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GENOTYPE X ENVIRONMENT (GXE) INTERACTION AND STABILITY ANALYSIS FOR SEED YIELD AND ITS COMPONENT TRAITS IN CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

The present investigation was undertaken to estimate the G x E interaction and to identify stable genotypes for seed yield and its component traits in chickpea under timely and late sown conditions. Forty five chickpea genotypes were evaluated during *Rabi* season for two consecutive years (2017-18 and 2018-19). Each genotype was sown in Randomized Block Design with three replications at the research farm of Department of Genetics and Plant Breeding, C.C.S. University, Meerut (U.P.), India. The pooled analysis of variance revealed highly significant differences among the genotypes for all the characters whereas environment and environment (linear) showed adequate variability among the environments. Genotype x Environment (GxE) and pooled deviation were found to be significant for all the studied characters except protein content and GxE (linear) revealed significant variation for all the studied characters except harvest index. Stability analysis revealed that the six genotypes *viz.* P-6225, BKG-21204, ICC-1608, BGG-21168, BG-547and PDG-84-10 has a high mean value ($\bar{x}$), regression coefficient (bi) in unity and non-significant deviation from regression (S^2d) were found more stable for seed yield across the environments over the years. Therefore, the above-mentioned genotypes can be incorporated as breeding stocks in any future breeding programs aiming to produce high yielding lines of chickpea.

Keywords: Chickpea, Genotype x Environment interaction, Stability, Seed yield

Chickpea (*Cicer arientinum* L.), also known as Bengal gram, is an important self pollinated leguminous crop belonging to family *Fabaceae* with a diploid genome (2n =16) and is grown in *Rabi* season. Chickpea has ability to use atmospheric nitrogen through biological nitrogen fixation, which makes it more economically viable (Kushwah *et al.,* 2020a). From a nutritional point of view, chickpea seeds contain about 61 - 62% carbohydrates and 18 to 22% crude proteins, while it also contains 4.5% fat (Kushwah *et al*., 2020b). Chickpea seeds contain many other nutritionally important minerals, particularly phosphorus (301mg/100g), calcium (280 mg/100 g), and iron (12.3 mg/100g) (Directorate of Pulses Development, Bhopal). The major chickpea producing countries are: India, Turkey Australia, Pakistan, Turkey, Myanmar, Ethiopia, Iran, Mexico, Canada, and the United States (Kushwah *et al*., 2021). It is the main legume crop of India, contributing over 40% of country's total pulse production, with a share of 70% in the global chickpea production. The global production of chickpea consists of around 75% *desi* and 25% of *kabuli* species. In 2019, the world production of chickpea was 14 million tones, led by India with 70% of the global followed by Turkey on second position (FAO STAT, 2021).

The Indian cropping pattern does not permit chickpea sowing at the same time and causes variation in its sowing time across the country. Therefore, chickpea crop shows differential response when it is grown under different environmental conditions mainly because of varying environmental factors such as soil moisture, drought, soil fertility, temperature, sowing time and day length etc. that strongly influence the vegetative and reproductive phase of plant growth resulting in yield loss of chickpea (Tilahun *et al*., 2015**)**. The fluctuation in seed yield of chickpea may also be due to the use of common genotypes that are not adapted to wide range of environments. To overcome this, it is important to identify the better adapted or stable genotypes that could perform consistently well over a wide range of environmental fluctuation with minimum variation in yield ability.

The development of cultivars or varieties that can be adapted to a wide range of diversified environments with high yielding potential is the ultimate goal of plant breeders in a crop improvement program. The

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adaptability and yield stability of genotypes for different environmental conditions may be tested by growing them in different environments and the performance can be measured by the degree of its interaction with their respective environment.

Genotype x environment interaction is the change in relative performance of genotypes across diversified environments (De Lacy *et al.,* 1996). Various statistical methods have been proposed to test the phenotypic stability of cultivars under different environments. The most popular and widely used model is Eberhart and Russell (1966) model, based on regression analysis which consists of three parameters to predict stable genotypes viz, mean performance over the locations or seasons ($\bar{x}$), regression coefficient (bi), and deviation from regression (S^2d).

