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Estimation of Genetic Parameters, Selection Indices and Association Analysis of Seed Yield and Its Component Traits in Chickpea (*Cicer arietinum* L.)

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ABSTRACT

Background: Chickpea is a second most important pulse crop grown in 56 countries and India rank first in production which shares 61.4% of the total world chickpea production however, productivity is very low as compared to other countries. Therefore, varietal development with inherent tolerance to biotic and abiotic stress is the prime objective to improve component productivity traits to get better yield in rainfed agro-climatic conditions.

Methods: Ninety germplasm accessions of chickpea along with four check *viz.,* JG 14, JG 16, JAKI 9218 and Radhey were evaluated in augmented block design at experimental research farm of Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India. Phenotypic data were subjected to study the genetic parameters and association analysis of yield and its component traits using SPAR 2.0 Package and Windostat Version 9.2.

Result: The significant variation was observed for all the traits except number of secondary branches, number of pod per plant, number of seeds per pod among the genotypes. The maximum GCV and PCV was observed for height of first pod (35.28 and 39.29), followed by seed yield per plant (29.77 and 40.32) and number of primary branches (25.63 and 31.44). The high magnitude of heritability with genetic advance was estimated for seed index (96.61%), while the high genetic advance as per cent of mean was recorded for first pod height (65.27%). The positive and significant association of seed yield with number of pods per plant, seed index, number of seeds per pod, number of secondary branches, number of primary branches and height of first pod indicating the importance of these traits in selection criteria. Path analysis identified that number of seeds per pod, number of pods per plants, seed index and number of secondary branches per plant as highly desirable component for direct effect on seed yield per plant. The genotypes ICVT-181106 had highest selection indices for seed yield followed by ICVT-181107, PUSA-1053, JG-218, GNG-1999, ICVT-181102 and HC-5. Therefore, high GCV and PCV, significant positive direct and indirect correlation and high estimate of selection indices for grain yield can be directly and indirectly used for chickpea breeding program.

Key words: Chickpea, Correlation coefficient, Genetic advance, Heritability, Path analysis, Selection indices.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a cool season food legume crop belongs to family *fabaceae*, subfamily *papilionacea*. Primarily, it is grown in *rabi* season under rainfed ecology of tropical and subtropical regions of the globe. Chickpea is cultivated in around 56 countries across world and India ranked first in production and consumption. Globally, it is cultivated on 17.85 million ha area with the production of 17.23 million tons (FAOSTAT, 2018). In India, chickpea is grown in 11.89 million ha area and produced 11.38 million tonnes of grain with the productivity of 9568 kg/h (FAOSTAT, 2018). Chickpea shares 44.51% of total pulses production and covers 36.41% of the total area of pulses in India and continues to be largest chickpea producer (DACandFW, 2018). In India, more than 68% chickpea area is under rainfed cultivation (Sharma *et al*. 2019) and crop suffers from various biotic and abiotic stresses. Drought is one of the most important edaphic stressors affect the chickpea crop at reproductive phase which adversity impact on productivity. Alone Uttar Pradesh produced 7.27 million tons of chickpea on 5.72 million ha area with the productivity of 1272 kg/ha. Notably, Bundelkhand region of Uttar Pradesh is a major area of chickpea cultivation, where it grows on 3.90 million ha with the production and productivity of 4.86 million tons and 1324 kg/ha respectively (Department of Agriculture, 2018-19).

Genetically seed yield is complex trait, controlled by cumulative effect of several genes. The direct improvement in polygenic traits is rarely possible due to low heritability and genotype x environmental interaction. Thus, estimation of association of yield component traits coupled with seed

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yield is a key objective in chickpea breeding program. Association of secondary traits with yield would be effective for the selection of genotypes with improved yield potential (Padmavathi *et al*. 2013). The selection efficiency of yield contributing characters depends on the heritability which brings out the genetic gain from the selection. The several yield component traits are responsible for indirect selection of genotypes with high yield potential to be taken into consideration in chickpea breeding programme for development of improved chickpea genotype. Therefore, correlation coefficient helps to determines how the complex trait can be improved through indirect selection of yield contributing traits (Mohan *et al*. 2019). The aim of present study was to estimates the contribution of component traits into seed yield through direct and indirect ways and estimates the association between components traits.

MATERIALS AND METHODS

Experimental site and material

The experiment was carried out at the experimental research farm of Banda University of Agriculture and Technology, Banda U.P., India. The experimental material consisted of ninety germplasm accessions of chickpea and four check varieties viz., JG14, JG16, JAKI 9218 and Radhey. The germplasm comprised with high yielding advanced breeding lines, elite lines, released Indian varieties recommended in central zone (CZ) and North Western Zone (NWZ), genetic stocks and landraces acquired from SAUs, ICRISAT and IIPR Kanpur. The list of genotypes is given in Table 1. The experiment was laid in Augmented Block Design during rabi season of 2018-19. The entire experimental field was divided into 9 blocks of equal size and each block had 14 entries. Out of 14 entries in a block, 10 entries were test genotypes which were not replicated while remaining 4 were check varieties. The checks were randomly allocated along with the test genotypes in a block. The row length of each entry was 2 m in length, following inter and intra row spacing of 30 cm and 10 cm, respectively.

