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Estimation of Correlation and Path Coefficient Analysis for Quantitative Characters in Chickpea at Uttar Pradesh (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Author KT designed the study, performed the statistical analysis, wrote the protocol. Authors CHSNR and PVBB managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted and data were pooled for 22 genotypes including one check variety Uday in Field Experimentation Centre at Department of Genetics and Plant breeding, SHUATS, Prayagraj. The data was recorded for 11 quantitative traits to study the amount of variability, heritability, correlation analysis, direct and indirect effects of quantitative traits in chickpea genotypes. All the eleven quantitative traits under study displayed significant differences in Analysis of variance which indicates ample scope for selecting promising lines for further breeding programs. The genotypes ICC 8058, ICC 16796, and ICC 14199 were identified as the best genotypes for seed yield per plant among 22 genotypes under study. GCV values are slightly lesser compared to PCV values specifies the minor impact of environment on studied traits. The traits seed index, harvest index exhibited highly positive phenotypic and genotypic correlation for seed yield, which are the principal traits where selection can be operated for developing superior lines.

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Path coefficient analysis revealed that traits harvest index, biological yield, and the number of pods per plant showed highly positive direct effects at both genotypic and phenotypic levels on seed yield per plant. From the above results and outcomes traits seed index, harvest index, and biological yield, could be contemplated for selection criteria and yield improvement in chickpea.

Keywords: Chickpea; seed yield; correlation coefficient and path analysis.

1. INTRODUCTION

Chickpea or Bengal gram or chana or Egyptian pea is the World's third most significant winter season food pulse crop esteemed for its nutritive seeds with high protein content (25.3-28.9%) after de-hulling [1,2]. Chickpea has been perceived as a rich fountain of protein, nutrients, and minerals in human eating routine and involves a vital spot in human nourishment in many developing nations. Chickpea seed contains protein 21%, carbohydrates 61%, fiber 3%, oil 4.8-5.5, calcium 0.2%, phosphorous 0.3%, ash 3% and 0.012-0.33 mg riboflavin [3].

Through the past 40 years (1979-2019) the increase in yield, area and production of Egyptian pea or Bengal gram in the world was 57% (659 to 1033 kg/ha), 49% (2.80 to 4.17 million ha) and 133 % (1.85 to 4.31 MT) respectively, whereas, in southern and central India, production and area of Bengal gram have improved by 445% (from 1.27 to 6.95 MT) and 177% (2.42 to 6.71 Million ha.) respectively [4].

Population upsurge during the last piece of the twentieth century and mid-twenty-first century caused a shortage in food grain accessibility and increased mal-nourishing issues. Genetic improvement by the selection of quantitative traits depends on high heritability and genetic variability present in breeding lines. Chickpea has a wide source of genetic variability. Due to this reason, the plant breeders have underlined the assessment of genotypes for the improvement of yield potential among germplasm. The present study is based on eleven quantitative traits of 22 genotypes including check variety Uday. The observed genetic variability can be deliberated through genetic parameters like GCV, PCV, heritability (broad sense), Genetic advance and Genetic advance as percent mean.

The phenotypic correlation *i.e* directly observed association between two variables is assessed by phenotypic variances and covariances, whereas the genotypic correlation *i.e* inherent and heritable correlation is estimated from values of genotypic variances and covariances [5]. Path analysis is designed to quantify the interrelationship of different components and their direct and indirect effects on seed yield [6]. These statistical measures correlation coefficient analysis and path analysis helps in the selection of elite genotypes from diverse genetic populations.

2. MATERIALS AND METHODS

The details of materials used and the method adopted in the present study entitled “Estimation of correlation and path coefficient analysis for quantitative traits in chickpea at Uttar Pradesh (*Cicer arietinum* L.)” comprised of 22 chickpea genotypes counting check variety (Uday) at the Field Experimentation Centre of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj, U.P. during Rabi 2019 – 2020 and pooled data were analyzed. The experimental design understudy is Randomized Block Design (RBD) in three replications. The total number of plots was 66 and for all the plots plot size is 1x1 m2 and row to row spacing 30 cm and plant to plant spacing 10 cm. The fertilizer dose of N:P: K @ 20:40:20 kg/ha is applied as two splits of Nitrogen, phosphorus and potassium were given as basal application. During the cropping period, all the cultural and suggested package of practices were followed judiciously.