Due to the changing environment, there is a need to evaluate chickpea genotypes under different environments to assess the performances of genotypes for their use in future breeding programme through multi-location trials with appropriate stability analysis method for assessing the yield stability among varieties. The awareness about the nature of GXE interaction is very important to find out the stability of cultivar and enhance the ability of selection in breeding programs (Sabaghnia *et al.,* 2008). Therefore, the present investigation was aimed to assess the nature and extent of G x E interaction on chickpea genotypes and to further identify the relatively stable genotypes for seed yield and yield contributing characters that can be used in the breeding programme leading to crop improvement of chickpea.

MATERIALS AND METHODS

The experimental material consisted of 45 genotypes of chickpea and each genotype was evaluated in a Randomized Block Design (RBD) with three replications during the *rabi* season for two successive years i.e., 2017-18 and 2018-19 with two sowing dates (Timely and Late) at Research Farm of C.C.S. University, Meerut (U.P.), India (Table 1.) Each genotype was sown in single row of 4 m length with spacing 30 cm and 10 cm between lines and plants, respectively. To avoid the border effects, the experimental plot was surrounded by non-experimental rows from all sides. All recommended agronomic practices were adopted in each experiment to raise a good crop.

The observations were recorded on five randomly selected plants from each genotype in each replication for twelve quantitative characters *viz,* days to 50% flowering, days to maturity, plant height (cm), number of pods per plant, number of seeds per pod, number of seeds per plant, number of branches per plant, 100 seed weight (g), biological yield (g), harvest index (%), protein content (%) and seed yield (g). The mean values of the recorded data from each replication were subjected to statistical analysis. Combined analysis of variance over different environment was calculated as described by Allard (1964). Stability parameters for seed yield and its related traits of the forty five genotypes were calculated according to the Eberhart and Russell (1966) model.

RESULTS AND DISCUSSION

The results of pooled analysis of variance for stability analysis for seed yield and its components traits (Table 2**.**) revealed that mean squares due to genotypes were significant for all the characters, whereas mean square due to environment also showed significant differences and thus indicated presence of sufficient variability among the environment. However, mean squares due to the environment (linear) and genotypes x environments (GxE) were found to be significant for all the studied characters. Significant GxE indicated the differential response of the genotype to different environments.

The mean square due to the genotype x environment (linear) was also found significant for all studied characters except number of seeds per pod and harvest index. Further, it was noted that the major part of GxE interaction was attributed to linear component in respect to all characters (Table 3). The linear components of GxE suggested that the differences observed between various environments were considerable for all the studied characters and also indicated that the differential response of genotypes under all four environments (four different environments

Table 1. Details of four environments created in the present study

Year	Location	Date of sowing	Environment
2017-18	CCS University, Meerut, U.P.	Timely sown 26/10/2017	I
2017-18	CCS University, Meerut, U.P.	Late sown 26/11/2017	II
2018-19	CCS University, Meerut, U.P.	Timely sown 13/11/2018	III
2018-19	CCS University, Meerut, U.P.	Late sown 05/12/2018	IV

Table 2. Analysis of variance for stability analysis / Joint regression analysis for seed yield and yield component in chickpea (Eberhart and Russell, 1966).

Source of Variation	d.f	Mean squares											
		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of pods per plant	Number of seeds per pod	Number of seeds per plant	Number of branches per plant	100 seed weight (g)	Biological yield (g)	Harvest index (%)	Protein content (%)	Seed yield (g)
Genotype (G)	44	19.53**	12.16**	11.55**	27.95**	0.133**	56.96**	0.47**	50.52**	101.97**	64.98**	16.11**	24.90**
Environment (E)	3	22643.77**	15998.97**	1209.24**	2298.99**	0.162**	3926.82**	21.33**	22.93**	3637.27**	211.42**	220.46**	1042.39**
G X E	132	5.19**	5.44**	2.75**	11.53**	0.015**	18.70**	0.16**	0.95**	34.97**	33.66**	0.93	9.59**
Env. + (GXE)	135	508.27**	360.85**	29.56**	62.36**	0.018**	105.55**	0.63**	1.44**	115.02**	37.61**	5.81**	32.54**
Env. (Linear)	1	67931.76**	47998.13**	3627.77**	6896.95**	0.486**	11780.47**	64.00**	68.79**	10911.86**	634.18**	661.38**	3127.18**
GXE (Linear)	44	8.93**	11.09**	5.27**	32.44**	0.009	54.30**	0.28**	1.58**	91.83**	28.73	1.62**	20.12**
Pooled Deviation	90	3.24*	2.54**	1.45*	1.05**	0.017**	0.89*	0.10**	0.62**	6.39**	35.32**	0.58	4.22**
Pool Error	352	2.30	1.62	1.10	0.35	0.003	0.66	0.02	0.29	1.89**	3.75	0.96	0.41
Total	179	128.90	91.37	8.35	17.90	0.015	31.09	0.20	4.48	37.13	14.72	2.77	10.18

*, **= Significant at P = 0.05 and P = 0.01 levels, respectively

were created by choosing four different sowing dates) had linear effects. Similar results were also reported by Desai *et. al.* (2016), Verma *et. al.* (2019), and Srivastava *et. al.* (2020).

