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Genetic variability and correlation studies for yields and its component traits in chickpea under three sown environments

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Abstract
A field experiment was conducted during Rabi, 2019-20 at Sehore, Madhya Pradesh to investigate the impact of G×E interaction on seed yield of chickpea and identify variability using twenty-five chickpea genotypes in three environments. High variability was observed for majority of the traits in three environments. In late sown condition high GCV and PCV was recorded for number of seeds per plants, number of pods per plants, biological yield per plants, seed yield per plant, empty pods per plant, hundred seed weight. Ample variability available for these traits can be exploited by direct selection. In generally, the late and very- sown crop matured early due to restricted reproductive period and hastened maturity. Characters showing high heritability coupled and high genetic advance as percentage of mean were, plant height, total number of seeds per plants, total number of pods per plants, number of empty pods per plant, 100 seed weight per plants, harvest index, seed yield per plants under late sown environments. Occurrence of high estimates of heritability coupled with genetic advance as per cent of mean for these traits suggest that these traits can be considered as favourable attributes for improvement through selection. Seed yield per plant exhibited a positively and significantly association with number of pods per plant, Biological yield per plant and harvest index. These three traits were followed similar significant trend in all the environmental conditions and plant height, number of seeds per plants in mid-late and very-late sown conditions indicating that results suggested that improvement in these positive correlated traits will accelerate the improve a seed yield per plant

Keywords: Chickpea, genetic variability, correlation, seed yield, heat tolerance

Introduction
Chickpea (*Cicer arietinum* L.) is widely cultivated in over 50 countries across Asia, Africa, Europe, Australia, and North and South America. It is grown in India in all regions of the country. In 2017-18, the area and production of chickpeas in India were 105.73 lakh ha and 111.58 lakh tonnes, respectively. The Central and Southern states of Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, Andhra Pradesh, Karnataka, and Chhattisgarh account for the majority of area and production and have benefited greatly from the country's chickpea revolution. Over the last few decades, its annual production has fluctuated due to climatic change. (FAO Stat, 2018) [7]. Heat stress coupled with terminal drought is a major constraint in chickpea under warmer short season environments. A drastic reduction in yield of chickpea occurs when the crop is exposed to day temperatures of 35 °C and above during reproductive phase (Devasirvatham *et al*. 2012) [5]. It is essential to study the effect of high temperature during reproductive phase. So, there is an urgent need to search the gene bank for diverse sources of heat tolerance.

Heat stress adversely affects photosynthesis, respiration, membrane stability, fertilization, fruit maturation, quality of seed, nutrient absorption etc. (Basu *et al*. 2011) [1]. Heat tolerance is greatly needed in chickpea cultivars for realizing higher yields in all growing conditions that expose chickpea to high temperature, particularly during the reproductive stage. As a result, heat tolerant varieties are required to improve chickpea yields in late sown conditions. The genetic variability and correlation present in the base population for desired characters play an important role in development of desirable plant type. Less information is present in the cultivated chickpea lines grown under heat stress conditions. Therefore, the identification of heat tolerant genotypes is essential for development of high yielding chickpea variety under heat stress condition, considering this, the present investigation was carried out to assess the variability and correlation with yield and its contributing traits among the selected chickpea genotypes grown in three different environments.

Materials and Methods

Twenty-five chickpea genotypes were grown in three environments (Normal 28 Nov. mid-late 28 Dec. and very-late 28 Jan.2020) during Rabi season 2019-20 under all India coordinated research project in chickpea in the experiment field of Rafi Ahmad Kidwai College of agriculture, Sehore (M.P.). Data were accumulated on days to 50% flowering, days to maturity, plant height, number of pods per plant, number of empty pods per plant, number of seeds per plant, biological yield per plant, hundred seed weight, harvest index and seed yield per plant were recorded each of three environments. These were estimated from five randomly selected plants. The genotypes were organized in randomized complete block design with two replications. According to, (R.A. Fisher, 1918) were suggested estimating the genetic parameter and broad -sense heritability. Phenotypic correlation coefficients among characters will be computed utilizing variance and co-variance, by (Miller *et al*. 1958) [16].