Evaluation of 22 genotypes was done for all the for eleven quantitative traits viz., days to 50 percent flowering, days to maturity, number of primary branches per plant, number of secondary branches per plant, plant height (cm), number of pods per plant, number of seeds per pod, biological yield per plant (g), harvest index (%), Seed index (g), seed yield per plant (g) were recorded on a plot basis. Five plants were randomly selected from each plot observations were recorded for all traits except for days to 50% flowering and days to maturity for these traits observations were made from the whole plot. The average of the data collected from selected plants of each plot were used for

various statistical analyses. The data were recorded for all eleven traits.

ANOVA results in the present experiment were derived based on the methodologies projected by Fisher (1936), Coefficient of variation both Phenotypic coefficient of variation (PCV) and Genotypic coefficient of variation (GCV) were estimated based on methodology given by Burton (1952) and assessment of broad-sense heritability development determined by following strategy given by Burton and De Vane (1953). Genetic advance calculated by the following methodology given by Johnson et al., (1995). For determining yield components, biometrical techniques like Correlation coefficient analysis and Path analysis were utilized, following system is given by Al-Jibouri et al., (1958) and Dewey and Lu (1959) respectively. The analysis was processed using the statistical package Windostat Version 9.2 from Indostat services.

3. RESULTS AND DISCUSSION

The mean values, the coefficient of variation (C.V.), standard error of the mean (SE), the critical difference (C.D.) at 5% and 1%, Range of 22 genotypes and 11 quantitative traits are presented in Table 1, which revealed a wide range of variation for all traits studied. A perusal of mean performance among 22 chickpea genotypes recorded that out of 22 chickpea genotypes evaluated to various traits, nine genotypes were found superior for different traits. Among the lines, five genotypes ICC 8058 (14.23), ICC 16796 (13.73), ICC 14199 (13.40), ICC 4958 (10.60) and ICC 867 (10.10) were significantly showed a higher seed yield per plant as compared to the check Uday. These genotypes may be utilized in the future breeding program for the identification of high-yielding lines and transgressive segregants.

The coefficient of variation measures the magnitude of variability present in the population. So the PCV and GCV values are used as the indicators of observed phenotypic and genotypic variability, respectively. PCV values were higher than their corresponding GCV values for all the traits studied which indicated that the apparent variation is not only due to the genotype, but also due to the influence of the environment, the findings are per the findings of Jain et al. [7]. The estimate of genetic parameters of chickpea is presented in Table 2 and a bar chart depicting estimates of genetic parameters for the quantitative traits in chickpea germplasm is shown in Fig. 1.

A wide range of Genotypic Coefficient of Variation was observed for the traits ranging from 10.09 days to maturity to 58.03 for seed index. High magnitude of Genotypic and phenotypic Coefficient of Variation was recorded for seed index (58.03) & (58.45) followed by the number of pods per plant (46.53) & (47.28), seed yield per plant (41.42) & (42.57), total seeds per plant (39.43) & (40.15), harvest index (39.34) & (40.51), biological yield (31.39), number of secondary branches per plant (25.86) & (26.26), plant height (25.64) & (26.66), followed by the number of primary branches per plant (21.03) & (21.99). Moderate estimates of GCV & PCV were recorded for days to 50% flowering (14.21) & (14.49) followed by days to maturity (10.09) & (10.20) respectively.

Genetic parameters results showed that all the traits studied have a heritability (broad sense) percentage greater than sixty which indicates all the traits showed high heritability. Genetic advance and genetic advance as per cent of mean, values were high for the number of pods per plant and seed index, respectively, indicating that selection would be fruitful for improvement of these traits. High heritability (98.60) coupled with high genetic advance (118.60) is seen for traits like seed index and this directs that mostly heritability is unveiled because of additive genes and selection might be operative for this parameter.

Correlation coefficient analysis revealed that seed yield per plant exhibited positive and significant correlation associated with seed yield (0.730**), harvest index (0.672**), days to 50% flowering (0.544**), biological yield (0.456**), number of pods per plant (0.338**), days to maturity (0.331**), plant height (0.296*), total seeds per plant (0.267*). A negative significant correlation was exhibited by the number of primary branches per plant (- 0.276*). A negative non-significant correlation was exhibited by the number of secondary branches per plant (- 0.213). These findings were per Bhavani et al. [8], Gaur et al. [9], Usharani et al. [10], Bharti et al. [11] Correlation coefficient analysis revealed that seed yield per plant exhibited positive and significant correlation associated with total seeds per plant (0.711**), harvest index (0.654**), Days to 50% flowering (0.521**), biological yield (0.451**), number of pods per plant (0.325**), days to maturity (0.321**), plant height (0.277*),

total seeds per plant (0.257*) results showed that the genotypic correlation coefficient, in general, was higher than the phenotypic correlation coefficient. The genotypic correlation coefficient between seed yield and its components in chickpea for all the eleven traits were shown in Table 3 The inter-relationships were, therefore, strongly inherent, and low phenotypic expression was due to environmental factors.