The Stability performance of genotype is most desirable for its wide adaptability. Stability can be defined as the ability of a certain variety/ genotypes to maintain stable yield under changing environmental conditions. The estimation of stability of genotypes as per Eberhart and Russell (1966) model based on regression analysis has three stability parameters *viz*., mean performance ($\overline{X}$) over the environments, regression coefficient (bi) and deviation from regression coefficient (S^2d). As per this model, a stable genotype is one which showed high mean performance over the environments, regression coefficient around the unity (bi=1) and deviation from linear regression should be non-significant in nature or near to zero (S^2d =0). The mean value and deviation from regression of each genotype were considered for stability and the linear regression was used for examining the response of the genotype across the environments (Sharma and Johnson, 2017) and the genotype which had regression coefficient greater than one would be more adapted to favorable conditions, while regression coefficients less than one would be more adapted to unfavorable environmental conditions.

The identified stable genotypes for seed yield and related characters under study are presented in Table 5**.** Based on the mean performance and stability parameters together, it was observed that the six genotypes namely P-6225, BKG-21204, ICC-1608, BGG-21168, BG-547 and PDG-84-10 had high mean values and regression coefficient near to unity (bi=1) with minimum deviation from regression (S^2d =0), indicating stability of these genotypes for seed yield across the environment over the years. Seven genotypes *viz*. ICC-15911, ICC-14775, ICC-4648, RADHE, GL-29061, BG-8011 and PBG-85-4 showing high mean seed yield with regression coefficient greater than unity (b>1), clearly indicates that these genotypes are stable for seed yield under favourable environment, while six genotypes *viz*. BG-5028, P-602, K-850, BGM-572, P-85 and KPG-39 showed high mean performance and regression coefficient less than unity (b<1) which indicates that these genotypes are desirable for yield in unfavourable or poor environment. (Table 4). Many studies for stability in chickpea genotypes for the seed yield were also earlier reported by Dhuria and Babbar (2021), Babbar and Tiwari (2018) and Johnson *et. al.* (2015).

All six genotypes that showed stability for seed yield have also shown stability performance for other characters examined. The genotype P-6225 showed stability for the characters viz, number of seeds per

Table 3. Magnitude of linear and non-linear portion of GxE interaction for different characters

S.N.	Characters	Linear component (%)	Non-linear component (%)
1.	Days to 50% flowering	73.37	26.63
2.	Days to maturity	81.24	18.76
3.	Plant height (cm)	78.42	21.58
4.	Number of pods per plant	96.86	3.14
5.	Number of seeds per pod	34.61	65.39
6.	Number of seeds per plant	98.38	1.62
7.	Number of branches per plant	73.68	26.32
8.	100 seed weight (g)	71.81	28.19
9.	Biological yield (g)	93.39	6.61
10.	Harvest index (%)	44.85	55.15
11.	Protein content (%)	73.63	26.37
12.	Seed yield (g)	82.66	17.34

pod and number of branches per plant, the genotype BKG-21204 showed stable performance for biological yield and 100 seed weight. The genotype ICC-1608 showed stable performance for protein content, while the genotype BGG- 21168 showed stable performance for number of branches per plant and protein content. The genotype BG-547 showed stable performance for plant height and 100-seed weight and the genotype PDG-84-10 also showed stable performance for plant height.

Further, a perusal of Table 5 indicated that the genotype KDG-1288 showed stable performance for days to 50% flowering, days to maturity, plant height, no. of pods per plant, 100-seed weight while, genotype ICC-15911 showed stability for days to 50% maturity and no. of branches per plant. The genotypes ICC-15680 showed stability for plant height and protein content, genotype P-85 revealed stability for days to 50% flowering, no. of pods per plant, 100-seed weight and harvest index, genotype ICC-15896 stable for days to 50% maturity, no. of pods per plant and protein content. Genotype P-602 indicate stability for plant height, no. of seeds per pods, biological yield and protein content, whereas genotype GL-29061 reveal stable performance for no. of seeds per pod, harvest index, protein content.

