Plant Archives Vol. 25, Supplement 1, 2025 pp.1182-1188 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.160

CORRELATION AND PATH COEFFICIENT ANALYSIS IN READY TO ROAST GENOTYPES OF DESI CHICKPEA (*CICER ARIETINUM* L.)

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(Date of Receiving : 17-08-2024; Date of Acceptance : 23-10-2024)

ABSTRACT

The study evaluated correlation and path coefficient analysis of yield and yield contributing traits across 16 chickpea genotypes (12 ready to roast genotypes and four commercial checks *viz*., JG 11, A-1, SA-1 and GULAK) during *Rabi* 2023-24 at three locations (Bidar, Kalaburagi and Raichur) in Karnataka. Experiment was conducted in a Randomized Block Design, the experiment followed recommended agronomic practices for the region. Key yield-related traits identified include the number of pods per plant, number of branches per plant and test weight. The study also found positive correlations among swelling capacity, hydration capacity, cooking time and test weight. Roasting traits like expansion index and puffing index had negative correlation with yield Traits such as plant height, primary branches and pods per plant demonstrated strong positive effects on yield, underscoring their importance for breeding programs aimed at improving chickpea productivity.

Keywords: Roasting, genotype, correlations and path analysis.

Introduction

Chickpea (*Cicer arietinum* L.) is a self-pollinating, annual diploid species with a genome size of 738 Mb. Known by various names such as gram and garbanzo, it belongs to the fabaceae family and has two main types: Kabuli and Desi. India leads the world in chickpea area (9.59 million hectares) and production (11.04 million tonnes), with Karnataka contributing significantly 0.638 million hectares and 0.386 million tonnes (Anon 2023-24). Chickpeas are a staple food across all regions of India, enjoyed in both rural and urban areas.

Correlation and path co-efficient analyses help elucidate the relationships among yield components, identifying positive correlations that enhance breeding strategies. Path analysis further clarifies each component's direct and indirect contributions to yield, providing insights for effective crop improvement.

Chickpea seeds are processed through methods like soaking, sprouting, and roasting to enhance digestibility and remove anti-nutritional factors (Yadav and Bhatnagar, 2017). Roasted chickpeas, often coated with jaggery or spices, are a popular snack in India. Roasting improves texture, color, and flavor by converting carbohydrates into dextrins, which react with amino acids. It also makes the seeds more digestible, destroys harmful microorganisms, and prevents spoilage. Puffed chickpeas, high in protein and low in fat, are a growing healthy snack option. In the market, bold seeds with thin coats are preferred due to their better expansion during roasting (Kaur and Prasad 2021).

Material and Methods

In the present study 16 chickpea genotypes (12 genotypes and four commercial checks) were sown during *Rabi* 2023-24 across three locations *viz.,* Zonal Agricultural Research Station (ZARS), Kalaburagi, MARS, PG research block, UAS Raichur and Agriculture Research Station, Janwada, Bidar. Experiment was laid out in a Randomized Block Design (RBD) with three replications. Each genotype was sown in four rows of four meters in length with a spacing of 30 cm between rows and 10 cm between plants. Data were recorded on phenological traits *viz* days to 50 per cent flowering, days to maturity, yield attributing traits namely plant height, number of branches per plant, number of pods per plant, test weight; and quality traits *viz*., hydration capacity, swelling capacity, cooking time, moisture content, crude protein content, carbohydrate content, crude fat content, zinc content and iron content; qualitative traits like seed ribbing, seed shape and seed testa texture; roasting traits like expansion index and puffing index. Observations were recorded on five randomly selected plants per entry per replication for all the characters under study except for test weight, seed testa texture, seed ribbing, seed shape, moisture content, expansion index, puffing index, crude protein content, iron content, zinc content, carbohydrate content, crude fat content, zinc content, hydration capacity, swelling capacity and cooking time which were recorded on a whole plot basis. The average values of the random sample of the respective character used for analysis**.** Correlation Coefficient was subjected by the data obtained for various traits by the method Miller *et al*., (1958) and path Coefficient analysis by the method suggested by Dewy and Lu (1959).

