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Dissection of genetic variability, correlation of seed yield and yield contributing traits in chickpea (*Cicer arietinum* L.) in different temperature conditions

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Abstract
The present experiment was conducted at research farm of All India Coordinated Research Project on Chickpea, R.A.K., College of Agriculture, Sehore (M.P.). The experimental material consisted of 28 diverse genotypes including 19 desi and 9 kabuli genotypes of chickpea laid out in Randomized Complete Block Design with two replications, were tested in consecutively two year under different sowing condition to provide optimum, normal and high stress conditions to the genotypes and genetic parameters, correlations observed. The analysis of variance is clearly indicating the impact of environment, G×E interactions observed significant for all traits. All the traits affected severely under stressful condition, because of high temperature. The days to flower initiation reduced by 5 days, days to 50% flowering reduced by 3 days, Days to pod initiation reduced by 17 days, plant height reduced by 17(cm), Days to maturity reduced by 23 days, number of pods per plant reduced by 33, number of empty pods per plant reduced by 1.15, number of seeds per plant reduced by 20.68, biological yield per plant reduced by 9.91(g), harvest index reduced by 6.91, hundred seed weight reduced by 4.78 (g), and seed yield per plant reduced by 5.06 (g) in normal to stress condition. PCV and GCV and heritability was almost high everywhere. The seed yield per plant was noticed significant and positively associated with number of pods per plant, number of seeds per plant, biological yield per plant, harvest index, hundred seed weight and pollen fertility while its significant and negatively correlated with days to flower initiation, days to 50% flowering, days to pod initiation in all the environmental conditions. For increasing seed yield due importance should be put on number of pods per plant, number of seeds per plant, biological yield per plant, harvest index, hundred seed weight and pollen fertility.

Keywords: Chickpea, correlation, heritability, genetic advance, seed yield

Introduction
Chickpea (*Cicer arietinum* L.) is one of the earliest cultivated legumes, also known as Gram or Bengal gram or garbanzo bean. These are originally found in Mediterranean and Middle East region about 7500 years ago and now it is one of the most important legume crops widely growing all over the world ranking third in production among the pulses. The name chickpea is derived from the French word "chiche" and the genus "cicer" which is Latin of chickpea. Chickpea is well adapted within temperature range of 30- 15 °C (day maximum and night minimum) for growth and pod filling, (Basu *et al*. 2011) [1]. A temperature of 35°C was found to be critical in differentiating heat tolerant and sensitive genotypes in chickpea under field conditions (Gaur *et al*. 2013) [4]. Hence, the present study was attempted to explicate the genetic variation, association studies between yield and yield contributing traits chickpea over three different sowing conditions (optimum, medium, vary late) with two seasonal conditions.

Materials and Methods
The present experiment was conducted in the experimental site of All India Coordinated Research Project on Chickpea at R.A.K., College of Agriculture, Sehore (M.P.) during Rabi 2020-21 and 2021-2022. The experimental material consisted of 28 genotypes including 19 desi and 9 kabuli genotypes of chickpea laid out in Randomized Complete Block Design with two replications. All recommended package of practices was followed during the cropping period to raise a good crop.

The observation for thirteen morphological traits [days to flower initiation, days to 50% flowering, days to pod initiation, plant height (cm), days to maturity, number of pods per plant, number of empty pods per plant, number of seeds per plant, biological yield per plant (g),harvest index (%), hundred seed weight (g), pollen fertility (%), seeds yield per plant (g). The data was subjected to the standard statistical analysis for genetic parameters, correlation coefficient and path analysis. Correlation coefficients were estimated for all the character combinations at genotypic and phenotypic levels by the procedure suggested by Miller *et al*. (1958) [8]. Heritability for the present study was calculated in broad sense by adopting the formula suggested by Robinson *et al*. (1949) [15]. Expected genetic advance was calculated by the method suggested by Johnson *et al*. (1955) [9]. Genotypic and phenotypic coefficient of variance was evaluated according to Burton and Devane (1953) [3] based on estimate of genotypic and phenotypic variance.