Observations recorded

Seventeen traits were recorded at different growth stages *i.e.* germination, vegetative, reproductive and maturity. The post-harvest observations were also recorded on seed traits. The days to germination, early plant vigor, days to first flower initiation, days to 50% flowering, days to 100% flowering, days to first pod appearance and days to maturity represented by a single value and computed on plot basis. The data on other quantitative traits *viz*, plant height, height of first pod, average inter-nodal distance, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod and harvest index were recorded from the five randomly selected plants from each genotype. Harvest index was calculated by dividing the biological weight of five randomly selected plants to seed yield of each genotype. 100-seed weight was calculated by weighing 100 counted seed from each genotype with automatic seed counter machine from each plot and weighed by electronic weighing balance. Total yield per plot was calculated after harvesting in an area of 1.2 m^2 from each genotype and converted into kg/ha.

Statistical analysis

The averages of five randomly selected plants of each trait was subjected to analysis of variance (ANOVA) and estimates the genetic coefficient of variance and phenotypic coefficient of variance using SPAR 2.0 Package (Ahuja *et al.* 2008). The heritability in broad sense in percent and expected genetic advance was calculated by the procedure suggested by Dewey and Lu (1959) and genetic advance as percent of mean was estimated by the formula suggested by Robinson *et al.* (1949). The correlation coefficient analysis at phenotypic level was calculated based on formula given by Johnson *et al.* (1955). The path coefficient analysis was calculated according to the equation suggested by Dewey and Lu (1959). Selection index based on a number of measurements was calculated according to the equation suggested by Smith (1936). The estimators of heritability, genetic advance, correlation coefficient and path analysis were analysed using Windostat Version 9.2 from Indostat services.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA)

Analysis of variance confirms considerable genotypic variability present for all the characters under study except number of secondary branches, number of pod per plant and number of seeds per plant (Table 2). The significant difference in genotypes for flower initiation, primary branches, secondary branches, number of pods per plant and grain weight was reported by Aswathi *et al*. (2019) indicating the presence of variability which can be exploited through selection. There is ample scope of inclusion of identified promising genotypes in breeding program for improvement in yield and its components characters. The traits such as days to germination, days to flower initiation, days to 50% flowering, days to 100% flowering, days to first pod appearance, days to maturity, plant height, height of first pod and total grain yield were showed significant differences over the blocks. All traits except days to germination, early plant vigour, internode distance and seed index showed significant difference among the checks in contrast analysis, while days to germination, days to flower initiation, days to 50% flowering, days to 100% flowering, days to first pod appearance, days to maturity, internode distance, harvest index, seed index and total grain yield showed significant differences among test genotypes. In genotypes vs checks, days to 50% flowering, number of seed per plant, harvest index, seed index and total grain yield also showed significant difference.

Variability parameters

The phenotypic coefficient of variance (PCV), genotypic coefficient of variance (GCV), heritability, genetic advance

Table 1: List of genotypes used in the present investigation.

