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Genotypic Variability, Heritability And Correlation Of Yield And Its Components Under Different Planting Conditions In An Elite Genotypes Of Chickpea (*Cicer arietinum* L)

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Abstract

Twenty two elite genotypes of chickpea were evaluated during 2014-16 to study the magnitude of genetic variability, heritability, genetic advance and the correlation of seed yield and its contributing characters with respect to high temperature tolerance under different planting conditions. A high degree of significant variation was observed for all the characters in all planting conditions and over the years under study. Generally, there was an increase in phenotypic and genotypic coefficient of variation (GCV and PCV) under late and very late planting compared to normal planting condition for most of traits except days to maturity, plant height and plant biomass, which entail that when selecting for improving chickpea, the target environment should be taken in consideration. Further, plant biomass, number of seeds per pod, 100 seed weight and seed yield per plant showed high values of GCV and PCV coupled with high heritability and genetic advance in all environments and over the years. In addition, plant biomass, number of pods per plant, number of effective pods per plant, harvest index and 100 seed weight were positively correlated with seed yield in all environments. Therefore, emphasis should be given to these characters for the improvement of the seed yield of chickpea in a breeding program for heat tolerance. On overall basis, it was noticed from the present study that the genotypes ICCV 10 and JG 14 are found promising for earliness, high biomass, high harvest index and seed yield from favorable and unfavorable environments suggesting that theses genotypes are heat tolerant with best suited for all planting conditions and can be utilized in various breeding programmes.

Keya words: Chickpea, correlation, genetic advance, heritability, heat tolerance.

Introduction

Chickpea (*Cicer arietinum* L.) is the second most important food legume after dry beans (Varshney *et al.* 2013) in the world scenario. Currently, it is grown throughout the world from Mediterranean to sub-tropical. Nearly, 80 per cent of global chickpea is produced in Southern and Southeast Asia, wherein India ranks first in the world contributing 67.4 per cent of global chickpea production followed by Australia (6.21 %) and Pakisthan (5.73 %) (FAOSTAT, 2016).

In spite of its diverse germplasm, the average productivity of the crop is low (Jha *et al.* 2014) due to several biotic and abiotic stresses. Among abiotic stresses, temperature, drought

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and salt, affect the growth of chickpea at different developmental stages (Suzuki *et al.* 2014), which indicating great scope for genetic improvement as well as for increasing the productivity of the crop through varietal improvement. Although, in the recent report, chickpea suffers heavy yield losses when exposed to heat stress at the reproductive (during flowering and pod development) stage (Sita *et al.* 2017). Even more, it reduces the number of flowering branches and thus the number of flowers per plant in chickpea (Vara Prasad *et al.* 2001). Therefore, the main reason for low productivity in chickpea is the adverse ecologies, in which it is cropped and its vulnerability to biotic and abiotic stresses (Jha *et al.* 2014). On the other hand, reductions in various yield attributes due to heat stress also has been reported in chickpea (Krishnamurthy *et al.* 2011; Kaushal *et al.* 2013). Therefore, only way to tackle or overcome this constraint is by developing high yielding heat tolerant genotypes. Hence, there is an urgent need to explore the gene bank for diverse sources of heat tolerance in chickpea.

The present investigation was therefore taken up to estimate genetic variability, heritability, genetic advance and correlation of seed yield of chickpea with its components in respect of high temperature tolerance under different environmental conditions.

Materials And Methods

The present investigation was undertaken at the District Seed Farm (AB Block), Kalyani under Bidhan Chandra Krishi Viswavidyalaya during winter season of 2014-16 in upland situation. The farm is situated at approximately 22° 56´ N latitude and 88° 32´ E longitude with an average altitude of 9.75 m above mean sea level (MSL). Whereas, the air temperature varied from 7.5°C being minimum in January and more than 35.5°C being maximum in April. Therefore, the month of April is highly suitable for screening the heat tolerant genotypes under natural field conditions.