Results and Discussion

A. Analysis of variance

The analysis of variance indicated that the mean sum of square due to genotypes, environments, in all three individual optimum, mid late and late sown (in each year) environmental conditions and in pooled analysis were significant for all traits indicating the existence of considerable variability for some significant concerned characters in the present material which showed sufficient genetic variation in the genotypes, suggesting genotypes evaluated in this present study has broad genetic base (Table 1,2). As, genetic variability, the indispensable demand for any crop improvement programme, hence, utilization of these variability may accelerate to develop promising genotype in the future is the ultimate aim of plant breeder. It provides broad genetic base to genotypes to survive under wide range of changing environmental conditions. The existing of high genetic variability for seed yield per plant and its contributing traits furnish greater opportunity for utilization in further chickpea breeding programme. Results revealed that phenotypic coefficient of variation was higher than genotypic coefficient of variation that agreement with findings of Borate *et al*., (2010) [2] suggesting considerable role of environment over these traits.

B. Genetic parameters of variability

Phenotypic and genotypic coefficient of variances

A magnitude of high PCV % and GCV % for different traits revealed that the maximum amount of variability were found for plant height, number of pods per plant, number of empty pods per plant, number of seeds per plant, biological yield per plant, harvest index, hundred seed weight, seed yield per plant, leaf area at 45 days, leaf area at 60 days, leaf area index at 45 days after sowing, leaf area index at 60 days after sowing, crop growth rate, and total dry matter at 40, 60 days after sowing in all environmental conditions in chickpea. The PCV % was higher than the GCV% for all the traits. The highest genotypic and phenotypic coefficient of variation were recorded for Number of empty pods per plant (84.71% and 86.85%) followed by seed yield per plant (49.85% and 51.30%), Number of seeds per plant (48.17% and 48.37%), 100 Seed weight (46.27% and 46.61%), number of pods per plant (41.25% and 41.35%), Biological yield per plant (41.17% and 42.29%) in optimum sowing condition (E-I), whereas in mid late sown condition (E-II) for yield and yield attributing traits Number of empty pods per plant (82.75% and 87.83%), number of seeds per plant (52.79% and 54.06%), number of pods per plant (49.52% and 50.32), 100 seed weight (47.17% and 47.65%), seed yield per plant (45.85% and 50.07%) and harvest index (38.98% and 39.45) showed highest genotypic and phenotypic coefficient of variation. And in late sown condition (E-III) for yield and yield attributing traits, number of seeds per plant (92.49% and 94.94%), followed by number of empty pods per plant (87.90% And 93.47%), number of pods per plant (77.09% and 78.25%), seed yield per plant (74.93% and 79.33%), Plant height (67.20% and 68.31%) and 100 seed weight (57.98% and 59.13%) showed highest genotypic and phenotypic coefficient of variation. A trait having high GCV reveals high potential for effective selection for further breeding programme. These results are agreement to the findings of Hagos *et al*., (2018) [5], with three genotypes, Joshi *et al*., (2018) [10] in 252 intra-specific recombinant inbred line (RIL) population and Singh *et al*., (2017) [17] in 56 chickpea genotypes, Selection of these traits would be rewarding for chickpea improvement. Shanmugam and Kalaimagal (2020) [15] revealed little difference between phenotypic and genotypic variance for the days to 50% flowering and days to maturity, whereas number of secondary branches per plant, number of pods per plant, number of seeds per plant and seed yield per plant were more influence by the environment which is indicated by more difference between the phenotypic and genotypic coefficient of variation. (Table-3)

Heritability and Genetic advance.

Heritability depicts the proportion of phenotypic variance that is due to genotype. It is a good index of the transmission of characters from parents to their offspring and provides effectiveness of selection for improving traits.