Table 1 : List of 16 chickpea genotypes used for study.

Sl. No.	Genotype	Pedigree
1	ICCV-191256	ICC-4958/ICCV-00108//ICCV-93954/ICCV-94954///ICCV10/ICCV-97105//ICCV-93952/ICCV-96970
2	ICCV-191156	ICC-4958/ICCV-93954//ICCV-96970/ICCV-97105///ICCV-10/ICCV-93952//ICCV-94954/ICCV-00108
3	RG-2016-134	ICCV 03112 x ICCV10
4	ICCV-191151	ICC-4958/ICCV-10//ICCV-93952/ICCV-93954
5	ICCV-191251	ICC-4958/ICCV-10//ICCV 93952/ICCV 93954
6	ICCV-191255	ICC-4958/ICCV-10//ICCV-93952/ICCV-93954
7	ICCV-191161	ICC-4958/ICCV-10//ICCV-93952/ICCV-93954///ICCV-94954/ICCV-96970//ICCV-97105/ICCV-00108
8	ICCV-191253	ICC-4958/ICCV-97105//ICCV-10/ICCV-00108
9	ICCV-88202	PRR-1///H-208/T-3//26-2-B-BP-BP-BP-4P-1P-1P-1P-BP
10	ICCV-191159	ICC-4958/ICCV-97105//ICCV-10/ICCV-00108///ICCV-93952/ICCV-94954//ICCV-93954/ICCV-96970
11	ICCV-191126	JG 11///JG 11//Harigantars/JG 11
12	ICCV-191155	ICC-4958/ICCV-00108//ICCV-93954/ICCV-94954///ICCV-10/ICCV-97105//ICCV-93952/ICCV-96970
13	JG-11 (NC for yield)	ICCV-93954
14	SA-1 (RC for yield)	Annigeri-1 × WR-315
15	A-1 (LC for ready to roast/Parching)	Selection from land race
16	Gulak (Check Parching/ready to roast)	(N-59 × D-8) 1-88-88A

Results and Discussion

Studies on correlation co-efficient analysis

The correlation coefficient measures the degree of symmetrical association between two characters, aiding in the understanding of the nature and magnitude of the relationship between yield and its component traits. Improving seed yield is a crucial goal in plant breeding, which can be effectively attained through the direct selection of easily observable traits. However, achieving this goal necessitates a thorough understanding of how different traits relate to seed yield and to each other.

Yield per plant showed a significant positive correlation with number of primary branches (0.158), test weight (0.412) and number of pods per plant (0.614) is presented in Table 2. Similar findings for the seed yield per plant were reported by Srivastava *et al.* (2023), Srikanth *et al.* (2024) and Maring *et al.* (2024) for test weight; Katkani *et al.* (2022), Kumawat *et al.* (2021) and Kumar *et al.* (2020) for number of primary branches per plant; Nunavath *et al.* (2023), Jha *et al.* (2023) and Ningwal *et al.* (2023) for number of pods per plant. The trait showed a non-significant positive correlation with plant height (0.468), hydration capacity (0.333), swelling capacity (0.375), cooking time (0.229), crude fat content (0.004) and zinc content (0.0001). Jain *et al.* (2019), and Kumar *et al.* (2020) for plant height; Srivastava *et al.* (2023) and Sozen *et al.* (2018) for hydration capacity and swelling capacity.

The trait showed a non-significant negative correlation with days to 50 per cent flowering (-0.144), days to maturity (-0.201), expansion index (-0.106), puffing index (-0.118), moisture content (-0.079), protein content (-0.032), carbohydrate content (-0.127) and iron content (-0.100). Similar findings for the seed yield per plant were reported by Maring *et al.* (2024) and Jain *et al.* (2019) for days to 50 per cent flowering; Maring *et al.* (2024), Jain *et al.* (2019), Srikanth *et al.* (2024) and Astereki *et al. (*2017) for days to maturity; Mishra *et al.* (2020) for iron content. Yield per plant showed a significantly positively correlated with number of primary branches, test weight and number of pods per plant indicates that these traits directly impact the number and quality of seeds produced. More branches and pods lead to higher seed count and greater test weight indicates larger and denser seeds. Weak positive correlations with traits like plant height, hydration capacity, swelling capacity, cooking time, crude fat content and zinc content suggest these factors have minimal impact on yield, possibly due to their less direct role in seed production or growth Negative correlations with days to flowering, maturity, expansion index, puffing index, moisture content, protein content, carbohydrate content and iron content suggest that these traits may slightly influence yield, their effects are not strong enough to be statistically significant. Earlier flowering or maturity could allow more time for seed development but the impact is less. Similarly, traits like expansion and puffing indices, moisture content and nutritional content might affect seed characteristics or plant health but do not significantly alter overall yield.

