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Stability against heat stress in genotypes of chickpea (*Cicer arietinum* L.)

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Abstract
The chickpea crop is overly sensitive to abiotic factors; high temperature is one of them, which affects growth and development and yielding potential of the crop. The present investigation was carried out during rabi season 2019-20 at research field of all India coordinated research project on chickpea, R.A.K. college of agriculture, Sehore (M.P.) twenty- five genotypes of chickpea were grown in three environments (Normal 28 November 2019, mid-late 28 December 2019, and very-late 28 January 2020) in randomized complete block design with two replications. The investigation was undertaken to capture the relatively stable genotype under several variable sowing time using 25 chickpea genotypes, which included 15 Desi and 10 Kabuli type. Genotypes were tested in normal and very-late temperature conditions. Observations were recorded for ten quantitative characters. Analysis of variance revealed that significant difference among the genotypes for all the studied traits. The variation due to environment (linear) was found significant for all the traits studied. Genotype × environment (Linear) componentwas found significant for all the traits. Genotypes JG-11 (Desi), RVG-202 (Desi), RVG-204 (Desi), ICC-4958 (Desi), RVSSG-62 (Kabuli), RVSSG-61 (Kabuli) had regression coefficient more than one with higher mean values than grand mean. These genotypes recommended for very-late sown conditions with high seed yield. The above results have provided the opportunity of growing chickpea under late planting condition in double cropping (after rice) and very late (after soybean-potato/garden pea).

Keywords: Chickpea, heat stress, stability analysis

Introduction

Chickpea (*Cicer arietinum* L.) is an annual legume and the only cultivated species within genus *Cicer*. It is an important pulse crop in the world as a source of diet for mostly cultivated in arid and semi-arid condition. It is valued for its nutritive seeds with high protein content, 25.3- 28.9%, after dehulling (Hulse, 1991) [9]. Chickpea is grown worldwide in over 54 countries in 12.7 million hectares with annual production of 12 million tons. Its annual production has fluctuated over the last five years (2012-2016) due to climate change (FAO stat, 2018) [7] temperature is an important factor controlling crop growth and development (Zinn *et al*. 2010) [17] by affecting wide range of physiological processes and altering plant-water relationship.

Heat killing temperature in chickpea was found to be 44.3 °C for 41minutes (Srinivasan *et al.*1996) [13]. The crop often experiences abnormally high temperature (35 °C) during reproductive phase, which directly has negative impact in chickpea production (Devasirvatham *et al*. 2012) [5]. Heat stress during pod development decrease seed yield by more than 53 percent (Wing *et al.* 2006) [15]. In late sown chickpea crop experiences law temperature during sowing time and high temperature at the end of the cropping season. Low temperature at initial stage of crop growth results in poor and slow vegetative growth whereas high temperature at the end of cropping season leads to forced maturity and problem of poor biomass (Chaturvedi and Dua, 2003) [3]. Chickpea is cultivated in India mostly in rainfed conditions. It is also grown in irrigated condition in late sown condition. Now a day, farmer used to cultivate the chickpea in the month of December as well mid-January after harvesting of rice and potato. In such condition farmers need genotypes, which have heat escape mechanism and tolerant to temperature stress with average production. In recent year chickpeas varieties are available for late sown condition (December sown) but there is lacking chickpea variety for very late sown (January sown) condition. Therefore, present investigation was undertaken to identify chickpea genotypes for cultivation in late and extremely late irrigated sowing or high temperature conditions.

Materials and Methods

The investigation was carried out during Rabi season 2019-20 at research field of all India coordinated research project in chickpea, R.A.K. College of Agriculture, Sehore (M.P.). Twenty-five genotypes of chickpea were grown in three environments (Normal 28 November 2019 mid-late 28 December 2019 and very- late 28 January 2020) in randomized complete block design with two replications. Genotypes were tested in normal and high temperature conditions (temperature range 5-44 °C). Observations were recorded for ten quantitative characters. The traits were viz., 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 separately. Stability analysis of variances was performed for seed yield and its attributing traits method suggested by Eberhart and Russell (1966) [6] model for phenotypic stability of genotypes.