High heritability in broad sense was observed in optimum sowing condition (E-I) for number of pods per plant (99.52%) followed by Number of seeds per plant (99.18%), days to flower initiation (98.65%), hundred seed weight (98.52%), days to 50 per cent flowering (98.03%), days to pod initiation was (97.40%), days to maturity (96.09%), number of empty pods per plant (95.13%), Biological yield per plant (94.76%), seed yield per plant (94.46%), plant height (94.33%), pollen fertility (91.63%), Harvest index (89.28%), Whereas in mid late sown condition (E-II) for 100 seed weight was (98%) followed by number of pods per plant (96.83%), days to flower initiation (96.51%), number of seeds per plant (95.36%), days to maturity (94.90%), plant height (92.52%), biological yield per plant (92.22%), days to pod initiation (91.80%), days to 50 percent flowering (91.36%), number of empty pods per plant (88.75%), Harvest index (88.53%), pollen fertility (84.57%) and seed yield per plant (83.87%), and in late sown condition (E-III) for number of pods per plant (97.05%) followed by plant height (96.77%), 100 seed weight (96.15%), days to flower initiation (95.15%), number of seeds per plant (94.90%), biological yield per plant (93.96%), days to maturity (93.65%), days to 50 percent flowering (92.27%), days to pod initiation (90.44%), seed yield per plant (89.21%), number of empty pods per plant (88.42%), Pollen fertility (82.97%) and Harvest index (74.62%). Similar findings were noted by padmavathi *et al*. (2013) [12] reported similar result for biological yield per plat and seed yield per plan in 30 kabuli chickpea, Rajkumar *et al*. (2014) [13] reported high heritability with high GCV & PCV was noted for the characters *viz*. seed yield per plant, followed by 100 seed weight, harvest index, total number of pods per plant in 100 advance breeding lines in chickpea. Vijayakumar *et al*. (2019) [19] with Twenty five breeding lines of two crosses JG 11 x JG 14 and JAKI 9218 x JG 14 for days to maturity and hundred seed weight, days to first and 50% podding in chickpea under late sown environment. Katkani *et al* (2022) [6] revealed that high extent of heritability was detected in 100 seed weight followed by seed yield per plant, number of effective pods per plant, harvest index and biological yield per plant.

High Genetic advance as percentage of mean was noted maximum in optimum sowing condition (E-I) for number of empty pods per plant was (179.91%), followed by seed yield per plant (105.68%), number of seeds per plant (99.65%), hundread seed weight (96.03%), biological yield per plant (87.12%), number of pods per plant (85.19%), plant height (55.54%), harvest index (38.90%),days to flower initiation (38.80%), days to 50% flowering (30.11%), days to pod initiation (27.81%),while in mid late sown condition (E-II) for number of empty pods per plant (180.94%), number of seeds per plant (111.36%), number of pods per plant (103.67%), seed yield per plant (103.14%), 100 seed weight was (98.17%), biological yield per plant (80.06%), plant height (53.65%), harvest index (48.66%), days to flower initiation (34.27%), days to 50 percent flowering (30.49%), days to pod initiation (26.49%). although in late sown condition (E-III) for number of seeds per plant (195.59%), number of empty pods per plant (192.56%), seed yield per plant (163.42%), number of pods per plant (161.20%), plant height (140.72%), 100 seed weight (121.82%), biological yield per plant (109.12%), harvest index (81.16%), days to flower initiation (39.92%), showed high genetic advance as percentage of mean was noted. (Table-3)

Heritability estimates along with genetic advance were more helpful than heritability alone in predicting the resultant gain under selection of best individual. In the current study, high heritability along with high genetic advance as percentage of mean was observed for days to flower initiation, days to 50% flowering, days to pod initiation, plant height, number of pods per plant, number of empty pods per plant, number of seeds per plant, biological yield per plant, harvest index, 100 seeds weight, seed yield per plant, leaf area at 45 days, leaf area at 60 days, leaf area index at 45 days, leaf area index at 60 days, total dry matter at 45 days, total dry matter at 60 days, and crop growth rate in all optimum, late and very late sowing conditions, and days to maturity in E-I, E-II. The above results were in agreement with findings of Padmavathi *et al*. (2013) [12] for biological yield per plant and seed yield per plant. Rajkumar *et al*. (2014) [13] in 100 advance breeding lines Lines of chickpeas for seed yield per plant, harvest index. Ram *et al*. (2021) [14] for 100 seed weight, number of effective pods per plant and biological yield per plant and Xalxo *et al*. (2021) for 100 seed weight. Katkani *et al* (2022) [6] revealed that High heritability along with high genetic advance as percentage of mean was presented by100 seed weight, seed yield per plant, number of effective pods per plant, harvest index and biological yield per plant.