Sr. No.	Genotype name	Source	Sr. No.	Genotype name	Source
1	CSJ 868	Durgapur	48	DC 2012-5	IIPR, Kanpur
2	GNG 2372	RAS, Sriganganagar	49	DG 1012-3	IIPR, Kanpur
3	RG 2015-08	Raipur	50	BKD 876	IIPR, Kanpur
4	BG 3087	IARI, New Delhi	51	KDG 12-49	IIPR, Kanpur
5	CSJ 867	Durgapur	52	DC 2012-14	IIPR, Kanpur
6	KGD 2013-2	CSA, Kanpur	53	IC 244263	IIPR, Kanpur
7	BDNG 2010-1	Badnapur	54	IPK 16-103	IIPR, Kanpur
8	GNG 2391	RAS, Sriganganagar	55	EC-556270	IIPR, Kanpur
9	JG 2017-47	JNKV, Jabalpur	56	ICC-495468	IIPR, Kanpur
10	RLBG-2	RLBCAU, Jhansi	57	BG 5051	IARI, New Delhi
11	DBGV 215	Bijapur	58	JG 11	ICRISAT/PKV/JNKVV
12	PG 184	GBPAU, Pantnagar	59	JG 24	JNKV, Jabalpur
13	BRC 5	BAU, Sabour	60	JG 322	JNKV, Jabalpur
14	KGD 2017-1	CSA, Kanpur	61	JG 412	JNKV, Jabalpur
15	ICVT-181118	ICRISAT, Hydrabad	62	JG 315	JNKV, Jabalpur
16	ICVT-181312	ICRISAT, Hydrabad	63	JG 12	JNKV, Jabalpur
17	ICVT-181310	ICRISAT, Hydrabad	64	JG 130	JNKV, Jabalpur
18	ICVT-181108	ICRISAT, Hydrabad	65	PBG 7	PAU, Ludhiana
19	ICVT-181107	ICRISAT, Hydrabad	66	GPF 2	ARS, Faridkot
20	ICVT-181106	ICRISAT, Hydrabad	67	L 552	PAU, Ludhiana
21	ICVT-181105	ICRISAT, Hydrabad	68	PDG 3	PAU, Ludhiana
22	ICVT-181104	ICRISAT, Hydrabad	69	PBG-5	PAU, Ludhiana
23	ICVT-181103	ICRISAT, Hydrabad	70	HC 5	HAU, Hisar
24	ICVT-181102	ICRISAT, Hydrabad	71	PDG-4	PAU, Ludhiana
25	ICVT-181101	ICRISAT, Hydrabad	72	GNG 1947	RAS, Sriganganagar
26	ICVT-181109	ICRISAT, Hydrabad	73	K-850	CSA, Kanpur
27	ICVT-181110	ICRISAT, Hydrabad	74	PUSA-1053	New Delhi
28	ICVT-181111	ICRISAT, Hydrabad	75	CSJ-515	ARS, Durgapur
29	ICVT-181112	ICRISAT, Hydrabad	76	ICCV-205	ICRISAT, Hydrabad
30	ICVT-181113	ICRISAT, Hydrabad	77	BG 5030	IARI, New Delhi
31	ICVT-181114	ICRISAT, Hydrabad	78	GNG-1581	RAS, Sriganganagar
32	ICVT-181115	ICRISAT, Hydrabad	79	BG-212	IARI, New Delhi
33	ICVT-181116	ICRISAT, Hydrabad	80	GNG-469	RAS, Sriganganagar
34	ICVT-181117	ICRISAT, Hydrabad	81	GNG-2171	RAS, Sriganganagar
35	GNG 312	RAS, Sriganganagar	82	GNG-1999	RAS, Sriganganagar
36	GNG 1107	RAS, Sriganganagar	83	GNG 1929	RAS, Sriganganagar
37	GNG 2127	RAS, Sriganganagar	84	BDNG 804	MPKV, Maharastra
38	GNG 2081	RAS, Sriganganagar	85	GNG 1958	RAS, Sriganganagar
39	GNG 1926	RAS, Sriganganagar	86	GNG 1969	RAS, Sriganganagar
40	GNG 1854	RAS, Sriganganagar	87	Vijay	Rahuri
41	ICP-08-103	IIPR, Kanpur	88	JG 36	JNKV, Jabalpur
42	GNG-2226	IIPR, Kanpur	89	JG 218	JNKV, Jabalpur
43	BDG 1059	IIPR, Kanpur	90	JG 16	JNKV, Jabalpur
44	BDG 3038	IIPR, Kanpur	91	Radhey (Ch)	CSA, Kanpur
45	KGD 11-1	IIPR, Kanpur	92	JG 16 (Ch)	JNKV, Jabalpur
46	BG 11-1	IIPR, Kanpur	93	JG 14 (Ch)	JNKV, Jabalpur
47	DC 2012-13	IIPR, Kanpur	94	JAKI 9218 (Ch)	ICRISAT, Hydrabad

and genetic advance as percent of mean of each parameter are presented in Table 3. The PCV for all characters was higher than their corresponding GCV indicating the influence of environment on these traits. The effect of environmental variance was also reported by Sharma *et al*. (2019). The highest amount of GCV was recorded in height of first pod (35.29) followed by number of seed per plant (29.77), seed index (27.50), number of primary branches (25.63) and lowest was recorded in days to maturity (3.06). Maximum PCV was estimated in number of secondary branches (41.67) followed by number of pod per plant (41.37), total grain yield (40.32), height of first pod (39.29), number of

Table 2: Analysis of variance (ANOVA) for quantitative characters in chickpea.

Source	Mean sum of square					
	Block (Adj.)	Treatments (Adj.)	Error	Among control	Among test genotypes	Test-vs control
d.f.	8	93	24	3	89	1
GR	8.81**	4.90*	2.61	5.13	4.90*	0.00
EPVS	1.98	3.88*	1.91	6.70*	3.78*	4.34
FI	41.18*	102.49***	14.51	487.74***	90.48***	15.11
F50	49.12**	101.00***	11.76	437.62***	89.82***	86.42*
F100	76.12**	40.31*	17.78	177.65***	35.93*	18.10
FPA	106.87***	75.99***	7.75	225.29***	71.81***	0.38
PH	95.27*	79.05**	30.82	314.48***	70.39*	143.08*
HFP	155.02***	58.13***	8.74	120.11***	56.65***	3.93
DTP	0.04	0.15***	0.03	0.09	0.16***	0.03
PB	0.56	1.49***	0.39	3.18***	1.41***	2.85*
SB	8.15	5.53	4.37	25.65**	4.90	1.20
PPP	168.61	108.49	104.71	369.87*	100.89	0.97
SPP	0.15	0.27	0.18	1.13**	0.23	0.76
DM	62.87***	24.71***	6.52	14.92	25.32***	0.049
HI	6.76	39.53***	6.74	161.24***	34.87***	88.79**
GW	1.40	42.44***	1.02	14.22***	39.13***	422.40***
TGY	5959.93	8936.34**	3237.75	17961.22**	8338.19**	35097.22**