An experimental material comprised of twenty two genotypes of chickpea (*Cicer arietinum* L.). The genotypes were selected based on superior seed yield performance, early maturity and high biomass during previous studies. Among the genotypes, BG-256 and Anuradha were considered as local checks. Origin, pedigree and special features of the chickpea genotypes used in the experiment is given in Table 1. The experiment was laid out in *Randomized Complete Block Design* (RCBD) with two replications under different planting dates (20 days interval) *viz.,* normal (E1), late (E2) and very late planting (E3) during 2014-15 (year 1) and similarly during 2015-16 (year 2) as the procedure followed by Upadhyaya, *et al.* (2011) to identify heat-tolerant genotypes on the basis of their early maturity, grain yield and associated characters.

Each genotype was accommodated in a row length of two meter, keeping plant to plant distance of 10 cm and row to row distance of 30 cm. The recommended agronomical and plant protection practices were adopted for good crop growth. Observations were recorded on five randomly selected plants in each entry for ten characters *viz.,* days to 50 per cent flowering, days to maturity, number of primary branches per plant, plant height, number of pods per plant, number of seeds per pod, biological yield per plant (gm), 100-seed weight (gm), seed yield per plant (gm), and harvest index (%) and their mean values were used for the statistical analysis.

The statistical analysis was carried out using META-R (Multi Environment Trail Analysis with R for Windows) (Alvarado *et al*. 2017) software for analysis of variance and mean comparison of traits. The genotypic and phenotypic coefficient of variability (GCV and PCV) were estimated as per the formulae suggested by Burton (1952), while, heritability in broad sense was calculated by using the formulae suggested by Allard (1960).

Results And Discussion

The genetic parameters viz., mean, range, phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), heritability estimates and predicted genetic advance as per cent of mean for characters studied under three environments during two years are presented in Table 2 and 3. The results of the present investigation indicated the prevalence of significant differences among 22 genotypes studied in three environments with pooled analysis for all the ten characters over both years. This significance suggested the presence of substantial amount of genetic variability among the chickpea genotypes.

In general, mean performance under normal planting was higher as compared to late and very late planting condition and all the characters were adversely affected under these conditions over the years, indicating scope for selection of suitable basic material in breeding programmes for further improvement. In addition, genotypes differed significantly with respect to all traits under study across all the environments and over years. Four genotypes *viz.,* ICCV 10, JG 14, Annigeri 1 and RSG 888 showed higher seed yield, early flowering, early maturity, higher number of pods per plant, higher values of harvest index and 100 seed weight under all planting conditions over the years as compared to other genotypes. Whereas, genotypes JGG 1, Vikas, RSG 2, Vaibhav, Vijay and BG 256 showed very poor performance for almost all the characters in all the environmental conditions and over the years. These results are in conformity with the report of Meena *et al*. (2006), Upadhyaya *et al.* (2011) and Kumar *et al.* (2012 and 2013).

Generally, there was a reduction in genotypic and phenotypic variability for most of studied traits under late and very late planting compared to normal planting condition in both years, indicating that gene expression changes with the change in environment. These results are in agreement with earlier findings of Mohamed *et al.* (2014). However, the components of genotypic variance were greater than environmental variance for all the traits studied under different environments over the years, indicating the least environmental influence on their phenotypic variances. Hence, effective selection for these traits on the basis of phenotypic variability could be made. These results are in conformity with results of other investigations (Vaghela *et al.* 2009 and Babbar *et al.* 2012). On the other hand, under three different environments over the years, a narrow difference between the values of PCV and GCV were observed for all the traits except number of seeds per pod and 100 seed weight under normal planting and pooled analysis. While, days to 50 per cent flowering, number of seeds per pod and 100 seed weight under late and very late planting, but plant biomass, number of pods per plant, number of effective pods per plant recorded only under very late planting condition. Thus, indicating the negligible influence of extraneous factor on these traits. Similar observations of narrow difference were noticed by Babbar *et al.* (2012) in a study involving 44 promising lines of chickpea evaluated under late sown season.