Association analysis among quantitative traits

Knowledge of correlation is of great significant as all the biological attributes are the inter play of several factors among themselves and their individual and combined interaction with the environmental factors it also provides opportunity to estimates the correlated response to directional selection to predict genetic gain and thus could be utilized as selection parameter for formulation effective breeding programme correlation could be at phenotypic, genotypic or environmental level. Phenotypic correlation which includes genetic and non-genetic effects. A positive correlation between the desired traits is required by breeder for effective selection (Table 4). in optimum temperature condition (E-I) seed yield per plant was Exhibited highly significant and positive correlation with number of pod per plant (0.346**), number of seeds per plant (0.611), biological yield per plant (0.573**), harvest index (0.363**), hundred seed weight (0.309**), and pollen fertility (0.373**), whereas In mid late sowing condition (E-II) number of pods per plant (0.489**), number of seeds per plant (0.628**), biological yield per plant (0.715**), harvest index (0.387**), hundred seed weight (0.378**), and pollen fertility (0.311**), and In late sowing condition (E-III) seed yield per plant showed highly Significant and positive correlation with plant height (0.283**), number of pods per plant (0.507**), number of seeds per plant (0.770**), biological yield per plant (0.624**), harvest index (0.365**), hundred seed weight (0.391**), pollen fertility (0.194*). In the other hand significant and negative correlation with days to flower initiation (-0.406**), days to 50% flowering (-0.295**), and days to pod initiation (-0.258**) in optimum temperature condition (E-I), while flower initiation (-0.341**), days to 50% flowering (-0.307**), and days to pod initiation (-0.326**) in mid late sowing condition (E-II), whereas days to flower initiation (-0.279**), days to 50% flowering (-0.289**), and number of empty pods per plant (-0.186*) in late sowing condition (E-III), (Table 4). Similar findings for the seed yield were reported by several other researchers, the seed yield had positive significant associated with harvest index and number of pods per plant by Narayan and Reddy (2002) [11], Sohaib *et al*. (2016) [18] exhibited number of seeds per plant and harvest index had a significant and positive association with seed yield in chickpea. Rajkumar *et al*. (2014) [13] also found seed yield significantly highly positive correlation with plant height, number of primary branches, number of secondary branches, number of pods per plant and 100 seed weight reported in chickpea. Kumawat *et al* (2021) [7] observed seed yield per plant showed highly significant and positive association with biological yield per plant, harvest index, 100 seed weight, total number of effective pods per plant. This experiment revealed that number of seeds per plant, had the highest positive direct effect on seed yield per plant followed by biological yield per plant. For increasing seed yield due importance should be put on number of pods per plant, number of seeds per plant.

Table 1: Pooled Analysis of variance for yield and its contributing traits in chickpea genotypes over different environmental conditions

Source	D.f.	Mean sum of square												
		Days to flower initiation	Days to 50% flowering	Days to pod initiation	Plant height (cm)	Days to maturity	Number of pods per plant	Number of empty pods per plant	Number of seeds per plant	Biological yield per plant (g)	Harvest index (%)	100 seed weight (g)	Pollen fertility (%)	Seed yield per plant (g)
Replication	**3**	0.09	0.44	0.47	2.05	3.00	1.40	0.49	4.40	1.76	0.43	0.56	0.93	0.64
Environment	2	138.25**	539.58**	997.07**	4188.77**	8281.10**	4359.75**	34.37**	6138.67**	1609.72**	1125.51**	157.71**	546.07**	428.27**
Genotype	27	132.51**	151.34**	136.57**	155.37*	121.22**	453.96**	30.78**	709.56**	95.44**	142.73**	431.16**	3.54*	19.74**
G×E	54	2.88**	4.81**	16.57**	90.80**	52.32**	145.36**	14.52**	118.54**	39.09**	61.91**	4.55**	1.95*	8.35**
Pooled error	81	0.70	1.50	2.31	3.78	2.47	2.57	0.85	5.15	1.83	9.43	2.28	1.19	0.58

Note: * and ** significant at 5% and 1% level of probability, respectively

Table 2: Analysis of variance for seed yield and its contributing traits in different (E-I, E-II, E-III) environmental conditions in chickpea