In the present investigation path coefficient analysis was carried out by taking seed yield per plant as dependent variables and the rest of the quantitative traits as independent variables. Days to 50% flowering, plant height, number of pods per plant, seed index, biological yield, harvest index had positive direct effects on seed yield per plant. Whereas, negative direct effects on seed yield per plant were observed due to days to maturity, number of primary branches per plant, number of secondary branches per plant, total seeds per plant. Comparable results were reported by Vaghela et al. [12], Jha et al. [13], Pandey et al. [14], Padmavathi et al. [15]. The results of Direct and indirect effects of 11 traits on seed yield in Chickpea at Genotypic level and phenotypic level were presented in Tables 4 & 5 respectively. Genotypic and Phenotypic path diagram for seed yield per plant is presented in Fig. 2 and Fig. 3 respectively.

Genotypic and phenotypic path analysis revealed that the traits plant height (0.0486) and (0.0650), number of pods per plant (0.2550) and (0.2170), seed index (0.1122) and (0.2194), biological yield (0.5966) and (0.5243), and harvest index (0.8057) and (0.6977) recorded direct effects on seed yield per plant. Thus, the present study suggested that selection for high seed yield should be based on the number of pods per plant, seed index, biological yield and harvest index in chickpea. Therefore, due emphasis may be given to these traits for selecting high yielding genotypes in chickpea.