Path analysis for yield and yield contributing traits

It demonstrates the relationship between these independent characters and seed yield results from their direct influence on yield or from their indirect impact through other component characters. The phenotypic correlation was partitioned into direct and indirect effects on grain yield is presented in Table 3.

Days to 50 per cent flowering has a negative direct effect (-0.038) on yield per plant, implying that delayed flowering might reduce yield. This could be because more days to flowering might shorten the grain filling period, negatively impacting overall yield. Similar findings reported by Sanjay *et al*. (2024) and Vikram *et al*. (2022). Days to maturity also showed a negative direct effect on yield per plant (-0.059), suggesting that longer maturity time could reduce yield. Prolonged maturity might result in increased exposure to environmental stress, which could lower yield per plant. Similar findings reported by Karthikeyan *et al*. (2022) and Kumar *et al*. (2024).

Plant height has a substantial positive direct effect (0.026) on yield per plant, indicating that taller plants tend to have higher yields. This is likely due to the increased photosynthetic area, which can enhance biomass and grain production. Similar findings reported by Yajavathi *et al*. (2022), Pravalika *et al.* (2024) and Kumar *et al*. (2024).

Primary branches have a positive direct effect (0.170) on yield per plant, suggesting more branches contribute to higher yields. More branches support additional flowers and pods, increasing the overall yield. Similar findings reported by Srikanth *et al.* (2024) and Jain *et al*. (2022).

Pods per plant showed a strong positive direct effect (0.664) on yield per plant, highlighting that more pods directly correlate with increased yield. This result is logical, as pods contain the seeds, directly determining yield quantity. Similar findings reported by Deshmukh *et al.* (2024) and Vikram *et al*. (2022).

Test weight has a moderate positive direct effect (0.563) on yield per plant. Higher test weight indicates better seed quality and size, contributing positively to the overall yield. Similar findings reported by Tamatam and Pandey (2024), Karthikeyan *et al*. (2022) and Kumar *et al*. (2024).

Hydration capacity has a mild negative direct effect (-0.066) on yield per plant, implies that higher hydration capacity might lead to excessive water uptake, potentially causing physiological stress and reducing yield. Swelling capacity has a moderate positive direct effect (0.240) on yield per plant. Enhanced swelling capacity could indicate better seed quality, potentially leading to better growth performance and yield. Cooking time showed a smaller positive direct effect (0.080) on yield per plant. Shorter cooking time may correlate with softer seeds, possibly reflecting better quality traits, indirectly influencing yield positively. Similar findings reported by Prasanthi *et al*. (2023) for hydration capacity, swelling capacity and cooking time.

Table 2 : Estimation of phenotypic correlation coefficients for phenological traits, seed yield, roasting and quality traits in chickpea