Source of Variation	ENV.	d.f.	Mean sum of square												
			DFI	D50%F	DPI	PH (cm)	DM	NPP	NEPP	NSPP	BYPP (g)	HI	100SWT (g)	PF	SYPP
Replication	E1	2	0.86	1.15	2.01	6.09	1.11	0.41	0.86	6.29	4.79	0.44	7.54	0.95	1.43
	E2		2.47	10.04	2.15	10.07	10.42	1.92	1.40	7.79	1.05	0.80	0.74	0.02	0.83
	E3		0.51	0.71	5.82	3.31	3.65	1.95	4.67	30.65	4.45	8.66	1.80	0.99	0.89
Environment	E1	1	8.58**	315.73**	12.89*	550.04**	1309.72**	2850.5**	6.98*	1278.17**	27.61*	54.76**	15.02**	61.19**	6.22*
	E2		33.22**	8058**	8058**	760.05**	408.89**	376.11**	19.68**	259.47**	36.78**	313.80**	15.03*	121.29**	24.19**
	E3		78.89**	34.32**	155.57**	89.32**	1715.79**	200.80**	11.47*	129.36**	95.18**	553.82**	68.24**	16.77*	32.54**
Genotype	E1	27	106.21**	124.47**	155.04**	266.67**	231.97**	501.78**	51.83*	749.43**	167.24**	117.57**	277.74**	21.90*	42.31**
	E2		90.25**	112.27**	121.90**	209.84**	132.47**	489.91**	28.13*	499.12**	79.75*	148.85**	252.61**	22.85**	16.59*
	E3		94.64**	64.78**	62.93**	385.14**	131.03**	519.36**	39.68**	644.72**	84.81**	285.39**	306.31**	29.34**	15.23**
G*E	E1	27	21.48**	23.21**	19.17*	75.21**	32.31**	248.15**	25.27**	133.45**	7.72*	12.00*	40.80**	8.66**	2.36*
	E2		20.77**	15.12**	10.14*	99.47**	44.22**	189.47**	11.89**	174.69**	33.23**	25.16**	19.49**	8.47**	8.24**
	E3		10.04**	11.24**	17.44**	27.99**	68.13**	30.23**	4.32*	51.44**	8.27**	142.62**	20.02**	4.46*	4.12**
Error	E1	54	0.71	1.22	2.03	7.77	4.61	1.18	1.29	3.08	4.49	6.65	2.06	0.95	1.20
	E2		1.34	5.06	5.21	8.14	3.46	7.70	1.67	11.87	3.22	5.70	2.54	2.09	1.45
	E3		2.35	2.60	3.15	6.31	4.29	7.75	2.43	16.86	2.63	4.87	6.00	2.46	1.86

Note: * and ** significant at 5% and 1% level of probability, respectively

Table 3: Genetic parameters of variation for seed yield and its contributing traits over different (E-I, E-II, E-III) environmental conditions

Characters	Env.	Mean	Range		h^2 (bs) (%)	GCV (%)	PCV (%)	Genetic advance	GA as % of mean
			Max	Min					
Days to flower initiation	E-I	39.03	53	33	98.65	18.70	18.83	15.06	38.80
	E-II	37.45	50	32	96.51	16.34	16.64	12.78	34.27
	E-III	35.87	48	30	95.15	18.90	19.38	14.34	39.92
Days to 50 percent flowering	E-I	54.21	69	48	98.03	14.47	14.61	16.30	30.11
	E-II	51.74	66	45	91.36	14.15	14.80	15.77	30.49
	E-III	48.74	66	40	92.27	11.76	12.24	11.95	25.22
Days to pod initiation	E-I	65.68	85	55	97.40	13.32	13.50	18.25	27.81
	E-II	61.97	83	55	91.80	12.32	12.86	16.42	26.49
	E-III	57.07	68	50	90.44	9.52	10.01	11.84	20.63
Plant height (cm)	E-I	43.55	58	29	94.33	26.18	26.96	24.13	55.54
	E-II	40.08	55	26	92.52	25.05	26.04	21.50	53.65
	E-III	30.68	41	22	96.77	67.20	68.31	28.82	140.72
Days to maturity	E-I	105.1	114	84	96.09	10.16	10.37	22.40	21.36
	E-II	95.20	102	86	94.90	8.45	8.68	16.98	17.88
	E-III	81.21	91	73	93.65	10.01	10.34	16.94	21.31
Number of pods per plant	E-I	39.22	67	24	99.52	41.25	41.35	32.66	85.19
	E-II	29.83	57	11	96.83	49.52	50.32	31.77	103.67
	E-III	20.50	40	7	97.05	77.09	78.25	33.44	161.20
Number of empty pods per plant	E-I	5.97	13	2	95.13	84.71	86.85	10.61	178.91
	E-II	4.65	11	1	88.75	82.75	87.83	7.95	180.94
	E-III	4.82	14	2	88.42	87.90	93.47	9.45	192.56
Number of seeds per plant	E-I	39.4	66	18	99.18	48.17	48.37	39.95	99.65
	E-II	29.13	51	10	95.35	52.79	54.06	32.92	111.36
	E-III	18.72	46	5	94.90	92.49	94.94	37.46	195.59
Biological yield per plant (g)	E-I	20.94	31	15	94.76	41.17	42.29	19.08	87.12
	E-II	16.26	25	7.65	92.22	37.32	38.86	13.26	80.06
	E-III	11.03	24	4.81	93.96	51.35	52.97	13.62	109.12
Harvest Index	E-I	40.91	54.34	27.96	89.28	17.84	18.83	16.23	38.90
	E-II	37.92	48.73	28.77	88.53	38.98	39.45	18.10	48.66
	E-III	34.0	46.35	20.25	74.62	34.03	39.40	26.33	81.16