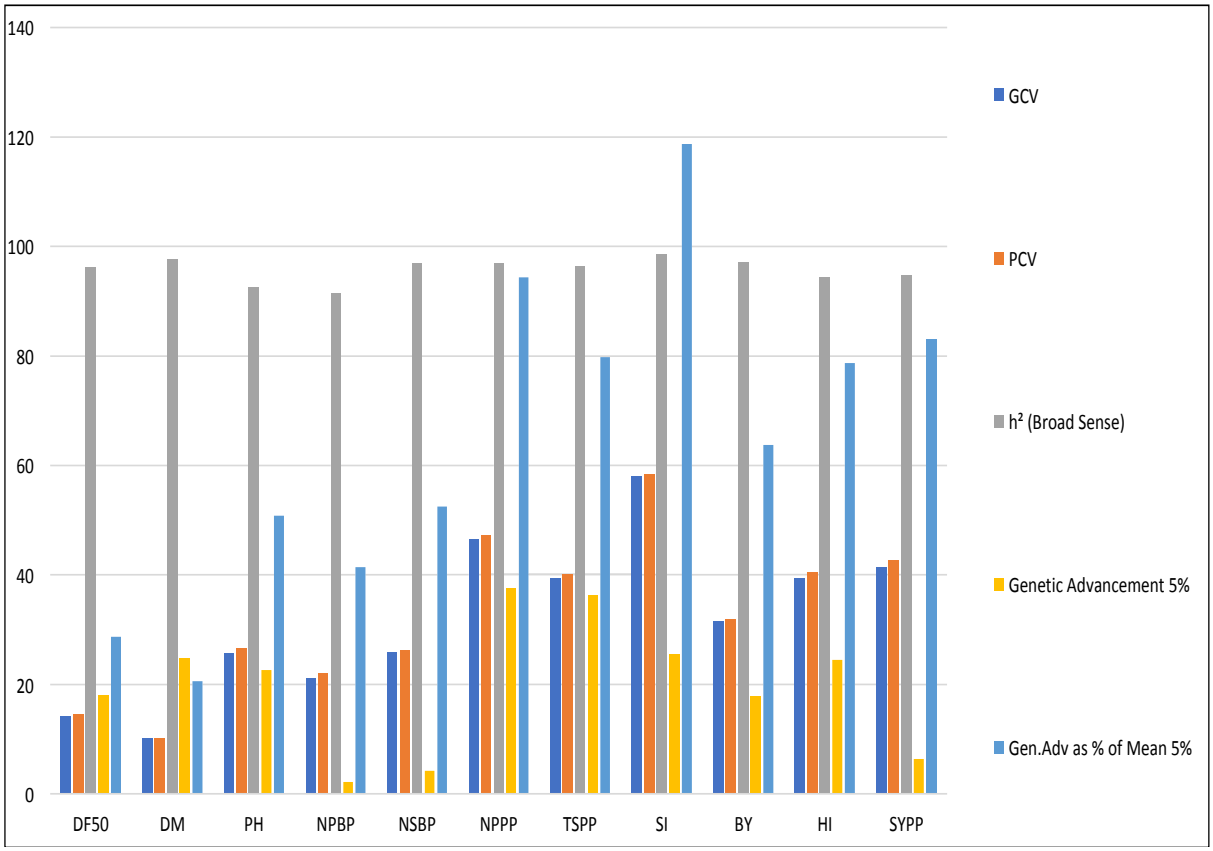

Fig. 1. Bar chart depicting estimates of genetic parameters for the quantitative traits in chickpea *(Cicer arietinum* L.) germplasm

DF50 : Days to 50% flowering, DM : Days to Maturity, PH : Plant height, NPBP : Number of Primary Branches per plant, NSBP : Number of secondary branches per plant, NPPP : Number of Pods Per Plant, TSPP : Total Seeds Per Plant, SI : Seed index, BI : Biological yield, HI : Harvest index, SYPP : Seed yield per plant

Table 1. Mean Performance of eleven traits evaluated under field conditions in Rabi, 2019-20

MEANS TABLE												
S. No.	**Traits**	**Days to 50% Flowering**	**Days to maturity**	**Plant Height(cm)**	**Number of Primary Branches per Plant**	**Number of Secondary Branches per Plant**	**Numberof Pods Per Plant**	**Total Seeds PerPlant**	**Seed index(g)**	**Biological Yield (g)**	**Harvest Index (%)**	**Seed Yield Per Plant (g)**
1	**ICC 94919-4**	64.33	125.33	40.97	4.07	6.90	30.93	33.23	15.33	34.30	15.66	5.87
2	**ICC 94916-8**	65.33	118.33	43.60	4.80	8.23	30.20	28.53	20.53	32.50	21.09	6.53
3	**ICC 867**	57.33	117.67	38.00	6.77	8.67	72.80	70.83	15.37	27.13	40.82	10.10
4	**ICC 4958**	53.33	104.33	41.57	4.53	5.93	31.50	29.80	31.00	35.73	34.40	10.60
5	**ICC 3325**	62.00	113.00	33.80	6.50	7.90	22.10	30.67	11.23	25.23	17.91	3.77
6	**ICC 3776**	61.33	110.33	48.13	6.23	6.57	41.50	52.33	11.33	18.07	29.83	5.33
7	**ICC 7184**	61.67	133.67	62.03	4.70	7.40	34.33	42.33	10.00	16.73	31.59	5.27
8	**ICC 7272**	52.67	133.67	33.53	5.67	8.47	27.20	25.83	29.03	16.83	40.67	5.80
9	**ICC 7373**	73.33	146.00	73.80	3.80	5.17	36.67	48.33	18.70	42.00	21.25	8.33
10	**ICC 8058**	84.67	135.67	43.67	4.80	5.13	52.80	50.27	35.13	31.67	50.44	14.23
11	**ICC 14199**	66.00	125.00	41.77	5.80	11.67	29.87	28.50	60.00	42.77	38.33	13.40
12	**ICC 14402**	49.33	109.33	43.00	5.23	10.83	26.40	33.33	12.10	12.73	35.14	3.87
13	**ICC 14778**	68.67	112.67	34.57	6.23	11.17	42.40	43.77	13.47	27.53	20.32	5.17
S. No.	**Traits**	**Days to 50% flowering**	**Days to maturity**	**Plant Height (cm)**	**Number of Primary Branches per Plant**	**Number of Secondary Branches per Plant**	**Number of Pods Per Plant**	**Total Seeds Per Plant**	**Seed index (g)**	**Biological Yield (g)**	**Harvest Index (%)**	**Seed Yield Per Plant (g)**
14	**ICC 14799**	52.67	122.67	43.13	6.10	8.97	36.13	37.33	17.40	32.20	18.14	5.13
15	**ICC 16796**	72.67	136.67	70.03	5.17	9.43	33.77	38.67	44.60	25.13	58.50	13.73
16	**ICC 1205**	68.67	118.67	44.46	3.40	6.60	73.13	79.67	15.43	26.83	31.94	8.43
17	**ICC 1882**	60.00	115.00	30.67	6.33	12.07	56.63	61.00	16.40	25.40	24.78	6.37
18	**ICC 10448**	48.00	96.00	27.77	4.23	6.70	44.20	50.33	17.80	38.17	19.62	7.43
19	**ICC 5680**	56.33	107.33	43.60	5.80	9.07	23.27	47.17	10.93	16.47	33.45	4.67
20	**ICC 8261**	60.67	128.67	43.93	5.27	8.90	15.23	16.83	31.10	28.13	20.04	5.23
21	**ICC 283**	58.67	114.67	42.67	4.93	8.07	89.33	82.67	15.40	38.13	25.54	9.93
22	**UDAY (CHECK VARIETY)**	72.67	128.67	53.93	2.47	4.53	25.73	71.00	19.33	17.87	55.53	10.00
Mean		62.29	120.61	44.48	5.13	8.11	39.82	45.57	21.44	27.80	31.14	7.69

