seed weight (g)	Yield/plant (g)
1	**Days to 50% flowering**	**1.000**	0.579**	0.145	0.813**	0.414**	0.516**	0.563**	0.565**	0.599**
2	**Days to maturity**		**1.000**	-0.195	0.662**	0.433**	0.397**	0.205	0.246*	0.407**
3	**Plant height (cm)**			**1.000**	0.037	0.341**	0.524**	0.031	0.255**	0.277*
4	**Number of primary branches/plant**				**1.000**	0.686**	0.803**	0.603**	0.632*	0.759**
5	**Number of secondary branches/plant**					**1.000**	0.790**	-0.013	0.858**	0.914**
6	**Number of pods/plant**						**1.000**	0.16	0.741**	0.834**
7	**Number of seeds/pod**							**1.000**	0.253*	0.254*
8	**100 seed weight (g)**								**1.000**	0.957**
9	**Yield/plant (g)**									**1.000**

Muhammad *et al.* (2004).

Number of primary branches per plant

Environment I and II, number of primary branches per plant has a positive direct effect on yield per plant (0.079) and (0.330). Its genotypic correlation with yield per plant was also highly positive and highly significant (0.897). In Environment III, number of primary branches per plant has positive direct effect on yield per plant (0.081). Its genotypic correlation with yield per plant was also highly positive and significant (0.759) due to high positive indirect effect observed through characters such as 100 seed weight (0.408), number of secondary branches per plant (0.128), number of pods per plant (0.103), days to maturity (0.050) and number of seeds per pod (0.016). These findings supported by Kiran *et al.* (2023), Bharat *et al.* (2024).

Number of secondary branches per plant

In Environment I and II, number of secondary branches per plant has a highest positive direct effect on yield per plant (0.541) and (0.066), respectively. Its genotypic correlation with yield per plant was positive and significant (0.874) and (0.803) in environment I and II due to high positive indirect effect observed in these characters. For Environment III, number of secondary branches per plant showed positive direct effect on yield per plant (0.187). These findings supported by Nikita and Lal (2022) and Singh (2007).

Number of pods per plant

For Environment I, number of pods per plant has a positive direct effect on yield per plant (0.130). Its genotypic correlation with yield per plant was also highly positive and highly significant (0.808). In Environment II, number pods per plant showed positive direct effect on yield per plant (0.249). Its genotypic correlation with yield per plant was also positive and significant (0.898) and Environment III, number of pods per plant has a high positive direct effect on yield per plant (0.128). Its genotypic correlation with yield per plant was also positive and highly significant (0.834). These findings supported by Nikita and Lal (2022) and Singh (2007).

Number of seeds per pod

Environment I, number of seeds per pod showed negative direct effect on yield per plant (-0.075). While, it's genotypic correlation with yield per plant was also positive and highly significant (0.386). It is due to high positive indirect effect observed through characters such as days to maturity (0.164), number of secondary branches per plant (0.148) and 100 seed weight (0.125), days to 50% flowering (0.022) and number of primary

Table 5 : Estimates of genotypic direct (diagonal) and indirect effects (above and below diagonal) of component characters on seed yield in twenty one chickpea genotypes in Environment I (Sowing date: 05 Oct. 2023).

S. no.	Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches/plant	Number of secondary branches/plant	Number of pods/plant	Numbers of seeds/pod	100 seed weight (g)	Genotypic correlation with yield/plant (g)
1	**Days to 50% flowering**	**0.135**	0.139	-0.004	0.068	0.253	0.070	-0.012	-0.017	0.632**
2	**Days to maturity**	0.072	**0.260**	-0.006	0.062	0.226	0.043	-0.048	0.097	0.706**
3	**Plant height (cm)**	0.075	0.215	**-0.007**	0.057	0.205	0.036	-0.051	0.087	0.617**
4	**Number of primary branches/plant**	0.117	0.205	-0.005	**0.079**	0.422	0.107	-0.020	-0.007	0.897**
5	**Number of secondary branches/plant**	0.063	0.109	-0.003	0.061	**0.541**	0.111	-0.021	0.012	0.874**
6	**Number of pods/plant**	0.073	0.085	-0.002	0.065	0.460	**0.130**	0.008	-0.011	0.808**
7	**Number of seeds/pod**	0.022	0.164	-0.005	0.021	0.148	-0.013	**-0.075**	0.125	0.386**
8	**100 seed weight (g)**	-0.011	0.118	-0.003	-0.002	0.031	-0.007	-0.044	**0.214**	0.297*

Residual Effect = 0.23 **Bold figures indicate direct effect** *** , **** Significant at 5% and 1% levels, respectively.

Table 6 : Estimates of genotypic direct (diagonal) and indirect effects (above and below diagonal) of component characters on seed yield in twenty one chickpea genotypes in Environment II (Sowing date: 31 Oct. 2023).