* Indicates significance at P=.05., ** Indicates significance at P=.01., *** Indicates significance at P=.001.

GR: Days to germination, EPVS: Early plant vigour, FI: Flower initiation, F50: Days to 50% flowering, F100: Days to 100% flowering, FPA: Days to first pod appearance, PH: Plant height, HFP: Height of first pod, DTP: Internodes distance, PB: Primary branches, SB: Secondary branches, PPP: Pods per plant, SPP: Seeds per pod, DM: Days to maturity, HI: Harvest index, GW: 100 seed weight, TYP: Total yield per plot.

Table 3: Genetic parameters ofquantitative characters in chickpea.

Characters	h^2 (Broad Sense)	Genetic Advance		Gen. Adv. as % of Mean		GCV	PCV
		5%	1%	5%	1%		
GR	39.91	1.72	2.20	19.23	24.65	14.78	23.40
EPVS	42.66	1.61	2.06	28.43	36.44	21.13	32.35
DFI	79.93	14.00	17.94	19.08	24.45	10.36	11.59
F50	83.48	14.50	18.59	17.94	23.00	9.53	10.44
F100	43.70	5.06	6.49	4.99	6.39	3.66	5.54
FPA	86.27	13.36	17.12	15.11	19.37	7.90	8.50
PH	49.42	7.95	10.18	16.24	20.81	11.21	15.95
HFP	80.65	11.17	14.31	65.28	83.66	35.29	39.29
DTP	74.38	0.56	0.71	34.04	43.62	19.16	22.21
PB	66.45	1.48	1.90	43.04	55.16	25.63	31.44
SB	8.60	0.39	0.50	7.38	9.46	12.22	41.67
PPP	2.86	0.59	0.76	2.43	3.12	6.99	41.37
SPP	17.73	0.17	0.22	12.62	16.18	14.55	34.56
DM	68.68	6.46	8.27	5.22	6.69	3.06	3.69
HI	76.05	8.31	10.65	16.18	20.74	9.01	10.33
GW	96.61	10.90	13.97	55.69	71.37	27.50	27.98
TGY	54.51	94.74	121.41	45.28	58.03	29.77	40.32

seed per pod (34.56), early plant vigour (32.35), number of primary branches (31.44), seed index (27.98) and lowest was recorded in days to maturity (3.69). Shengu *et al.* (2018) recorded the lower PCV and GCV for plant height, number of pod per plant, seed index and total grain yield and also reported that the small influences of environmental on the traits plant height, number of pod per plant, number of seed per plant, days to 50% flowering, days to maturity and seed index.

The traits seed index, days to first pod appearance, days to 50% flowering, height of first pod, days to flower initiation, internode distance, days to maturity, harvest index and number of primary branches had high heritability ranged from 96.61 to 66.45% whereas, trait early plant vigour, days to 100% flowering, plant height and total grain yield showed medium heritability ranged from 54.54 to 42.66%. Least degree of heritability (≤ 39.91%) were estimated for days to germination, number of secondary branches, number of seed per pod and number of pod per plant. Highest genetic advance was estimated for total grain yield (94.73), however, rest of the traits showed low degree of genetic advance. The highest genetic advance as per cent of mean at 5% level of selection intensity was recorded for the traits height of first pod (65.27%) followed by grain weight (55.69). Though, at 1% level of selection intensity, highest genetic advance as per cent of mean was observed for height of first pod (83.66) followed by grain weight (71.36), total grain yield (58.02), number of primary branches (55.16), internode distance (43.61), early plant vigour (36.43), days to germination (24.65), days to flower initiation (24.44), days to 50% flowering (22.99), plant height (20.81) and harvest index (20.74). The estimated heritability gives the information about heritable proportion of variability which would be effective for selection of genotype. These finding are in confirmation with the results of Shengu *et al.* (2018) who reported the highest heritability for total grain yield and Kumar *et al.* (2019) reported moderate heritability for number of pod per plant along with high genetic advance. The high heritability and genetic advance for seed index indicates that the trait governed by additive gene action.

Correlation coefficient analysis

The correlation coefficient is used tofind out degree and direction of the association between secondary independent and dependent variables. The correlation coefficients between all the 17 characters among germplasm lines are presented in Table 4.