Range	**Minimum**	48.00	96.00	27.77	2.47	4.53	15.23	16.83	10.00	12.73	15.66	3.77
	Maximum	84.67	146.00	73.80	6.77	12.07	89.33	82.67	60.00	42.77	58.50	14.23
S.E.		1.01	1.07	1.87	0.19	0.21	1.92	1.99	0.87	0.85	1.74	0.44
C.D. (5%)		2.90	3.05	5.34	0.54	0.61	5.47	5.69	2.48	2.42	4.96	1.25
C.V.		2.82	1.54	7.29	6.44	4.54	8.34	7.58	7.01	5.29	9.66	9.84

Table 2. Estimation of genetic parameters for eleven traits in Chickpea (*Cicer arietinum* L.)

S. No.	Traits	Genotypic coefficient of variation (%)	Phenotypic coefficient of variation (%)	Heritability 2 (h) (%) (broad sense)	Genetic advance (5% LOS)	Genetic advance as per cent of mean	General Mean
1	**DF50**	14.21	14.49	96.20	17.88	28.71	62.29
2	**DM**	10.09	10.20	97.70	24.77	20.54	120.61
3	**PH**	25.64	26.66	92.50	22.60	50.81	44.48
4	**NPBP**	21.03	21.99	91.40	2.12	41.41	5.13
5	**NSBP**	25.86	26.26	97.00	4.25	52.47	8.11
6	**NPPP**	46.53	47.28	96.90	37.58	94.36	39.82
7	**TSPP**	39.43	40.15	96.40	36.34	79.76	45.57
8	**SI**	58.03	58.45	98.60	25.44	118.68	21.44
9	**BY**	31.39	31.83	97.20	17.72	63.76	27.80
10	**HI**	39.34	40.51	94.30	24.50	78.70	31.14
11	**SYPP**	41.42	42.57	94.70	6.39	83.02	7.69

DF50 : Days to 50% flowering, DM : Days to Maturity, PH : Plant height, NPBP : Number of Primary Branches per plant, NSBP : Number of secondary branches per plant, NPPP : Number of Pods Per Plant, TSPP : Total Seeds Per Plant, SI : Seed index, BI : Biological yield, HI : Harvest index, SYPP : Seed yield per plant

Table 3. Genotypic correlation coefficient of eleven quantitative traits in chickpea (*Cicer arietinum* L.)

S. No.	Traits	Days to maturity	Plant Height(cm)	Number of Primary Branches per Plant	Number of Secondary Branches per Plant	Number of Pods Per Plant	Tot al Seeds Per Plant	Seed index (g)	Biological Yield (g)	Harvest Index (%)	Seed Yield Per Plant (g)
1	**DF50**	0.628**	0.496**	-0.333**	-0.323**	0.088	0.191	0.310*	0.177	0.380**	0.544**
2	**DM**	**1.000**	0.683**	-0.263*	-0.215	-0.138	-0.118	0.368**	0.055	0.338**	0.331**
3	**PH**		**1.000**	-0.413**	-0.343**	-0.141	0.042	0.148	-0.020	0.355**	0.296*
4	**NPBP**			**1.000**	0.688**	0.021	-0.250*	-0.015	-0.158	-0.193	-0.276*
5	**NSBP**				**1.000**	-0.040	-0.251*	0.171	-0.116	-0.151	-0.213
6	**NPPP**					**1.000**	0.821**	-0.195	0.263*	0.026	0.338**
7	**TSPP**						**1.000**	-0.366**	-0.008	0.211	0.267*
8	**SI**							**1.000**	0.403**	0.473**	0.730**
9	**BY**								**1.000**	-0.341**	0.456**
10	**HI**									**1.000**	0.672**