	DFF	DM	PH	PB	PP	TW	HC	SC	CT	EI	PI	M	P	F	C	Fe	Zn	YP
DFF	1.00																	
DM	0.391**	1.00																
PH	-0.085	-0.063	1.00															
PB	0.069	-0.017	0.028	1.00														
PP	-0.082	-0.170*	0.175	0.164*	1.00													
TW	-0.142	-0.090	0.539**	-0.149	-0.225**	1.00												
HC	0.109	0.030	0.419**	-0.226**	0.014	0.489**	1.00											
SC	0.112	0.060	0.480**	-0.240**	0.073	0.460**	0.905**	1.00										
CT	-0.348**	-0.272**	0.082	-0.093	-0.093	0.466**	0.260**	0.128	1.00									
EI	-0.106	0.152	-0.307**	-0.106	0.030	-0.207*	-0.522**	-0.536**	-0.070	1.00								
PI	-0.048	0.130	-0.336**	-0.098	0.027	-0.244**	-0.509**	-0.523**	-0.088	0.973**	1.00							
M	0.307**	0167*	-0.0310	0.057	-0.017	-0.250**	0.086	0.135	-0.302**	-0.338**	-0.312**	1.00						
P	-0459**	-0.223**	-0.255**	0.129	0.035	-0.061	-0.449**	-0.423**	0.224**	0.262**	0.238**	-0.431**	1.00					
F	0.495**	0.206*	0.067	0.106	0.097	-0.248**	0.310**	0.292**	-0.351**	-0.361**	-0.327**	0.518**	-0.738**	1.00				
C	0.177*	0.013	-0.015	0.188*	-0.137	0.030	-0.249**	-0.272**	0.036	0.062	0.032	-0.160	0.061	-0.110	1.00			
Fe	0.0001	0.066	-0.199*	0.123	-0.004	-0.149	-0.499**	-0.446**	-0.065	0.142	0.091	-0.038	0.298**	-0.110	0.285**	1.00		
Zn	0.260**	0.232**	0060	0.223**	-0.016	0.012	-0.148	-0.172*	-0.244	0.109	0.083	0.152	-0.096	0.108	-0.083	-0.038	1.00	
YP	-0.144	-0.201	0.468	0.158**	0.614**	0.412**	0.333	0.375	0.229	-0.106	-0.118	-0.079	-0.032	0.004	-0.127	-0.1000	0.0001	1.00

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

DFF: Days to 50 per cent flowering, **DM**: Days to maturity, **PH**: Plant height(cm), **PB**: Primary branches, **PP**: Pods per plant, **TW**: Test weight (g), **HC**: Hydration capacity (g/seed), **SC**: Swelling capacity (ml/seed), **CT**: Cooking time (mints), **EI**: Expansion index (%), **PI**: Puffing index (%), **M1**: Moisture content (%), **P**: Protein content (%), **F**: Fat content (%), **C**: Carbohydrate content (%), **Fe**: Iron content (ppm), **Zn**: Zinc content (ppm), **YP**: yield per plant (g)

Table 3 : Estimates of direct and indirect effects of phenological traits, yield attributes, roasting and quality traits on seed yield in chickpea