Further, there was an increase in phenotypic and genotypic coefficient of variation under late and very late planting compared to normal planting condition over the years for most of traits under study except days to maturity, plant height and plant biomass. These results entail that when selecting for improving chickpea the target environment should be taken in consideration. Mohamed *et al.* (2014) and Dhuria (2016) also reported similar results. Similarly, under three environments over the years and pooled analysis, a moderate to low estimates of genotypic and phenotypic coefficient of variation were observed for all the traits except number of seeds per pod, 100 seed weight and seed yield per plant, which noticed higher GCV and PCV. These results are in agreement with the earlier reports of Vaghela *et al.* (2009), Babbar *et al.* (2012) and Dhuria (2016).

Generally, there was a decrease in estimates of heritability under late and very late planting as compared to the normal planting condition across the years. The high estimates of heritability were observed in the present study for plant biomass, number of seeds per pod and seed yield per plant in all the environments along with pooled analysis, for plant height, number of pods per plant, number of effective pods per plant, 100 seed weight and harvest index recorded only under normal and late planting with pooled analysis. However, for days to 50 per cent flowering and days to maturity it was recorded only in normal planting and pooled analysis across the years.

Hence, selection for seed yield and yield related traits like plant biomass and number of seeds per pod to be consider to improve the yield in all the planting conditions, while under normal and late planting condition, plant height, number of pods per plant, number of effective pods per plant, 100 seed weight and harvest index are taken into consideration. Since, these traits are less influenced by environment and such characters have also indicated that they are under influence of more number of fixable factors. Vaghela *et al.* (2009) and Devasirvatham (2012) had also reported similar results for these traits.

Furthermore, in all three environments and over the years, high heritability coupled with high genetic advance were observed for plant biomass, number of seeds per pod, 100 seed weight and seed yield per plant, which may be attributed to the preponderance of additive gene action and selection pressure could profitably be applied on these characters for yield improvement for respective environment. Sewak *et al.* (2012), Mohamed *et al.* (2014) and Dhuria (2016) were also noticed similar results of high heritability coupled with high genetic advance for the same traits. Whereas, moderate heritability coupled with high genetic advance was obtained for days to 50 per cent flowering, number of effective pods per plant and 100 seed weight under very late planting condition during the first year indicating that selection based on these characters would be rewarding and useful in improvement of chickpea under this plating condition. These observations are in contradiction to Mohamed *et al.* (2014) in a study of 88 recombinant inbred lines of chickpea under favorable and heat stress environments.

In addition, number of seeds per pod, 100 seed weight and seed yield per plant exhibited high magnitude of genetic advance expressed as percentage of mean coupled with high heritability values and greater genotypic and phenotypic coefficient of variations in all the environments and over the years. Thus, the phenotypic selection for these traits would, therefore was be most effective under respective environments. Similar kind of results was reported by Babbar *et al.* (2012) and Mohamed *et al.* (2014).

The information on variability alone may not help in identifying characters for enforcing selection; therefore, variability estimates in conjunction with association of characters with yield and its components are more reliable (Khan *et al.* 2016). However, characters having a high genotypic coefficient of variation indicate high potential for reliable selection in any environments (Burton and DeVane, 1953). The implications of genotypic correlation between seed yield and its component characters of 22 chickpea genotypes under three different environments (normal, late and very late planting condition) with pooled analysis over two years are presented in Table 4 and 5.