The genotype GPF-02 showed stability for no. of seeds per pod, no. of seeds per plant and no. of branches per plant, genotype K-1052 stable for days to flowering, no. of seeds per pod, harvest index and genotype B-714 stable for plant height, no. of seeds per pod, genotype ICC-11218 showed stability for no. of branches per plant, protein content and genotype BG-547 stable for plant height and 100-seed weight, genotype BGM-572 stable for no. of branches per plant, biological yield per plant, protein content and genotype BG-5028 for biological yield per plant and for protein content.

The genotype PDG-05 showed stable performance for no. of pods per plant, no. of seeds per plant, biological yield per plant and genotype K-850 stable for 100-seed weight, biological yield per plant and genotype BKG-21204 stable for 100-seed weight, biological yield per plant, and the genotype IPC-02-2 indicate stability for no. of seeds per pods and no. of seeds per plant.

The genotype ICC-71 and ICC-6874 had higher mean over environment, regression coefficient around to unity and deviation from regression non significant or minimum deviation from regression indicating stability and these genotypes showed stable performance for days to 50% flowering and the genotypes ICC-14268, P-740 and P-79086 revealed stability for no. of seeds per plant, while genotypes KPG-39, Vishal are stable for harvest index and genotypes BG-8011, ICC-1608 and ICC-14775 are stable for protein content. Several similar findings for stability analysis in chickpea have been earlier reported by Azam *et. al.* (2020), Sharma and Johnson (2017), Kumar *et.al.* (2016), Qureshi *et. al.* (2015), Mohamed *et.al.* (2015), and Yadav *et. al.* (2014).

It may be concluded that the combined analysis of variance exhibited significant variation due to genotypes, environment and genotype x environment (G X E). Out of total forty five genotypes of chickpea undertaken for study, six genotypes namely; P-6225, BKG-21204, ICC-1608, BGG-21168, BG-547 and PDG-84-10 were found stable for seed yield and other related characters across the environment over the years due to their superior mean performance, regression coefficient (bi) near to one with non significant deviations from regression (S^2d) or near to zero. Therefore, these genotypes may be grown under wide range of environments including high

Table 4. Estimates of stability parameters for yield traits in forty five genotypes of chickpea