DF50 : Days to 50% flowering, DM : Days to Maturity, PH : Plant height, NPBP : Number of Primary Branches per plant, NSBP : Number of secondary branches per plant, NPPP : Number of Pods Per Plant, TSPP : Total Seeds Per Plant, SI : Seed index, BI : Biological yield, HI : Harvest index, SYPP : Seed yield per plant

Table 4. Direct and indirect effects of 11 traits on seed yield in Chickpea at Genotypic level

S. No.	Traits	Days to 50% flowering	Days to maturity	Plant Height (cm)	Number of Primary Branches per Plant	Number of Secondary Branches per Plant	Number ofPods Per Plant	Total Seeds PerPlant	Seed index (g)	Biological Yield(g)	Harvest Index (%)	Seed Yield Per Plant (g)
1	**DF50**	**0.141**	-0.077	0.024	0.005	0.005	0.022	-0.022	0.035	0.106	0.306	**0.544****
2	**DM**	0.088	**-0.122**	0.033	0.004	0.003	-0.035	0.014	0.041	0.033	0.272	**0.331****
3	**PH**	0.070	-0.083	**0.049**	0.006	0.005	-0.036	-0.005	0.017	-0.012	0.286	**0.296***
4	**NPBP**	-0.047	0.032	-0.020	**-0.014**	-0.010	0.005	0.029	-0.002	-0.095	-0.156	**-0.276***
5	**NSBP**	-0.045	0.026	-0.017	-0.010	**-0.014**	-0.010	0.029	0.019	-0.069	-0.122	**-0.213**
6	**NPPP**	0.012	0.017	-0.007	0.000	0.001	**0.255**	-0.096	-0.022	0.157	0.021	**0.338****
7	**TSPP**	0.027	0.014	0.002	0.004	0.004	0.209	**-0.117**	-0.041	-0.005	0.170	**0.267***
8	**SI**	0.044	-0.045	0.007	0.000	-0.002	-0.050	0.043	**0.112**	0.240	0.381	**0.730****
9	**BY**	0.025	-0.007	-0.001	0.002	0.002	0.067	0.001	0.045	**0.597**	-0.275	**0.456****
10	**HI**	0.054	-0.041	0.017	0.003	0.002	0.007	-0.025	0.053	-0.203	**0.806**	**0.672****

Bold values show direct and normal values show indirect effects

DF50 : Days to 50% flowering, DM : Days to Maturity, PH : Plant height, NPBP : Number of Primary Branches per plant, NSBP : Number of secondary branches per plant, NPPP : Number of Pods Per Plant, TSPP : Total Seeds Per Plant, SI : Seed index, BI : Biological yield, HI : Harvest index, SYPP : Seed yield per plant

Table 5. Direct and indirect effects of 11 traits on seed yield in Chickpea at Phenotypic level

S. No.	Traits	Days to 50% flowering	Days to maturity	Plant Height(cm)	Number of Primary Branches per Plant	Number of Secondary Branches per Plant	Number of Pods Per Plant	Total Seeds Per Plant	Seed index(g)	Biological Yield(g)	Harvest Index (%)	Seed Yield Per Plant (g)
1	**DF50**	**0.140**	-0.080	0.031	-0.015	0.024	0.018	-0.007	0.066	0.085	0.260	0.521**
2	**DM**	0.089	**-0.126**	0.042	-0.012	0.016	-0.030	0.004	0.079	0.026	0.231	0.321**
3	**PH**	0.066	-0.081	**0.065**	-0.018	0.026	-0.032	-0.001	0.031	-0.014	0.237	0.277*
4	**NPBP**	-0.045	0.031	-0.026	**0.046**	-0.050	0.003	0.009	-0.003	-0.077	-0.135	-0.246*
5	**NSBP**	-0.043	0.026	-0.022	0.030	**-0.076**	-0.010	0.009	0.036	-0.062	-0.095	-0.207
6	**NPPP**	0.011	0.017	-0.010	0.001	0.004	**0.217**	-0.030	-0.041	0.136	0.020	0.325**
7	**TSPP**	0.026	0.014	0.002	-0.011	0.019	0.178	**-0.037**	-0.078	-0.004	0.148	0.257*
8	**SI**	0.042	-0.045	0.009	-0.001	-0.013	-0.040	0.013	**0.219**	0.208	0.319	0.711**
9	**BY**	0.023	-0.006	-0.002	-0.007	0.009	0.056	0.000	0.087	**0.524**	-0.234	0.451**
10	**HI**	0.052	-0.042	0.022	-0.009	0.010	0.006	-0.008	0.100	-0.176	**0.698**	0.654**

Bold values show direct and normal values show indirect effects.