Results and Discussion

The analysis of variance for seed yield and its components pooled over three environments were presented in table 1. The analysis of variance revealed significant differences among genotypes for all the characters. The mean sum of squares was due to environment (linear) was highly significant for all the characters. It revealed that environment differ significantly from one another. The magnitudes of deviation from linearity for all the characters were observed suggesting large fluctuations in the expression of all the characters over different environments (Eberhart and Russell, 1966) [6]. Significant genotype × environment (linear) interaction is obtained for all the characters. Although the mean sum of squares due to pooled deviation (non-linear components) were found significant for all the traits. Partitioning of analysis of variance (table 1) showed highly significant results for genotype, environment(linear), genotype × env. (Linear), Env. +Geno. × Env. These results supporting the earlier findings of Hasan *et al.* (2008) [10], Alwawi and Choumane (2010) [1], Tilahun *et al*. (2015) [14] and Babbar and Tiwari (2018) [2]. The stability parameters, viz., mean, regression coefficient and mean deviation from regression were estimated for all the traits of each genotype and presented in table 2.

The genotypes had regression coefficient less than one and mean values greater than grand mean. Hence, these genotypes suitable for cultivation in normal sowing (normal temperature) as well as mid-late sowing (optimum temperature) conditions with high seed yield. Genotypes had regression coefficient more than one with higher mean values than grand mean. These genotypes recommended for very-late sown conditions with high mean yield. Genotypes had regression coefficient less than one with lower mean values than grand mean. It indicated that these genotypes stable in normal and mid-late sown conditions with low mean yield. Genotypes had regression coefficient more than one with lower mean values than grand mean. It indicated that these genotypes stable in very-late sown conditions with low mean yield.

The genotypes RVG-201, JG-14, RVSSG-54, RVSSG-51 had regression coefficient less than one and more mean values than grand mean. Hence, these genotypes suitable for cultivation in normal sowing (normal temperature) as well as mid-late sowing (optimum temperature) conditions with high seed yield. Genotypes JG-11, RVG-202, RVG-204, ICC-4958, RVSSG-62, RVSSG-61had regression coefficient more than one with higher mean values than grand mean. These genotypes recommended for very-late sown conditions with high mean yield. Genotypes JG-74, JGK-3, KAK-2, JGK-5, RVSSG-61-1, RVSSG-63, RVSSG-72 had regression coefficient less than one with lower mean values than grand mean. It indicated that these genotypes stable in normal and mid-late sown conditions with low mean yield. Genotypes JG-315, RVKG-151, RVSSG-36 had regression coefficient more than one with lower mean values than grand mean. it indicated that these genotypes stable in very-late sown conditions with low mean yield. The genotypes included in the present investigation did not depict uniform stability and responsiveness pattern for the different traits. The stability and response appeared to be specific for individual traits of individual genotypes and did not common for all the traits (Yadav et al. 2013) [6]. It is evident that genotypes JG-11, RVG-202, RVG-204, ICC-4958, RVSSG-62, RVSSG-61 Were stable most of the yield contributing traits indicating that the stability of various traits might be responsible for observed high seed yield.

Table 1: Stability analysis of variance for seed yield and its contributing traits over three environments