S.N.	Genotype	Number of pods per plant			Number of seeds per plant		
		$\bar{X}$	b	S^2d	$\bar{X}$	b	S^2d
1	GL-769	10.49	0.75*	0.35	15.46	0.91	-0.18
2	IPC-5-74	10.33	0.78*	0.39	13.55	0.82	0.71
3	PDE-2-E	15.53#	1.33**	0.45	23.68#	1.48**	-0.12
4	IPC-95-01	13.73	1.21*	1.21	15.83	1.14*	0.15
5	ICC-10489	13.66	1.38**	0.14	18.47	1.16*	0.61
6	ICC-15911	12.70	0.93	0.37	24.02#	1.67**	-0.20
7	PDG-05	13.97#	0.88	-0.11	19.73#	0.92	0.09
8	ICC-17007	15.58#	1.41**	-0.10	20.73#	1.48**	-0.01
9	GPF-02	13.46	1.11	0.72	21.49#	1.24	-0.09
10	ICC-11218	10.01	0.36**	-0.02	13.16	0.37**	0.07
11	ICC-15119	9.21	0.23**	-0.07	11.25	0.31**	-0.20
12	PDG-84-10	14.45#	1.30*	0.52	20.51#	1.38*	0.68
13	ICC-14775	17.86#	1.51**	0.28	20.94#	1.30*	0.32
14	BKG-21204	13.03	1.04	-0.05	17.83	0.85*	1.05
15	ICC-71	15.44#	1.55**	0.22	20.68#	1.33*	0.39
16	ICC-15680	18.27#	1.66**	1.51+	15.28	0.70*	-0.01
17	ICC-1608	10.54	0.76*	1.46+	12.71	0.55**	-0.08
18	ICC-15896	14.69#	1.25	-0.07	20.22#	1.35*	-0.05
19	ICC-4648	14.97#	1.41**	0.94	22.50#	1.72**	3.65++
20	BGG-21168	17.97#	1.21*	1.13	18.62	0.77*	0.90
21	BG-5028	8.14	0.22**	-0.09	9.49	0.35**	-0.19
22	ICC-6874	18.71#	2.20**	4.03++	20.53#	1.88**	1.26
23	IPC-02-2	12.60	1.12	1.09	19.44#	1.36	0.01
24	RADHE	12.22	1.08	0.54	17.35	1.12	8.63++
25	ICC-14268	11.46	0.58**	0.24	21.49#	1.19	0.05
26	P- 1059	14.03#	1.33**	0.49	23.08#	1.55**	1.65+
27	P- 602	11.05	0.65**	0.04	16.87	0.81	-0.18
28	B- 714	10.80	0.73*	0.03	18.54	0.99	-0.14
29	P- 740	12.65	1.11	-0.09	18.82#	1.20	0.22
30	K-850	12.59	0.71*	0.18	14.53	0.49**	-0.08
31	ICC-74040	8.57	0.09**	0.37	15.07	0.14**	0.76
32	P- 145	12.34	0.86	0.67	15.94	0.84	0.18
33	BG-547	12.29	0.91	-0.02	13.09	0.71*	0.71
34	K- 1052	11.27	0.78*	-0.08	18.60	0.80	1.74++
35	KDG-1288	14.00#	0.81	-0.12	15.81	0.37**	-0.11
36	BGM-572	14.32#	0.69**	0.34	18.22	0.64**	-0.02
37	P- 85	13.85#	1.06	-0.08	18.11	0.75*	-0.04
38	P- 6225	16.98#	1.16*	4.33++	25.85#	1.22*	0.20
39	GL-29061	13.47	1.05	7.88++	22.68#	1.32*	0.32
40	VISHAL	9.06	-0.06**	0.32	11.20	-0.02**	0.20
41	KPG- 39	13.21	0.61**	2.66++	18.46	0.63**	6.39++
42	P- 79086	12.35	0.84	2.70++	20.02#	1.07	0.33
43	BG-8011	12.71	1.00	-0.09	17.52	0.85	-0.12
44	ICC-78126	13.10	1.33**	6.40++	18.48	1.33*	-0.07
45	PBG-85-4	18.76#	2.09**	0.82	24.67#	1.93**	0.68
	SE mean	0.49			0.54		
	Pop. Mean	13.25			18.23		
	SE(d)	0.23			0.33		