DF50 : Days to 50% flowering, DM : Days to Maturity, PH : Plant height, NPBP : Number of Primary Branches per plant, NSBP : Number of secondary branches per plant, NPPP : Number of Pods Per Plant, TSPP : Total Seeds Per Plant, SI : Seed index, BI : Biological yield, HI : Harvest index, SYPP : Seed yield per plant

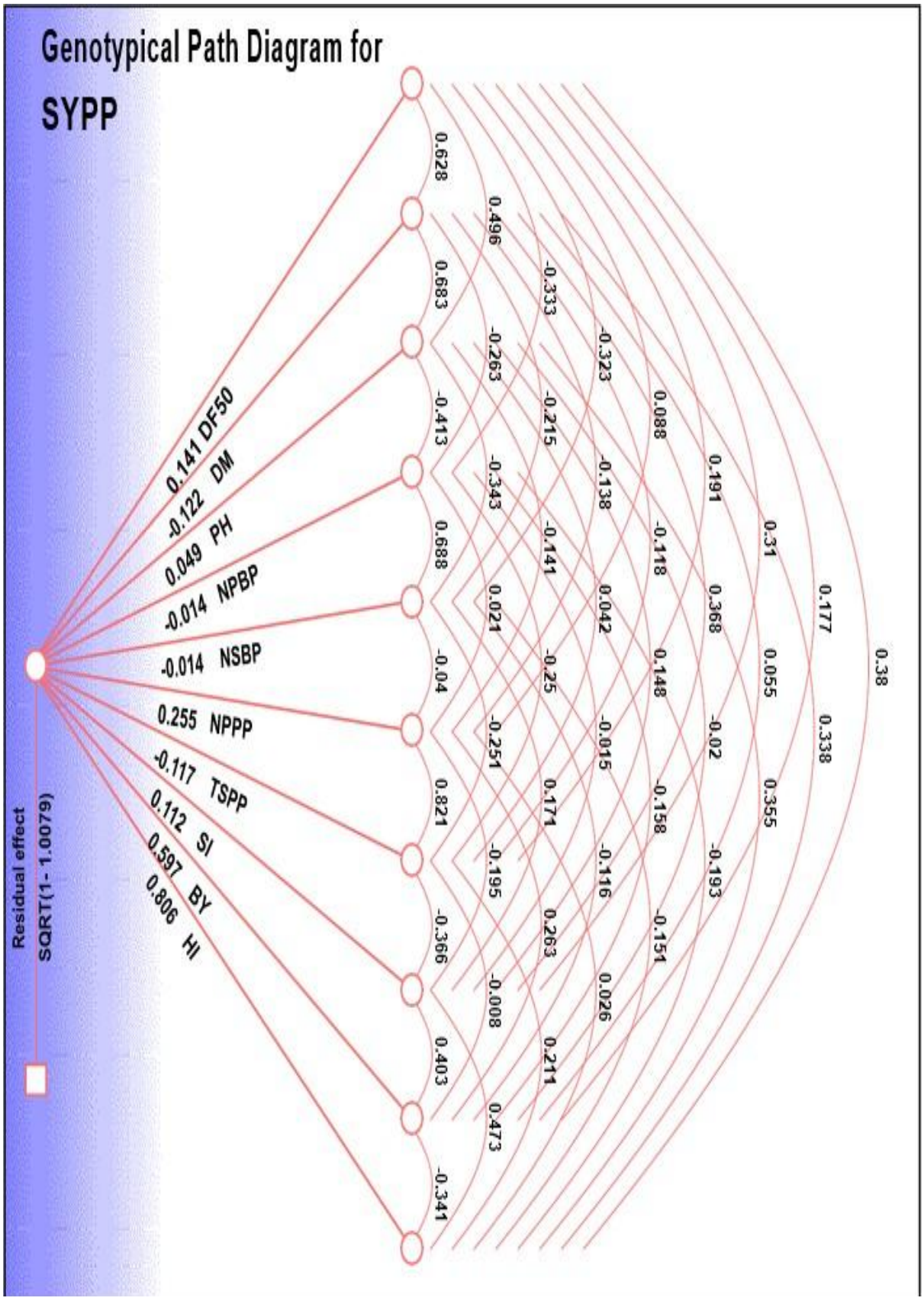

Fig. 2. Genotypic path diagram for seed yield per plant

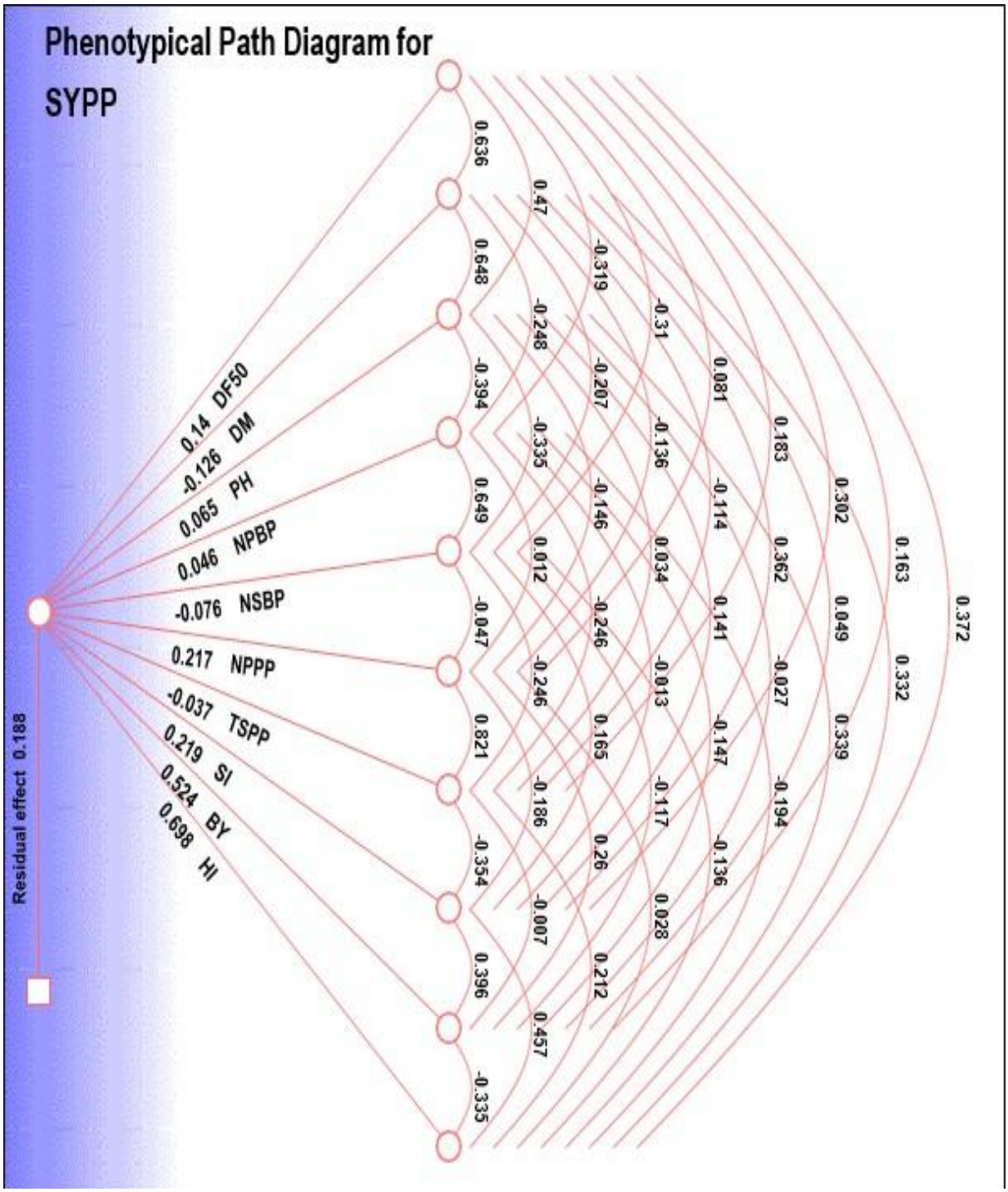

Fig. 3. Genotypic path diagram for seed yield per plant

4. CONCLUSION

The results from the present investigation can be concluded that genotype ICC 8058 was identified as a desirable genotype with high seed yield per plant, number of pods per plant and the total number of seeds per plant. A considerable amount of genetic variability was observed among the studied genotypes. High GCV, PCV, heritability and genetic advance in seed index implies selection will be effective in this studied population. Seed yield per plant exhibited significant positive genotypic and phenotypic correlation with seed index, harvest index, biological yield, number of pods per plant and number of seeds per plant, these traits help in

the selection of elite genotypes from diverse genetic populations. Harvest index, biological yield, seed index and the number of pods per plant showed a high positive direct effect on seed yield per plant at both genotypic and phenotypic levels, Thus utmost priority should be given to those traits during selection for yield improvement in chickpea.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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