	DFF	DM	PH	PB	PP	TW	HC	SC	CT	EI	PI	M	P	F	C	Fe	Zn	rp (YP)
DFF	**-0.038**	-0.015	0.003	-0.003	0.003	0.005	-0.004	-0.004	0.013	0.004	0.002	-0.012	0.018	-0.019	-0.007	0.000	-0.010	**-0.144**
DM	0.023	**-0.059**	0.004	0.001	0.010	0.005	-0.002	-0.004	0.016	-0.009	-0.008	-0.010	0.013	-0.012	-0.001	0.004	-0.014	**-0.201**
PH	-0.002	-0.002	**0.026**	0.001	0.005	0.014	0.011	0.013	0.002	-0.008	-0.009	-0.001	-0.007	0.002	0.000	-0.005	0.002	**0.468**
PB	0.012	-0.003	0.005	**0.170**	0.028	-0.025	-0.039	-0.041	-0.016	-0.018	-0.017	0.010	0.022	0.018	0.032	0.021	0.038	**0.158**
PP	0.054	-0.113	0.116	0.109	**0.664**	-0.149	0.009	0.048	-0.062	0.020	0.018	-0.012	0.023	0.065	-0.091	-0.003	-0.010	**0.614**
TW	-0.080	-0.051	0.304	-0.084	-0.127	**0.563**	0.276	0.259	0.262	-0.117	-0.138	-0.141	-0.035	-0.140	0.017	-0.084	0.007	**0.412**
HC	-0.007	-0.002	-0.028	0.015	-0.001	-0.032	**-0.066**	-0.060	-0.017	0.035	0.034	-0.006	0.030	-0.021	0.017	0.033	0.010	**0.333**
SC	0.027	0.015	0.115	-0.058	0.017	0.111	0.218	**0.240**	0.031	-0.129	-0.126	0.032	-0.102	0.070	-0.065	-0.107	-0.041	**0.375**
CT	-0.028	-0.022	0.007	-0.008	-0.007	0.037	0.021	0.010	**0.080**	-0.006	-0.007	-0.024	0.018	-0.028	0.003	-0.005	-0.020	**0.229**
EI	-0.001	0.001	-0.002	-0.001	0.000	-0.002	-0.004	-0.004	-0.001	**0.008**	0.008	-0.003	0.002	-0.003	0.001	0.001	0.001	**-0.106**
PI	-0.009	0.023	-0.061	-0.018	0.005	-0.044	-0.092	-0.094	-0.016	0.175	**0.180**	-0.056	0.043	-0.059	0.006	0.017	-0.015	**-0.118**
M	0.032	0.017	-0.003	0.006	-0.002	-0.026	0.009	0.014	-0.032	-0.035	-0.033	**0.104**	-0.045	0.054	-0.017	-0.004	0.016	**-0.079**
P	0.039	-0.019	-0.022	0.011	0.003	-0.005	-0.038	-0.036	0.019	0.022	0.020	-0.037	**0.085**	-0.063	0.005	0.026	-0.008	**-0.032**
F	0.070	0.029	0.010	0.015	0.014	-0.035	0.044	0.041	-0.050	-0.051	-0.046	0.073	-0.104	**0.141**	-0.016	-0.016	0.015	**0.004**
C	-0.003	0.000	0.000	-0.003	0.002	-0.001	0.004	0.005	-0.001	-0.001	-0.001	0.003	-0.001	0.002	**-0.175**	-0.005	0.002	**-0.127**
Fe	0.000	-0.002	-0.006	0.003	0.000	-0.004	-0.014	-0.012	-0.002	0.004	0.003	-0.001	0.008	-0.003	0.008	**0.027**	-0.001	**-0.100**
Zn	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	**0.000**

DFF: Days to 50 per cent flowering, **DM**: Days to maturity, **PH**: Plant height(cm), **PB**: Primary branches, **PP**: Pods per plant, **TW**: Test weight (g), **HC**: Hydration capacity (g/seed), **SC**: Swelling capacity (ml/seed), **CT**: Cooking time (mints), **EI**: Expansion index (%), **PI**: Puffing index (%), **M1**: Moisture content (%), **P**: Protein content (%), **F**: Fat content (%), **C**: Carbohydrate content (%), **Fe**: Iron content (ppm), **Zn**: Zinc content (ppm), **YP**: yield per plant (g).