100 seed weight (g)	E-I	25.88	49.80	11.40	98.52	46.27	46.61	24.36	96.03
	E-II	23.98	44	10.42	98	47.17	47.65	23.26	98.17
	E-III	21.1	40.61	8.72	96.15	57.98	59.13	25.74	121.82
Pollen fertility	E-I	95.53	97.52	94.07	91.63	3.40	3.55	6.96	7.32
	E-II	92.54	93.80	90.09	84.57	3.66	3.99	7.58	8.22
	E-III	89.31	92.67	87.39	82.97	3.82	4.12	8.72	9.49
Seed yield per plant	E-I	8.64	13.12	4.89	94.46	49.85	51.30	9.60	105.68
	E-II	5.93	9.21	2.59	83.87	45.85	50.07	6.18	103.146
	E-III	3.58	8.51	1.44	89.21	74.93	79.33	5.84	163.42

Table 4: Correlation coefficient analysis between phonological traits under different temperature conditions (E-I, E-II, E-III)

Characters	Env.	DFI	D50F	DPI	PH	DM	NPP	NEPP	NSPP	BYPP	HI	TW	PF	SYPP
DFI	E-I	1	0.6991 **	0.7123 **	0.1502	0.2631 **	0.0791	-0.1088	-0.2373 *	-0.1097	-0.2891 **	-0.4507 **	-0.1734	-0.4061 **
	E-II	1	0.7063 **	0.564 **	-0.1574	0.2329 *	0.0213	0.161	-0.2698 **	-0.2699 **	-0.1647	-0.47 **	-0.137	-0.3801 **
	E-III	1	0.6379 **	0.5999 **	-0.096	0.3184 **	0.0134	0.3718 **	-0.2489 **	-0.3245 **	-0.0546	-0.5351 **	-0.0709	-0.2792 **
D50F	E-I		1	0.7296 **	0.1788	0.1835	0.1737	0.0243	-0.1467	-0.1114	-0.2141 *	-0.5071 **	-0.2493 **	-0.2956 **
	E-II		1	0.5877 **	-0.1121	0.1327	0.1509	0.2532 **	-0.2177 *	-0.2148 *	-0.1086	-0.4749 **	-0.0876	-0.3075 **
	E-III		1	0.4989 **	-0.185	0.0992	-0.0751	0.2959 **	-0.3144 **	-0.4157 **	-0.1275	-0.5404 **	-0.1533	-0.2891 **
DPI	E-I			1	0.3762 **	0.3932 **	0.2676 **	0.0369	-0.2185 *	0.0494	-0.2693 **	-0.381 **	-0.0357	-0.2589 **
	E-II			1	0.0944	0.4201 **	0.192 *	0.3533 **	-0.2925 **	-0.1011	-0.1709	-0.3425 **	0.0211	-0.3267 **
	E-III			1	-0.1806	0.3746 **	0.2291 *	0.3979 **	-0.0815	-0.1368	-0.1938 *	-0.4258 **	-0.037	-0.1496
PH	E-I				1	0.5638 **	0.0573	0.0978	-0.1636	0.2908 **	-0.0228	0.0941	0.1149	0.1518
	E-II				1	0.172	-0.0496	-0.0662	-0.2458 **	0.0584	0.0273	0.1736	0.2596 **	0.0877
	E-III				1	-0.1182	0.0843	-0.1042	0.1341	0.3356 **	0.0982	0.1905 *	0.2406 *	0.283 **
DM	E-I					1	0.11	0.0578	-0.1296	0.1202	-0.011	-0.0119	0.0287	-0.0307
	E-II					1	-0.0548	0.1547	-0.3378 **	-0.019	-0.1841	-0.0347	0.067	-0.1361
	E-III					1	0.2818 **	0.2392 *	-0.0411	0.0549	0.0124	-0.0785	0.0434	-0.1607
NPP	E-I						1	0.3767 **	0.5369 **	0.5543 **	0.0114	-0.2709 **	0.3041 **	0.3461 **
	E-II						1	0.4037 **	0.5977 **	0.6317 **	0.144	-0.0817	0.2293 *	0.4897 **
	E-III						1	0.3608 **	0.7042 **	0.6739 **	0.2515 **	0.1638	0.1071	0.5079 **
NEPP	E-I							1	-0.0038	0.2097 *	-0.218 *	0.0609	-0.0353	0.0934
	E-II							1	0.0289	0.0106	-0.0548	-0.2176 *	-0.0159	-0.1411
	E-III							1	-0.0597	-0.061	-0.1206	-0.3437 **	0.0286	-0.186 *
NSPP	E-I								1	0.2755 **	0.2567 **	-0.2706 **	0.1917 *	0.6113 **
	E-II								1	0.6035 **	0.2058 *	0.0474	0.1491	0.6289 **
	E-III								1	0.7327 **	0.2187 *	0.3194 **	0.0342	0.7703 **
BYPP	E-I									1	-0.0761	0.3293 **	0.4852 **	0.5734 **
	E-II									1	0.0963	0.3629 **	0.3069 **	0.7152 **
	E-III									1	0.1763	0.5094 **	0.1363	0.6242 **
HI	E-I										1	0.1936 *	0.1572	0.3631 **
	E-II										1	0.1476	0.1198	0.3877 **
	E-III										1	0.1017	0.226 *	0.3657 **
100SW	E-I											1	0.2274 *	0.3099 **
	E-II											1	0.1194	0.3784 **
	E-III											1	0.2686 **	0.3931 **
PF	E-I												1	0.3733 **
	E-II												1	0.3115 **
	E-III												1	0.1947 *