Many reports (Mishra and Babbar, 2011, Babbar *et al.* 2012, Tesfamichael *et al.* 2015 and Dhuria, 2016) including our own study indicate plant biomass, number of pods per plant, number of effective pods per plant, number of seeds per pod and harvest index to be highly significant and positively correlated with seed yield per plant. Whereas, days to 50 per cent flowering and days to maturity exhibited a highly significant but negative association. Similar results were reported by Babbar and Patel (2005) and Meena *et al.* (2006). On the other hand, non-significant and positive association was seen with plant height and 100 seed weight. These results are in conformity with the studies of Kumar *et al.* (2002). Thus, it is evident from the results that the selection for shorter duration among chickpea genotypes result in higher yields. It is mainly because, days to 50 per cent flowering and days to maturity are negatively associated with several yield components, which are intern negatively associated with yield.

Among yield components, positive associations were also observed between plant height and plant biomass, number of seeds per pod and 100 seed weight, whereas, remaining traits expressed negative association with this trait. Dhuria (2016) had also reported similar results for these traits. However, plant biomass recorded a significant and positive correlation with number of pods per plant, number of effective pods per plant, number of seeds per pod and harvest index. Similar findings were reported by Babbar *et al.* (2012).While, plant biomass, number of effective pods per plant, number of seeds per pod and harvest index were showed highly significant and positive correlation with number of pods per plant. These results are in agreement with earlier finding of Khorgade (1985). A positive, significant correlation was observed between harvest index and plant biomass, number of pods per plant and number of effective pods per plant. These findings support the works of Kumar *et al.* (2002). These results evidenced that selection of plant with high plant biomass, high number of pods per plant and effective pods per plant, higher harvest index and seeds per pod would likely to be helpful in improving yield of chickpea under studied environments.

Conclusion

Genetic improvement in chickpea under favorable and unfavorable environment is possible through selection exercised for the plant biomass, number of seeds per pod, 100 seed weight and seed yield per plant, which all showed high values of GCV and PCV coupled with high heritability and genetic advance in all environments and over the years. Whereas, plant biomass, number of pods per plant, number of effective pods per plant, harvest index and 100 seed weight were most important traits related to heat stress tolerance, since these characters were positively correlated with seed yield in all environments under study. Therefore, emphasis should be given to these characters for the improvement of the seed yield of chickpea in a breeding program for heat tolerance. Further, on overall basis, it was noticed from the present study that the genotypes ICCV 10 and JG 14 are found promising for earliness, high biomass, high harvest index and seed yield per plant in all the environments suggesting that theses genotypes are heat tolerant with best suited for all planting conditions and can be utilized in various breeding programmes.

Table 1: Origin, pedigree and special features of the chickpea (*Cicer arietinum* L.) genotypes used in the present study.

Sl. No.	Genotypes	Pedigree	Origin	Special features[a]
1	Annigeri 1	Selection from local germplasm	ARS, Gulbarga, Karnataka	WR, E
2	JG 6	(ICCV 10 X K 850)x (H208 X RS11)	JNKVV, Jabalpur, Madhya Pradesh	DRR, PBR
3	RSG 888	RSG 44 x E 100 Y	RAU, Durgapura, Rajasthan	HY, WR, DP
4	ICCV 10	P 1231 x P 1265	ICRISAT, Hyderabad	E, HY, WR, DRR, HT
5	Chaffa	Selection from Niphad (MS)	JAU, Junagarh, Gujarat	E, LS
6	GCP 105	ICCL 84224 x Annegeri 1	JAU, Junagarh, Gujarat	WR, LS
7	JAKI 9218	(ICCC 37 x GW 5/7) x ICCV 107	PDKV, Akola, Maharashtra	E, LS
8	JG 14	(GW-5/7 x P-326) x ICCL 83149	JNKVV, Jabalpur, Madhya Pradesh	E, WR, HT
9	JG 16	(ICCC 42 x ICCV 88506) x (KPG 59 x JG 74)	PDKV, Akola, Maharashtra and ICRISAT, Hyderabad	E, HY
10	JG 315	Selection from WR 315	JNKVV, Jabalpur, Madhya Pradesh	WR, LS
11	JGG 1	Selection from germplasm	JNKVV, Jabalpur, Madhya Pradesh	SS, WR, HY
12	Vikas	GW 5/7 x Ceylon 2	IIPR, Kanpur, Uttar Pradesh	E, WR, PBR, LS
13	Pusa 372	P 1231 x P 1265	IARI, New Delhi	DRR, WR, SS
14	Pusa 547	Mutant of BG 256	IARI, New Delhi	LS
15	RSG 2	Mutant of RS 10	RAU, Durgapura, Rajasthan	DP, HY
16	RSG 945	RSG 668 x RSG 817	ARS, Durgapura, Rajasthan	E, SP, WR, DRR, LS
17	RSG 963	RSG 524 x PDG 84-10	RAU, Durgapura, Rajasthan	LS
18	RSG 974	K-850 x RSG-515	RAU, Durgapura, Rajasthan	SP, HY, WR, DRR, HT
19	Vaibhav	Selection from GP ICCV 91106	IGKV, Raipur, Chhattisgarh	E, SS
20	Vijay	P 127 X Annegeri 1	MPKV, Rahuri, Maharashtra	SS, HY
21	Anuradha (C1)	Mahamaya 1 x Radhey	Research station, Berhampur, West Bengal	WR
22	BG 256 G(C2)	(JG 62 x 850-3/27) x (L 550 X H 208)	IARI, New Delhi	LS, WR