Source of Variation	d.f.	DF	DM	PH	NPPP	NEPPP	NSPP	BYPP	100 SW	HI	SYPP
Variety	24	65.69**	32.30**	66.01**	274.45**	5.39**	340.95**	17.49**	296.86**	95.43**	8.43**
Environment	2	773.76**	2130.96**	845.17**	1700.59**	1.2	1972.39**	1268.86**	77.34**	677.57**	200.67**
Var. X Envion.	48	1.88*	4.01**	7.86**	23.79**	1.6*	20.41**	4.36**	9.33**	29.44**	1.49*
Env+Var X Env	50	32.75**	89.09**	41.36**	90.86**	1.59*	98.49**	54.94**	12.05**	55.36**	9.46**
Env (Linear)	1	1547.52**	4261.92**	1690.34**	3401.19**	2.41*	3944.79**	2537.72**	154.69**	1355.14**	401.35**
Env X Var(Lin)	24	2.54**	5.39**	12.01**	24.72**	2.04*	25.92**	3.59**	9.24**	23.79**	1.46*
Pooled Deviation	25	1.17	2.52**	3.57**	21.94**	1.12	14.31**	4.93**	9.05**	33.68**	1.46*
Pooled Error	72	1.11	1.636	3.628	6.445	1.103	7.429	1.927	0.683	17.727	0.546
Total	74										

Note * and ** significant at 5% and 1% level of probability, respectively against pooled deviation and pooled error.

Table 2: Stability parameters for seed yield and its contributing traits in 25 chickpea genotypes over three environmental conditions

No.	Genotypes	Seed yield per plant		
		Mean	Bi	s2di
1	JG- 6	8.79	1.061	6.64**
2	JG-11	7.322	1.213	-0.246
3	JG-14	7.573	0.802	-0.273
4	JG-74	4.663	0.721	0.232
5	JG-315	5.597	1.089	0.28
6	RVG-201	7.352	0.989	0.306
7	RVG-202	7.57	1.059	-0.189
8	RVG-203	6.135	1.229	6.513
9	RVG-204	8.847	1.145	1.049
10	ICC-4958	9.153	1.017	0.52
11	JAKI-9218	7.085	0.909	5.88**
12	JGK-3	4.563	0.953	1.376
13	KAK-2	5.12	0.919	-0.162
14	JGK-5	5.815	0.904	0.444
15	RVSSG-61-1	6.512	0.99	-0.078
16	RVKG-101	5.195	1.099	2.71**
17	BGD-112	3.697	0.342	2.448
18	RVKG-151	5.82	1.424	0.696
19	RVSSG-62	7.423	1.575	0.598
20	RVSSG-54	9.875	0.929	-0.273
21	RVSSG-63	6.007	0.827	0.078
22	RVSSG-72	4.038	0.356	-0.273
23	RVSSG-36	6.02	1.197	-0.141
24	RVSSG-51	8.187	0.659	0.438
25	RVSSG-61	8.582	1.592	1.106
General mean		6.68	1	
SE (mean)		0.85	0.3	

Note: * and ** significant at 5% and 1% level of probability, respectively against pooled deviation.

The above findings have provided the chance to sowing chickpea under late and extremely late sowing or high temperature in double cropping pattern. The results of the present study indicated that yield was highly influenced by the temperature and sowing time because there were significant variations in all the traits including yield also affected at adverse environments. The mean, regression coefficient and deviation from regression of seed yield indicated that the genotypes JG-11, RVG-202, RVG-204, ICC-4958, RVSSG-62, RVSSG-61 could be recommended the best suitable genotypes for temperature tolerance because their higher yield performance were recorded in very-late sowing conditions. Variety RVG-202 (Gour *et al.* 2010 and Dixit *et al*. 2019) [5, 4] were also released for the late sowing conditions in M.P. and central zone of India for commercial cultivation also confirming in this study. Babbar and Tiwari also reported specific adaptation mechanism for ICC-4958 for seed yield in very- late sowing condition.

Conclusion

The stability parameters concluded that the genotypes RVG-201, JG-14, RVSSG-54, RVSSG-51 were the best in early as well as mid-late sowing conditions and JG-11, RVG-202, RVG-204, ICC-4958, RVSSG-62, RVSSG-61 were the best genotypes in very-late temperature conditions.

Author's Contributions

Mr. Pavan Dhopre conducted this experiment, guided by Dr. M. Yasin for taking observations, Analysis of data and interpretation of results.

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