Result and Discussion

The present investigation aimed to assess genotype variability and correlation with yield and its contributing traits in three environments (normal, mid-late, very-late), respectively. The analysis of variance for ten quantitative characters of twenty-five chickpea genotypes derived from three environments and evaluated under normal, mid-late, very-late sown conditions are shown in Table 1. The mean sum of squares due to various sources of variation for quantitative characters revealed that all three environments obtained significant differences, indicating that the variability among the selected genotypes was significant. The presence of high variability in the material indicates that through appropriate amelioration of variability of yield contributing traits it would be possible to harness the benefits of higher yield under diverse environments. The estimations of the genetic variability parameters for various quantitative traits are shown in Table 2. The mean and range of values for the 10 quantitative characters showed that all the traits' values were higher in the normal season than in the case of late sown conditions. Reduced days were reported during late sowing for the characters' days to 50% flowering and days to maturity. These differences in the mean values of the reproductive traits may be attributed to restricted reproductive period and hastened maturity due to higher temperatures coinciding during a reproductive phase of the very-late sown crop. Heat stress accompanying the flowering period decreases the duration of developmental phases due to higher temperatures (Upadhyaya *et al*. 2011, Devasirvatham *et al.* 2015) [14, 6]. Chickpeas is cool season crop, its need an average temperature of 15-25 °C as well as a consistent night and day temperature to induce normal flowering, pod development. Seed Yield per plant (g) under heat stress conditions ranged from 1.27 g/plant to 7.43 g/plant, compared to 3.70 g/plant to 14,43 g/plant under normal sown conditions, indicating a 15-47 percent reduction in yield per plant. Heat stress are known to adversely affect pollen viability, fertilization and seed development leading to reduced harvest index (Gaur *et al*. 2018) [8]. Heritability helps to know the extent of genetic expression in a given environment. Higher heritability for days to 50% flowering, days to maturity, number of pods per plants, number of seeds per plants, hundred seed weight, biological yield per plant and seed yield per plants was noticed under three sown environments which suggested that these traits are least influenced by environmental factors and also indicates dependency of phenotypic expression which reflects the genotypic ability of cultivars to transmit the genes to their progenies. These results similar to shown by Bicer and Sarkar, (2008) [4]. The estimate of PCV were higher than an estimate of GCV for all most the traits, that suggested the apparent variation is not only due to genotypes but also due to the influence of environment. Higher estimates of heritability and genetic advance as per of mean were noticed for plant height, total number of seeds per plants, total number of pods per plants, number of empty pods per plant, 100 seed weight per plants, harvest index, seed yield per plants in late sown conditions. These finding match with the results of earlier researchers Yadav *et al.* (2003) [15]. Occurrence of high estimates of heritability coupled with genetic advance as per cent of mean for these traits suggest that these traits can be considered as favourable attributes for improvement through selection as additive gene action may be pre-dominant in expression of these traits (Anand Kumar *et al*. 2017) [9]. whereas, plant height, harvest index had moderate phenotypic and genotypic coefficient of variation while, other traits *viz*. days to maturity, days to 50% flowering exhibited low phenotypic and genotypic coefficient of variation. The higher GCV and PCV under stress environments and moderate GCV and PCV under non-stress environments indicate that heat stress has large effect on the progenies for creating variation in them (Paul *et al.* 2018) [11].

Correlation analysis provides a good measure of the linear association between characters (s) and helps to identify the most important character (s) to be considered to be effective in selection for yield increment. The knowledge of genetic association among seed yield and its component helps in improving the efficiency of selection for yield components for maximum genetic gain. The phenotypic correlation coefficient analysis for quantitative traits was shown in table 2. Where, seed yield per plant exhibited a positively and significantly with Number of pods per plant, Biological yield per plant and harvest index. These three traits were followed similar significant trend in all the environmental conditions and plant height, number of seeds per plants in mid-late and very-late sown conditions indicating that results suggested that improvement in these positive correlated traits will accelerate the improve a seed yield per plant. These results were in accordance with those reported by Babbar *et al*., (2012) [2] for total number of pods per plant, biological yield. Shanmugam and Kalaimagal, (2019) [12] for positively significant correlation with biological yield per plant and harvest index with seed yield per plant. Under very-late sown conditions, among the yield traits number of pods per plant was positively and significantly associated with number of seeds per plant, seed yield per plant. When increase in seed size under heat stress leads to reduction in number of seeds as well as seed yield. These signifies that early maturing genotypes with better canopy spread are capable of high yield under very-late sown environment. Number of pods per plant, number of seeds per plant showed significant negative correlation with hundred seed weight under very-late sown condition. This is because adverse effect of temperature stress on the membrane leads to disruption of cellular activity. Injury to membranes from a sudden heat stress event results from either denaturation of the membrane proteins or from melting of membrane lipids, which leads to membrane rupture and loss of cellular contents (Pouresmaela *et al*., 2013) [10].