[a]SP, single poded; DP, double pods; HT, heat tolerant; E, early maturing; WR, wilt resistant; HY, high yield; DRR, dry root rot resistant; PBR, pod borer resistant; LS, large seed size; SS, small seed size.
C,check

Table 2: Estimates of components of variability, heritability (broad sense), genetic advance and genetic advance as percent of mean for ten quantitative traits under three different environments with pooled analysis during 2014-15.

Characters	Environment	Grand mean	Range		PCV	GCV	h^2 (bs)	Genetic advance	Genetic advance (as %of mean)
			Min	Max					
Days to 50 per cent flowering	NP	56.90	38.40	67.00	15.90	12.80	65.30	12.20	21.40
	LP	53.70	36.50	65.00	17.20	13.00	57.30	10.90	20.30
	VLP	49.00	33.50	60.50	18.00	13.30	54.80	9.90	20.30
	Pooled	53.20	36.10	63.80	15.50	14.20	84.00	14.30	26.80
Days to maturity	NP	113.80	94.00	125.00	7.20	5.80	64.70	11.00	9.60
	LP	109.10	92.50	120.50	7.80	5.70	54.10	9.40	8.60
	VLP	102.20	88.00	115.50	7.80	5.60	50.80	8.30	8.20
	Pooled	108.40	91.50	120.30	6.80	6.00	79.50	12.00	11.10
Plant height (cm)	NP	51.20	40.00	62.50	11.10	9.10	66.50	7.80	15.20
	LP	47.40	38.00	58.00	10.90	8.60	62.00	6.60	14.00
	VLP	41.50	36.50	48.00	8.20	6.00	54.30	3.80	9.20
	Pooled	46.70	38.20	56.20	9.20	8.60	87.40	7.70	16.50
Plant biomass (g)	NP	127.80	99.00	164.50	17.80	16.60	86.50	40.60	31.70
	LP	122.10	98.00	158.50	17.60	15.90	82.20	36.40	29.80
	VLP	109.70	87.50	143.50	18.60	14.90	64.00	26.90	24.50
	Pooled	119.80	96.80	154.00	17.10	16.50	93.50	39.30	32.80
Number of pods per plant	NP	86.50	71.00	106.00	13.70	11.10	65.90	16.00	18.50
	LP	82.00	68.00	100.00	13.20	10.40	61.80	13.80	16.80
	VLP	73.10	61.00	93.50	16.20	11.90	54.20	13.20	18.10
	Pooled	80.50	67.70	99.80	13.30	12.00	81.90	18.00	22.40
Number of effective pods per plant	NP	83.50	67.50	102.00	13.70	11.20	66.70	15.70	18.90
	LP	76.50	60.00	95.50	14.50	11.40	61.80	14.20	18.50
	VLP	68.70	52.00	89.50	17.20	12.90	56.80	13.80	20.10
	Pooled	76.20	60.80	95.70	14.00	12.70	81.70	18.00	23.60
Number of seeds per pod	NP	1.90	1.00	3.90	39.20	35.90	83.90	1.30	67.80
	LP	1.80	1.00	3.50	42.30	37.00	76.60	1.20	66.70
	VLP	1.60	1.00	3.10	44.80	36.50	66.40	0.90	61.30
	Pooled	1.80	1.00	3.50	39.40	38.20	94.10	1.30	76.40
100 seed weight (g)	NP	21.10	12.50	28.50	22.00	20.00	79.30	7.60	35.90
	LP	18.30	10.50	25.80	25.60	22.80	65.30	12.20	21.40
	VLP	15.70	9.50	22.60	30.20	22.60	56.10	5.50	34.80
	Pooled	18.40	10.80	25.60	23.90	22.90	91.40	8.30	45.00
Harvest index (%)	NP	39.40	31.50	47.40	9.60	8.00	70.50	5.50	13.90
	LP	37.00	29.40	46.30	10.80	8.80	66.60	5.50	14.80
	VLP	33.90	22.50	44.70	15.30	11.70	58.20	6.20	18.40
	Pooled	36.80	28.40	46.10	10.50	9.80	86.70	6.90	18.70
Seed yield per plant (g)	NP	50.60	32.50	75.00	22.80	21.10	85.80	20.40	40.30
	LP	46.30	30.50	70.50	24.50	21.20	74.40	17.40	37.60
	VLP	37.80	20.00	62.50	30.90	25.70	69.30	16.70	44.10
	Pooled	44.90	27.70	69.30	24.70	23.40	89.50	20.50	45.60