In the present study, number of seed per pod, number of pod per plant, seed index, number of secondary branches, number of primary branches and height of first pod were found positively and significantly associated with total grain yield. The positive significant association of number of pod per plant, number of seed per pod and seed index with grain yield was reported by Samyuktha *et al.* (2017). He has also been reported that traits *viz*., days to 50% flowering and days to maturity showed significant positive association with single plant yield. Similar results have also been reported by Kuldeep *et al.* (2014) for number of pod per plant, number of secondary branches, plant height and Pandey *et al*. (2013) for days to flowering, plant height, number of total branches, number of pod per plant and seed index. The highest degree of association of total grain yield was observed with number of seed per pod (0.607) followed by with number of pod per plant (0.524), seed index (0.414), number of secondary branches (0.400), number of primary branches (0.376) and height of first pod (0.239). On the other hand, association of other characters such as days to germination, early plant vigour, days to flower initiation, days to 50% flowering, days to first pod appearance, days to 100% flowering, internode distance, plant height, days to maturity and harvest index were observed insignificant with total grain yield. The relationship between two or more variables is presented through line diagram in Fig 1.

Seed index showed positive and significant correlation with height of first pod and number of primary branches but negative and significant correlation with harvest index. Early

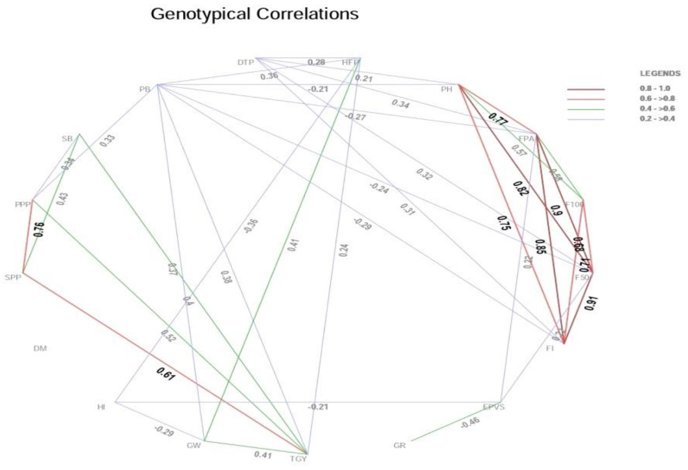

Fig 1: Line diagram showing association between the traits.

Table 4: Correlation coefficient betweenyield and yield contributing traits among chickpea genotypes.

Characters	GR	EPVS	FI	F50	F100	FPA	PH	HFP	DTP	PB	SB	PPP	SPP	DM	HI	SI	TGY
GR	1	**-0.464*****	-0.03	-0.127	0.102	-0.159	-0.095	-0.168	-0.137	-0.187	0.027	-0.01	0.059	0.086	0.102	-0.084	-0.107
EPVS		1	0.174	**0.222***	-0.077	**0.216***	0.181	0.069	0.117	0.115	-0.027	0.022	-0.052	0.012	**-0.213***	-0.071	-0.161
FI			1	**0.911*****	**0.708*****	**0.854*****	**0.749*****	-0.021	**0.309****	**-0.285****	-0.069	-0.052	-0.07	0.074	-0.057	-0.198	-0.076
F50				1	**0.676*****	**0.904*****	**0.816*****	0.033	**0.321****	**-0.243***	-0.096	0.001	-0.042	-0.013	-0.129	-0.074	-0.034
F100					1	**0.578*****	**0.569*****	-0.014	0.056	-0.157	-0.057	0.129	0.117	0.097	-0.094	-0.162	0.076
FPA						1	**0.771*****	0.07	**0.344*****	**-0.275****	-0.023	-0.107	-0.107	0.033	-0.094	-0.13	-0.062
PH							1	0.058	**0.212***	**-0.214***	-0.063	0.006	0.039	0.031	0.051	-0.136	-0.004
HFP								1	**0.281****	**0.356*****	0.097	-0.132	0.004	0.116	**-0.359*****	**0.408*****	**0.239***
DTP									1	0.016	0.077	-0.121	-0.108	0.011	-0.033	0.198	0.06
PB										1	0.164	**0.328****	0.165	0.015	-0.158	**0.371*****	**0.376*****
SB											1	**0.335*****	**0.431*****	-0.14	-0.085	0.086	**0.400*****
PPP												1	**0.757*****	-0.2	0.024	0.139	**0.524*****
SPP													1	-0.189	0.185	0.029	**0.607*****
DM														1	-0.066	-0.09	-0.147
HI															1	**-0.290****	0.138
GW																1	**0.414*****
TGY																	1

* Indicates significance at P=.05., ** Indicates significance at P=.01., *** Indicates significance at P=.001.

Table 5: Path coefficients of component characters contributing towards seed yield.