Early maturing varieties can escape the adverse effects of heat stress on yield. (Paul *et al*., 2018) [11] opined that higher yield under heat stress could be achieved through higher number of filled pods per plant and seeds rather than seed mass. Plant height, number of pods per plant, number of seeds per plant, biological yield per plant, harvest index was identified as important traits positive associations with seed yield per plants under very-late sown environment which suggested that these characters are least influenced by the environment factors and also indicated as favourable attributes for improvement through selection

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

Source of variations	Env.	d.f.	Days to 50% flowering	Days to maturity	Plant height	Number of Pods per Plant	Number of Empty pods per plant	Number of Seeds per plant	Biological yield per plant	Hundred seed weight	Harvest index	Seed yield per plant
Replication	E1	1	4.5	0.08	4.71	17.25	2.41	4.3	0.29	1.8	30.37	1.61
	E2	1	0.98	1.28	0.046	25.92	1.5	31.49	1.87	0.051	13.65	1.43
	E3	1	0.98	3.38	8.29	16.42	0.49	7.47	0.03	0.071	43.64	0.29
Genotypes	E1	24	53.78**	27.45**	69.07**	283.14**	6.15**	351.7**	25.81**	229.98**	91.71**	9.25**
	E2	24	52.18**	19.33**	57.47**	168.38**	5.02**	224.36**	17.98**	188.94**	109.8**	9.24**
	E3	24	32.95**	33.87**	36.95**	192.54**	6.03**	187.51**	8.65**	212.14**	107.11**	4.34**
Error	E1	24	1.25	1.62	3.31	5.78	1.43	9.32	4.28	0.96	19.78	1.06
	E2	24	1.06	1.11	2.78	8.58	0.97	8.33	1.08	0.62	16.24	0.4
	E3	24	1.02	2.17	4.78	4.96	0.89	4.62	0.41	0.45	17.14	0.16

Table 2: Genetic parameters of variation for seed yield and its contributing traits over three environmental conditions.

Characters	Environment	MEAN	RANGE		h^2 (bs) (%)	GCA (%)	PCA (%)	Genetic advance	GA as % of mean
			Max.	Min.					
Days of 50% flowering	E-I	56.34	71	50	95.46	9.1	9.31	10.32	18.31
	E-II	52.02	68	45	96.01	9.72	9.92	10.21	19.62
	E-III	45.3	58	38	93.99	8.82	9.1	7.98	17.62
Days to maturity	E-I	107.96	120	101	88.85	3.33	3.53	6.98	6.46
	E-II	103.8	112	97	89.11	2.91	3.08	5.87	5.65
	E-III	90.3	98	83	87.95	4.41	4.7	7.69	8.52
Plant height (cm)	E-I	44.14	61.33	30	90.85	12.99	13.63	11.26	25.51
	E-II	39.88	52.33	28.33	90.74	13.11	13.76	10.26	25.73
	E-III	32.64	44	24.33	77.08	12.29	14	7.25	22.22
Number of pods per plant	E-I	35.61	57.66	18.33	96	33.07	33.75	23.77	66.75
	E-II	26.09	43.33	11	90.3	34.26	36.05	17.5	67.07
	E-III	19.18	40	5.66	94.97	50.48	51.8	19.44	101.35
Number of empty pods per plant	E-I	3.6	8.33	1	62.11	42.6	54.06	2.49	69.17
	E-II	3.45	9.66	1.33	67.41	41.23	50.22	2.41	69.73
	E-III	3.88	9.33	1.33	74.21	41.28	47.91	2.85	73.25
Number of seeds per plant	E-I	35.57	70	17	94.83	36.78	37.77	26.25	73.79
	E-II	26.34	46.33	9.33	92.84	39.46	40.96	20.63	78.32
	E-III	17.81	36.66	3.33	95.19	53.69	55.03	19.22	107.91
biological yield per plant (g)	E-I	21.27	28.54	12.54	71.54	15.42	18.24	5.72	26.88
	E-II	15.62	22.14	10.16	88.65	18.61	19.77	5.64	36.1
	E-III	7.12	10.62	3.01	90.79	28.51	29.92	3.98	55.96
100 seed weight (g)	E-I	29.42	54.18	9.44	99.16	36.38	36.53	21.95	74.62
	E-II	28.34	53	9.78	99.34	34.48	34.59	19.92	70.79
	E-III	25.79	49	9.32	99.57	39.66	39.75	21.15	81.53
Harvest index (%)	E-I	44.44	60.13	24.75	64.51	13.49	16.8	9.92	22.33
	E-II	42.56	60.76	28.36	74.22	16.07	18.65	12.14	28.52
	E-III	51.87	64.82	38.24	72.4	12.81	15.05	11.76	22.45
Seed yield per plant (g)	E-I	9.47	14.43	3.7	79.35	21.36	23.98	3.71	39.2
	E-II	6.76	11.97	3.21	91.58	31.11	32.51	4.14	61.33
	E-III	3.81	7.41	1.27	92.67	37.98	39.45	2.87	75.31