NP, Normal planting; LP, Late planting; VLP, Very late planting

Table 3: Estimates of components of variability, heritability (broad sense), genetic advance and genetic advance as percent of mean for ten quantitative traits under three different environments with pooled analysis during 2015-16.

Characters	Environment	Grand mean	Range		PCV	GCV	h^2 (bs)	Genetic advance	Genetic advance (as % of mean)
			Min	Max					
Days to 50 per cent flowering	NP	56.20	40.00	65.80	15.50	12.60	66.30	11.90	21.10
	LP	52.70	38.00	61.00	15.60	12.50	64.00	10.80	20.60
	VLP	50.10	35.50	60.50	16.10	12.30	58.50	9.70	19.40
	Pooled	53.00	37.80	61.70	14.70	13.50	84.30	13.50	25.50
Days to maturity	NP	114.60	90.00	126.50	8.60	7.50	75.10	15.30	13.40
	LP	108.80	85.50	120.50	10.10	7.70	58.70	13.30	12.20
	VLP	103.80	80.50	117.00	10.60	7.70	52.50	11.90	11.40
	Pooled	109.10	85.30	121.00	9.00	8.30	83.90	17.00	15.60
Plant height (cm)	NP	52.50	43.50	65.00	10.90	9.10	69.50	8.20	15.60
	LP	46.90	39.50	59.50	13.90	10.80	60.40	8.10	17.20
	VLP	41.00	32.50	50.50	13.90	10.60	58.10	6.80	16.60
	Pooled	46.80	40.30	58.20	11.60	10.30	78.90	8.90	18.90
Plant biomass (g)	NP	131.00	104.00	168.50	17.10	15.90	86.40	39.90	30.40
	LP	125.70	95.00	165.00	17.90	15.80	78.10	36.30	28.80
	VLP	118.40	90.50	158.00	19.30	16.80	75.80	35.70	30.20
	Pooled	125.00	96.50	163.00	17.40	16.60	90.80	40.80	32.60
Number of pods per plant	NP	89.40	73.50	109.50	13.60	11.80	74.80	18.80	21.00
	LP	83.60	70.50	101.00	13.10	10.70	66.00	14.90	17.90
	VLP	77.10	66.50	96.00	13.80	10.30	55.40	12.20	15.80
	Pooled	83.40	70.50	102.20	12.70	11.50	82.40	18.00	21.60
Number of effective pods per plant	NP	85.20	70.00	107.50	13.90	12.20	77.90	18.90	22.20
	LP	79.90	66.00	98.00	14.10	10.50	54.70	12.70	15.90
	VLP	67.70	57.50	87.00	16.60	12.00	52.50	12.20	18.00
	Pooled	77.60	64.80	97.50	13.50	12.40	84.20	18.20	23.50
Number of seeds per pod	NP	2.10	1.10	3.80	35.10	29.80	72.10	1.10	52.00