Characters	GR	EPVS	FI	F50	F100	FPA	PH	HFP	DTP	PB	SB	PPP	SPP	DM	HI	GW
GR		0.0794	0.0047	0.0217	-0.0173	0.0272	0.0162	0.0287	0.0234	0.0320	-0.0047	0.0018	-0.0101	-0.0147	-0.0174	0.0144
EPVS	0.0724		-0.0270	-0.0346	0.0119	-0.0337	-0.0282	-0.0108	-0.0182	-0.0178	0.0042	-0.0035	0.0080	-0.0018	0.0332	0.0110
FI	-0.0024	0.0151		0.0791	0.0615	0.0742	0.0650	-0.0018	0.0268	-0.0248	-0.0060	-0.0045	-0.0061	0.0065	-0.0050	-0.0172
F50	0.0067	-0.0117	-0.0479		-0.0356	-0.0475	-0.0429	-0.0017	-0.0169	0.0127	0.0050	-0.0001	0.0022	0.0007	0.0068	0.0039
F100	0.0119	-0.0090	0.0832	0.0794		0.0680	0.0669	-0.0017	0.0065	-0.0184	-0.0067	0.0151	0.0137	0.0114	-0.0111	-0.0191
FPA	-0.0125	0.0170	0.0671	0.0709	0.0454		0.0605	0.0055	0.0270	-0.0215	-0.0018	-0.0084	-0.0084	0.0026	-0.0073	-0.0102
PH	0.0077	-0.0146	-0.0604	-0.0659	-0.0459	-0.0622		-0.0046	-0.0172	0.0172	0.0051	-0.0005	-0.0032	-0.0025	-0.0041	0.0109
HFP	-0.0201	0.0083	-0.0025	0.0040	-0.0017	0.0083	0.0069		0.0337	0.0425	0.0116	-0.0157	0.0004	0.0139	-0.0428	0.0488
DTP	0.0043	-0.0037	-0.0097	-0.0101	-0.0018	-0.0108	-0.0067	-0.0089		-0.0005	-0.0024	0.0038	0.0034	-0.0003	0.0011	-0.0062
PB	-0.0267	0.0163	-0.0407	-0.0345	-0.0224	-0.0391	-0.0305	0.0507	0.0023		0.0233	0.0467	0.0235	0.0021	-0.0224	0.0529
SB	0.0045	-0.0044	-0.0115	-0.0159	-0.0095	-0.0039	-0.0105	0.0161	0.0127	0.0272		0.0557	0.0717	-0.0232	-0.0141	0.0143
PPP	-0.0008	0.0017	-0.0041	0.0001	0.0100	-0.0083	0.0005	-0.0102	-0.0094	0.0255	0.0261		0.0590	-0.0155	0.0018	0.0108
SPP	0.0235	-0.0204	-0.0279	-0.0167	0.0463	-0.0421	0.0156	0.0014	-0.0426	0.0654	0.1706	0.2997		-0.0747	0.0731	0.0116
DM	-0.0002	0.0000	-0.0002	0.0000	-0.0002	-0.0001	-0.0001	-0.0003	0.0000	0.0000	0.0003	0.0004	0.0004		0.0001	0.0002
HI	0.0256	-0.0534	-0.0144	-0.0324	-0.0236	-0.0235	0.0128	-0.0900	-0.0084	-0.0395	-0.0213	0.0059	0.0464	-0.0165		-0.0727
GW	-0.0304	-0.0255	-0.0714	-0.0269	-0.0586	-0.0469	-0.0490	0.1476	0.0715	0.1342	0.0312	0.0502	0.0106	-0.0326	-0.1046	
TGY	**-0.1071**	**-0.1608**	**-0.0758**	**-0.0343**	**0.0761**	**-0.0620**	**-0.0040**	**0.2395***	**0.0598**	**0.3764*****	**0.4007*****	**0.5246*****	**0.6073*****	**-0.1470**	**0.1382**	**0.4149*****
Indirect effect	-0.1707	-0.1557	0.0868	-0.0526	0.1175	0.0785	-0.0806	0.1194	-0.0315	0.1423	0.1662	0.0779	0.3956	-0.0022	0.2509	0.3613
Partial R^2	0.0183	0.0250	-0.0066	0.0018	0.0089	-0.0049	0.0003	0.0286	-0.0019	0.0536	0.0666	0.0409	0.2402	0.0003	0.0347	0.1499

R Square = 0.6558 Residual effect = 0.5867.

plant vigour had negative and significant correlation with days to germination. Similarly, Shengu *et al.* (2018) reported positive and significant association between seed index and total grain yield but negative and significant association between pod length and total grain yield. The traits which have positive significant relationship with seed yield could be useful for selection of genotypes through these characters with high yield potential. These results are confirmation with the result of Kumar *et al.* (2019); Mir *et al.* (2018) and Jain *et al.* (2019).