Table 4. Contd.,

S.N.	Genotype	100 seed weight			Seed yield per plant		
		$\bar{X}$	b	S^2d	$\bar{X}$	b	S^2d
1	GL-769	10.72	0.36**	-0.06	12.64	0.98	1.17
2	IPC-5-74	12.51	1.16	0.05	12.36	1.01	1.00
3	PDE-2-E	10.03	-0.39**	0.23	16.61	1.15	1.29
4	IPC-95-01	13.20	0.62**	0.13	14.86	1.49*	3.22+
5	ICC-10489	11.77	1.27	0.27	15.85	1.49*	0.87
6	ICC-15911	12.44	0.98	0.09	19.06#	1.79**	1.48
7	PDG-05	12.33	0.97	0.24	15.65	1.21	8.85++
8	ICC-17007	11.01	0.59**	0.20	15.04	1.28*	5.21+
9	GPF-02	11.84	0.86	0.22	15.23	1.04	5.79+
10	ICC-11218	12.18	3.53**	2.68++	12.78	0.61**	-0.01
11	ICC-15119	11.59	-0.18**	1.38+	11.03	-0.03**	0.35
12	PDG-84-10	11.60	0.98	0.03	17.22#	1.27	3.21
13	ICC-14775	10.83	0.78*	0.00	17.26#	1.24*	5.21+
14	BKG-21204	13.73#	1.05	-0.08	19.26#	0.97	2.44
15	ICC-71	8.66	0.43**	0.03	13.66	1.06	2.23
16	ICC-15680	14.03#	1.44	0.51	16.89	0.81*	3.04
17	ICC-1608	19.65#	0.98	1.07+	18.09#	1.10	3.82
18	ICC-15896	11.33	0.70*	0.17	16.14	1.23*	1.73
19	ICC-4648	10.58	1.05	0.03	17.20#	1.72**	12.47++
20	BGG-21168	13.17	0.45**	0.18	20.87#	0.97	3.52
21	BG-5028	27.19#	4.11**	1.54++	16.98#	0.46**	2.60
22	ICC-6874	10.57	0.56**	0.25	14.56	2.11**	6.10+
23	IPC-02-2	10.18	0.10**	-0.02	13.86	1.31*	2.18
24	RADHE	15.39#	1.79	0.93	17.17#	1.33*	9.06++
25	ICC-14268	11.32	1.54	-0.02	14.48	0.57**	1.49
26	P- 1059	9.54	0.97	-0.02	16.33	1.46*	9.11++
27	P- 602	18.60#	0.59**	0.32	20.43#	0.63**	14.92++
28	B- 714	9.81	0.68**	0.12	12.62	0.79*	2.95
29	P- 740	12.64	0.42**	0.82	15.59	1.45*	0.66
30	K-850	19.18#	1.56	0.49	21.61#	0.46**	3.96+
31	ICC-74040	9.86	0.44**	0.22	13.38	0.02**	1.86
32	P- 145	12.18	1.59	0.06	14.76	1.02	0.46
33	BG-547	20.51#	2.14	0.41	17.35#	0.81	3.57
34	K- 1052	10.56	1.09	0.40	15.54	0.54**	0.86
35	KDG-1288	13.81#	0.80	0.17	15.82	0.33**	5.23+
36	BGM-572	11.94	0.51**	0.20	17.17#	0.23**	0.45
37	P- 85	14.21#	1.32	0.15	19.18#	0.75*	0.95
38	P- 6225	10.91	1.00	0.15	19.70#	1.11	0.89
39	GL-29061	11.60	1.40	0.08	18.22#	1.30*	-0.05
40	VISHAL	18.85#	3.11**	0.46	16.45	-0.19**	13.20++
41	KPG- 39	15.78#	-2.54**	8.62++	20.38#	0.03**	26.65++
42	P- 79086	10.05	0.24**	-0.09	13.50	1.02	1.69
43	BG-8011	12.80	1.89**	0.67	16.94#	1.30*	0.95
44	ICC-78126	11.61	1.56	-0.08	14.69	1.56**	2.08
45	PBG-85-4	12.42	0.49**	0.10	19.69#	2.24**	5.19+
	SE mean	0.45			0.59		
	Pop. Mean	12.99			16.31		
	SE(d)	0.20			0.28		

Table 5. Genotypes showing high mean and stable performance for different characters (b=1 and S^2d= 0)

S.N.	Character	Stable genotypes
1.	Days to 50% flowering	ICC-15911, ICC-71, ICC-6874, KDG-1288, P- 85
2.	Days to maturity	ICC-15911, PDG-84-10, ICC-15896, KDG-1288, K- 1052
3.	Plant height (cm)	IPC-5-74, ICC-15680, P- 602, B-714, BG-547, KDG-1288
4.	No. of pods per plant	P- 85, ICC-15896, KDG-1288, PDG-05
5.	No. of seeds per pod	PDE-2-E, GL-29061, IPC-02-2, P- 602, B-714, K-1052, P- 6225, GPF-02
6.	No. of seeds per plant	PDG-05, GPF-02, IPC-02-2, ICC-14268, P-740, P-79086
7.	No. of branches per plant	BGG-21168, GPF-02, ICC-11218, PBG-85-4, BGM-572, P- 6225, ICC-15911
8.	100 seed weight (g)	BKG-21204, ICC-15680, RADHE, K-850, BG-547, KDG-1288, P- 85
9.	Biological yield (g)	PDG-05, BKG-21204, BG-5028, P- 602, K-850, BGM-572
10.	Harvest index (%)	K-1052, P-85, GL-29061, KPG-39, VISHAL
11.	Protein content (%)	ICC-11218, BG-8011, ICC-15680, ICC-1608, ICC-15896, BGG-21168, BG-5028, P-602, BGM-572, GL-29061, ICC-14775
12.	Seed yield per plant (g)	P-6225, BKG-21204, ICC-1608, BGG-21168, BG-547, PDG-84-10

temperature in late sowing condition. These genotypes could be useful in genetic improvement programs for enhancing stability of chickpea.

Authors' contribution

Conceptualization of research work and designing of experiments (DP, TS, RST); Execution of field experiments and data collection (RST, AK, AAK); Analysis of data and interpretation (DP, RST, TS, SK); Preparation of manuscript (RST, DP, TS).

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