Note: * and ** significant at 5% and 1% level of probability, respectively

Where, DFI: Days to flower initiation, D50%F: Days to 50% flowering, DPI: Days to pod initiation, DM: Days to maturity, PH: Plant height, NPPP: Total number of pods per plant, NEPP: Number of effective pods per plant, NSPP: Number of seeds per pod, 100 SW: 100 seed weight, BY: Biological yield per plant, HI: Harvest index, PF: Pollen fertility, and SYPP: Seed yield per plant.

Conclusions

The analysis of variance showed genotypes were highly significant for all the traits suggesting presence of considerable amount of variation for all the traits among the genotypes suggesting genotypes evaluated in this present study has broad genetic base. Hence, utilization of these variability may accelerate to develop promising genotype in the future is the ultimate aim of plant breeder. high PCV % and GCV% for different traits revealed that the maximum amount of variability were found for plant height, number of pods per plant, number of empty pods per plant, number of seeds per plant, biological yield per plant, harvest index, hundred seed weight, seed yield per plant, in all environmental conditions in chickpea, Hence, selection of these traits may be productive for further chickpea breeding programme. High heritability coupled with high genetic advance as % of mean were noted for all traits, in all optimum, late and very late sowing conditions, suggested primarily the existence of additive gene action and provides the possibility of enhancing these traits through simple selection. Seed yield per plant was noticed significant and positively associated with number of pods per plant, number of seeds per plant, biological yield per plant, harvest index, hundred seed weight and pollen fertility in all the environmental conditions hence, designing the plant ideotype by selecting these traits for seed yield.

Future Scope

The current analysis provides a better path forward for the chickpea breeding programme. Furthermore, an ideotype should be created using evidence from phenotypic and genotypic coefficients of variation, heritability, genetic advancement, and association studies. Promising genotypes should be evaluated across years and locations to estimate their stability and yield and yield attributing traits in different agro-climatic zones for long-term chickpea production. As a result, incorporating these genotypes into a hybridization programme may result in possible pre-breeding in chickpea.

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