Path analysis

Total grain yield had the highest positive and direct effect on the number of seed per pod (0.607), number of pod per plant (0.524), seed index (0.414), number of secondary branches (0.400), number of primary branches (0.376), height of first pod (0.239) and harvest index (0.138). These results was similar to the finding of Samyuktha *et al.* (2017) and Pandey *et al.* (2013), who estimated the maximum direct positive effect of number of pod per plant and seed index on single plant yield. The direct and indirect effects of all yields contributing components on seed yield are presented in Table 5. Lenka and Mishra (1973) suggested the measurement of direct and indirect effect of yield components on yield and characterize as negligible (0.00 to 0.09), low (0.10 to 0.19), moderate (0.20 to 0.29), high (0.30 to 0.99) and very high (> 1.00).

This study shows negligible or very low (0-0.09) indirect effect of the maximum characters under studies. The indirect effect of some traits *viz*. height of first pod *via* seed index (0.147), number of primary branches via seed index (0.134), number of secondary branches via number of seed per plant (0.170) and number of pod per plant *via* number of seed per plant (0.299) had low and moderate indirect effect on total grain yield while the negative indirect effect was recorded for harvest index *via* seed index (-0.104). The maximum overall positive indirect effect was observed for the traits such as number of seed per pod (0.395), seed index (0.361) and harvest index (0.250). The positive indirect effect of days to 50% flowering *via* biological yield, number of pod per plant, seed index and number of primary branches was also reported by Kumar *et al*. (2019). The direct selection of traits which have highly positive influences on the seed yield would be effective for improvement in the grain yield of genotypes. The maximum value of partial correlation was observed for number of seed per pod (0.240) followed by seed index (0.149) and number of secondary branches (0.066). The higher level of residual effect (0.586) indicated that other variables needs to be considered in future studies. The direct and indirect effect of yield contributing traits on seed yield is presented in Fig 2.

Selection indices

Seed yield is a low heritable complex trait, thus direct selection are not reliable to improve productivity. A selection index is the useful method to exploit correlation among component trait with seed yield. The result of selection indices in respect of seed yield of ten best genotypes are shown in Table 6. Selection indices were observed ranging from 629.31 to 1168.12. The highest selection index value was recorded for the genotype ICVT 181106 and the lowest for PDG-4 genotype. On the basis of the index, the 10 best

Table 6: Selection indices for seed yield and seed yield percent in germplasm lines of chickpea.

Lines	Selection indices (seed yield)	Selection indices percent
ICVT-181106	1168.12	1.43
ICVT-181107	1160.22	1.42
PUSA-1053	1146.39	1.41
JG 218	1100.50	1.35
GNG-1999	1087.37	1.33
ICVT-181102	1040.34	1.28
HC 5	1036.85	1.27
GNG 1926	974.78	1.20
Vijay	972.56	1.19
JG 24	969.85	1.19

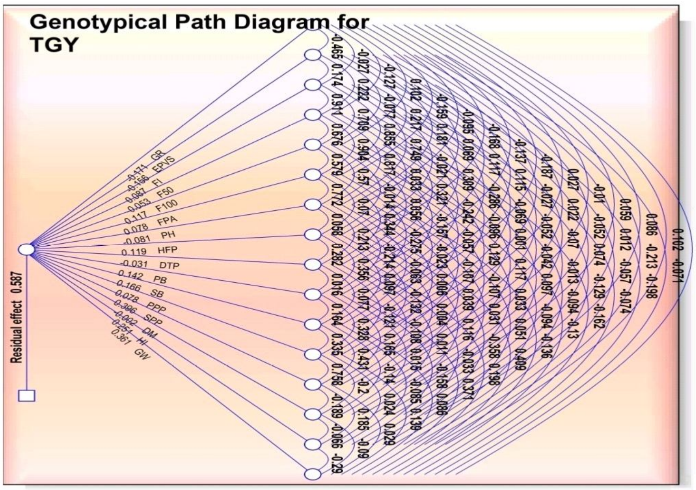

Fig 2: Direct and indirect effect of yields contributing components on seed yield in chickpea.

genotypes were selected under studies and they were given in descending order as follows ICVT 181106, ICVT 181107, PUSA-1053, JG 218, GNG-1999, ICVT 181102, HC 5, GNG 1926, Vijay and JG 24. Asghar *et al.* (2010) reported that the selection indices were found most effective in improving genotype in sweet corn.

CONCLUSION

The significant positive correlation of component traits with seed yield is useful in selecting genotypes with high yield potential. Seed yield showed positive and significant correlation with number of seed per pod followed by number of pod per plant, seed index and number of primary branches. Using correlation coefficient, genotypes selection with high yield potential would be effective. The traits, number of seed per pod, number of pod per plant, seed index, number of secondary branches and number primary branches, height of first pod and harvest index had positive and direct effect on the seed yield could also be effective for direct selection of genotypes. The trait with high heritability would be important for selection of potential parents for hybridization program. The genotype ICVT 181106 identified with highest selection indices for seed yield followed by ICVT 181107, PUSA-1053, JG 218 and GNG-1999. The knowledge generated on character association, genetic parameters and selection indices through the presented study will be utilised in future chickpea breeding programme.