S. no.	Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches/plant	Number of secondary branches/plant	Number of pods/plant	Numbers of seeds/pod	100 seed weight (g)	Genotypic correlation with yield/plant (g)
1	**Days to 50% flowering**	**-0.179**	0.035	0.028	0.254	0.006	0.027	-0.005	0.063	0.229
2	**Days to maturity**	-0.083	**0.076**	0.007	0.078	0.016	0.070	0.035	0.049	0.247*
3	**Plant height (cm)**	-0.122	0.013	**0.042**	0.275	0.022	0.121	-0.008	0.094	0.437**
4	**Number of primary branches/plant**	-0.138	0.018	0.035	**0.330**	0.037	0.243	0.004	0.237	0.765**
5	**Number of secondary branches/plant**	-0.016	0.018	0.014	0.185	**0.066**	0.180	0.036	0.319	0.803**
6	**Number of pods/plant**	-0.019	0.021	0.020	0.322	0.048	**0.249**	0.034	0.223	0.898**
7	**Number of seeds/pod**	0.025	0.070	-0.009	0.031	0.063	0.223	**0.038**	0.359	0.801**
8	**100 seed weight (g)**	-0.030	0.010	0.010	0.208	0.056	0.147	0.036	**0.377**	0.814**

Residual Effect = 0.37 **Bold figures indicate direct effect* , **** Significant at 5% and 1% levels, respectively.

Table 7 : Estimates of genotypic direct (diagonal) and indirect effects (above and below diagonal) of component characters on seed yield in twenty one chickpea genotypes in Environment III (Sowing date :22 Dec. 2023).

S. no.	Characters	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of primary branches/plant	Number of secondary branches/plant	Number of pods/plant	Numbers of seeds/pod	100 seed weight (g)	Genotypic correlation with yield/plant (g)
1	Days to 50% flowering	**-0.033**	0.044	0.000	0.066	0.077	0.066	0.015	0.364	0.599**
2	Days to maturity	-0.019	**0.076**	0.000	0.053	0.081	0.051	0.006	0.159	0.407**
3	Plant height (cm)	-0.005	-0.015	**-0.002**	0.003	0.064	0.067	0.001	0.164	0.277*
4	Number of primary branches/plant	-0.027	0.050	0.000	**0.081**	0.128	0.103	0.016	0.408	0.759**
5	Number of secondary branches/plant	-0.014	0.033	-0.001	0.055	**0.187**	0.101	0.000	0.553	0.914**
6	Number of pods/plant	-0.017	0.030	-0.001	0.065	0.148	**0.128**	0.004	0.478	0.834**
7	Number of seeds/pod	-0.018	0.016	0.000	0.049	-0.002	0.020	**0.027**	0.163	0.254*
8	100 seed weight (g)	-0.018	0.019	-0.001	0.051	0.160	0.095	0.007	**0.645**	0.957**

Residual Effect = 0.16 **Bold figures indicate direct effect** *, ** Significant at 5% and 1% levels, respectively.

branches per plant (0.021). Environment II and III, number of seeds per pod has a positive direct effect on yield per plant (0.038) and (0.027) respectively. Its genotypic correlation with yield per plant was also highly positive and highly significant (0.801) and (0.254) respectively for Environment II and III. Guler *et al*. (2001) recorded a similar result.

100 seed weight

Environment I, 100 seed weight has a positive direct effect on yield per plant (0.214). Its genotypic correlation with yield per plant was also positive and significant (0.297). For Environment II, 100 seed weight showed positive direct effect on yield per plant (0.377). Its genotypic correlation with yield per plant was also highly positive and highly significant (0.814). For Environment III, 100 seed weight showed highly positive direct effect on yield per plant (0.645). Correlation with yield per plant was also positive and significant (0.957). Similar findings recorded by Guler *et al*. (2001), Jeena and Arora (2002) and Muhammad *et al*. (2004).

Significant correlation and high direct positive effect showed by characters days to maturity, number of primary branches per plant, number of secondary branches per plant, number of pods per plant and 100 seed weight on yield per plant under all three environmental conditions. It showed a true association between them and direct selection based on these characters will be effective for improvement in yield. Similar results were obtained by Ali *et al*. (2009), Kuldeep *et al*. (2014), Bhanu *et al*. (2017), Banik *et al*. (2018) and Nikita and Lal (2022).

Conclusion

Yield per plant has significant positive genotypic genotypic correlation with days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of seeds per pod, number of pods per plant and 100 seed weight over all the three environments. Hence, selection for yield improvement more focus on these characters should be given. Path coefficient analysis revealed that days to maturity, number of primary branches per plant, number of secondary branches per plant and 100 seed weight had positive direct effect on seed yield per plant in all three environments. Positive correlation and direct effect reported a true relationship between these traits.

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