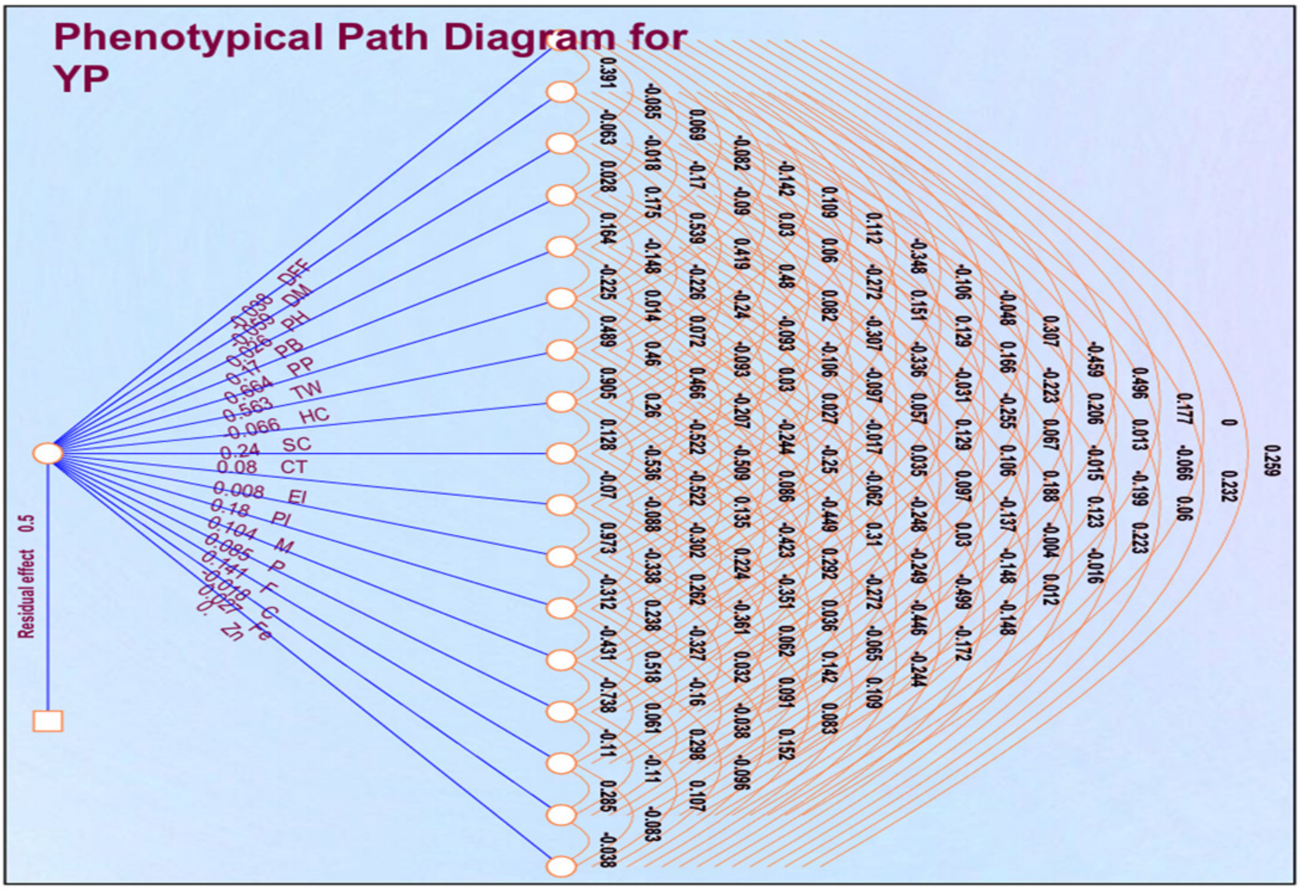

Fig. 1: Phenotypic path diagram for seed yield per plant

Expansion Index has a slight positive direct effect (0.008) on yield per plant. This suggests that the ability of seeds to expand may contribute marginally to overall plant productivity. Puffing Index has a minor positive direct effect (0.180) on yield per plant, indicates that higher puffing ability could slightly enhance yield by improving seed quality or volume. Moisture content has a small positive direct effect (0.104) on yield per plant, implies that optimal moisture content may contribute to better growth conditions, thereby improving yield.

Protein content has a moderate positive direct effect (0.085) on yield per plant, suggests that higher protein content supports better plant metabolism and growth, leading to increased yield. Similar findings reported by Vikram *et al.* (2022), Karthikeyan *et al.* (2022) and Prasanthi *et al.* (2023). Crude fat content showed a positive direct effect (0.141) and carbohydrate content showed a negative direct effect (-0.175) on yield per plant. Higher carbohydrate levels might not necessarily contribute to yield, as other factors such as protein and crude fat content could play more crucial roles in determining yield quality.

Iron content has a negligible direct effect (0.03) on yield per plant, suggesting minimal influence on yield. Iron is more related to plant health than yield directly. Zinc content showed a negligible direct effect on yield per plant. Adequate zinc levels are essential for growth, but its direct influence on yield per plant is limited. Similar findings reported by Prasanthi *et al.* (2023) for iron content and zinc content

Conclusion

According to present study, key traits that correlate with seed yield, including the number of pods per plant, number of branches and test weight, which are strongly associated with yield. Overall, swelling capacity, hydration capacity, and cooking time are positively correlated with test weight. Traits like plant height, primary branches and pods per plant have strong positive effects. Test weight and swelling capacity also contribute positively to yield. This suggests that these traits play a crucial role in determining yield and can be effectively targeted for improvement through breeding methods.

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