REFERENCES

Ahuja, S., Malhotra, P.K., Bhatia, V.K. and Parsad, R. (2008). Statistical Package for Agricultural Research (SPAR 2.0).

Asghar, M.J. and Mehdi, S.S. (2010). Selection indices for yield and quality traits in sweet corn. Pakistan Journal of Botany. 42(2): 775-789.

Aswathi, P.V., Ganesamurthy, K. and Jayamani, P. (2019). Genetic variability for morphological and biometrical traits in chickpea (*Cicer arietinum* L.). Electronic Journal of Plant Breeding. 10(2): 699-705.

DAC and FW, (2017-18), A.S.C.I. and NSDC, M., e-Bulletin.

Dewey, D.H. and Lu, K.H. (1959). A correlation and path analysis of components of crested wheat grass production. Journal of Agronomy. 51: 515-518.

FAOSTAT (2018). Statistical Databases. Food and Agriculture Organization of the United Nations.

Jain, M., Swarup, I., Panwar, N.K., Puri, P. and Meena, G. (2019). Assessment of polygenic character's association with yield in chickpea genotypes. International Journal of Chemical Studies. 7(3): 2507-2511.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimates of genetic and environmental variability in soybeans 1. Agronomy Journal. 47(7): 314-318.

Kuldeep, R., Pandey, S., Babbar, A. and Mishra, D.K. (2014). Research Note Genetic variability, character association and path coefficient analysis in chickpea grown under heat stress conditions. Electronic Journal of Plant Breeding. 5(4): 812-819.

Kumar, S., Suresh, B.G., Kumar, A. and Lavanya, G.R. (2019). Genetic variability, correlation and path coefficient analysis in chickpea (*Cicer arietinum* L.) for yield and its component traits. International Journal Current Microbiology and Applied Science. 8(12): 2341-2352.

Kumar, S., Suresh, B.G., Kumar, A. and Lavanya, G.R. (2019). Genetic variability in chickpea (*Cicer arietinum* L.) under heat stress condition. Current Journal of Applied Science and Technology. 1-10.

Lenka, D. and Misra, B., (1973). Path-coefficient analysis of yield in rice varieties. Indian Journal of Agricultural Sciences. 43(4): 376-379.

Mir, A.H., Fayaz, H., Bhat, M.A., Sofi, A.A.W.P.A. and Mir, R. (2018). Correlation and principal component analysis for study of yield improvement in chickpea genotypes in kashmir valley in north India. International Journal of Current, Agricultural Sciences. 8(A): 307-310.

Mohan, S. and Thiyagarajan, K. (2019). Genetic variability, correlation and path coefficient analysis in chickpea (*Cicer arietinum* L.) for yield and its component traits. International Journal Current Microbiology Applied Science. 8(05): 1801-1808.

Padmavathi, P.V., Murthy, S.S. and Rao, V.S. (2013). Correlation and path coefficient analysis in kabuli chickpea (*Cicer arietinum* L.). International Journal of Applied Biology and Pharmaceutical Technology. 4(3): 107-110.

Pandey, A., Gupta, S., Kumar, A., Thongbam, P.D. and Pattanayak, A. (2013). Genetic divergence, path coefficient and cluster analysis of chickpea (*Cicer arietinum* L.) cultivars, in the mid-altitudes of Meghalaya. Indian Journal of Agricultural Sciences. 83(12): 1300-4.

Robinson, H.F., Comstock, R.E. and Harvey, P.H. (1949). Estimates of heritability and degree of dominance in corn. Agronomy Journal. 41: 253-259.

Samyuktha, S.M., Geethanjali, S. and Bapu, J.R. (2017). Genetic diversity and correlation studies in chickpea (*Cicer arietinum* L.) based on morphological traits. Electronic Journal of Plant Breeding. 8(3): 874-884.

Sharma, R.N., Johnson, P.L., Nanda, H.C., Sao, A., Sarawgi, A.K., Umesh, S.K., Prabha, N. and Singh, A.K. (2019). Genetic variability, character association and coheritability for yield traits over the locations in chickpea (*Cicer arietinum* L.). Legume Research. DOI: 10.18805/LR-4150.

Shengu, M.K., Hirpa, D. and Wolde, Z. (2018). Genetic variability of some chickpea (*Cicer arietinum* L.) genotypes and correlation among yield and related traits in humid tropics of southern Ethiopia. Journal of Plant Breeding and Crop Science. 10(10): 298-303.

Smith, H.F., 1936. A discriminant function for plant selection. Annals of Eugenics. 7(3): 240-250.