Table 2a: Correlation analysis of yield of seed and its character in genotypes of chickpea in E-I

Traits	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8	CH9	CH10
CH1	1									
CH2	0.933**	1								
CH3	-0.065	-0.053	1							
CH4	0.336	0.313	0.048	1						
CH5	-0.168	-0.17	-0.239	0.273	1					
CH6	0.409*	0.401*	0.133	0.964**	0.048	1				
CH7	-0.452*	-0.424*	0.465*	0.342	0.233	0.295	1			
CH8	-0.641**	-0.654**	0.186	-0.642**	-0.002	-0.688**	0.316	1		

CH9	-0.245	-0.306	-0.009	0.242	-0.028	0.217	0.149	0.172	1	
CH10	-0.420*	-0.432*	0.316	0.404*	0.146	0.357	0.790**	0.315	0.712**	1

Table 2b: Correlation analysis of yield of seed and its character in genotypes of chickpea in E-II

Traits	**CH1**	**CH2**	**CH3**	**CH4**	**CH5**	**CH6**	**CH7**	**CH8**	**CH9**	**CH10**
CH1	1									
CH2	0.765**	1								
CH3	0.188	0.334	1							
CH4	0.369	0.433*	0.457*	1						
CH5	-0.375	-0.304	-0.455*	0.134	1					
CH6	0.527**	0.566**	0.467*	0.960**	-0.074	1				
CH7	0.123	0.205	0.587**	0.729**	0.097	0.640**	1			
CH8	-0.580**	-0.562**	0.034	-0.548**	0.064	-0.665**	0.007	1		
CH9	0.062	0.095	0.630**	0.552**	-0.03	0.489*	0.526**	0.111	1	
CH10	0.111	0.182	0.683**	0.741**	0.023	0.658**	0.881**	0.058	0.859**	1

Table 2c: Correlation analysis of yield of seed and its character in genotypes of chickpea in E-III

Traits	**CH1**	**CH2**	**CH3**	**CH4**	**CH5**	**CH6**	**CH7**	**CH8**	**CH9**	**CH10**
CH1	1									
CH2	0.796**	1						/		
CH3	0.327	0.286	1							
CH4	0.447*	0.470*	0.546**	1						
CH5	0.064	0.077	0.071	0.574**	1					
CH6	0.542**	0.536**	0.579**	0.959**	0.376	1				
CH7	0.128	0.096	0.575**	0.817**	0.508*	0.756**	1			
CH8	-0.697**	-0.685**	-0.06	-0.578	-0.246	-0.652**	-0.13	1		
CH9	-0.099	0.067	0.482*	0.519**	0.212	0.523**	0.533**	-0.1	1	
CH10	0.087	0.142	0.630**	0.820**	0.373	0.772**	0.934**	-0.147	0.783**	1

CH1- Days to 50% flowering, CH2- Days to maturity, CH3- Plant height, CH4- Number of Pods per Plant, CH5- Number of Empty pods per plant, CH6- Number of Seeds per plant, CH7- Biological yield per plant, CH8- Hundred seed weight, CH9- Harvest index, CH10- Seed yield per plant

Author's contributions

Mr. Pavan Dhopre carried out this experiment under the guidance of Dr. M. Yasin (Principal Scientist) for observation, data analysis, and result interpretation.

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