	LP	1.70	1.10	3.20	39.20	32.00	66.60	0.90	53.80
	VLP	1.60	1.00	3.20	46.70	37.50	64.40	1.00	61.90
	Pooled	1.80	1.10	3.40	36.60	35.20	92.40	1.20	69.60
100 seed weight (g)	NP	21.70	14.50	30.00	18.00	14.90	68.60	5.50	25.40
	LP	19.30	12.50	26.50	19.40	15.80	66.20	5.10	26.40
	VLP	16.40	9.50	24.00	24.40	19.00	60.80	5.00	30.60
	Pooled	19.10	12.30	26.80	18.80	17.50	86.90	6.40	33.60
Harvest index (%)	NP	41.20	34.80	48.40	9.90	8.30	70.80	5.90	14.40
	LP	39.30	30.40	47.00	11.20	9.10	66.00	6.00	15.20
	VLP	34.80	25.30	41.50	12.20	9.40	59.00	5.20	14.90
	Pooled	38.50	30.50	45.60	9.90	8.90	81.30	6.40	16.60
Seed yield per plant (g)	NP	54.30	37.50	81.00	23.00	20.80	81.60	21.00	38.70
	LP	49.60	33.00	77.50	25.40	22.50	78.50	20.30	41.00
	VLP	41.50	24.50	65.00	28.20	24.20	73.70	17.80	42.80
	Pooled	48.50	32.30	74.50	24.30	22.80	88.30	21.40	44.20

NP, Normal planting; LP, Late planting; VLP, Very late planting

Table 4: Genotypic correlation coefficients between different yield components of chickpea under normal, late and very late planting conditions with pooled analysis during 2014-15.

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Normal planting										
X_2	0.979**	1.000								
X_3	0.084	-0.065	1.000							
X_4	-0.556**	-0.643**	0.255	1.000						
X_5	-0.888**	-0.798**	0.305	0.893**	1.000					
X_6	-0.953**	-0.742**	0.317	0.883**	1.000	1.000				
X7	-0.820**	-0.740**	0.241	0.672**	0.695**	0.679**	1.000			
X_8	-0.365	-0.260	0.577**	0.322	0.537**	0.562**	0.606**	1.000		
X_9	-0.220	-0.224	0.538**	0.487*	0.606**	0.613**	0.365	0.254	1.000	
X_{10}	-0.573*	-0.537**	0.393	0.998**	0.898**	0.871**	0.661**	0.258	0.779**	1.000
Late planting										
X_2	0.853**	1.000								
X_3	0.076	0.133	1.000							
X_4	-0.662**	-0.691**	0.217	1.000						
X_5	-0.999**	-0.915**	0.148	0.968**	1.000					
X_6	-0.883**	-0.840**	0.267	0.904**	1.000	1.000				
X7	-0.842**	-0.649**	0.110	0.738**	0.611**	0.589**	1.000			
X_8	-0.347	-0.361	0.399	0.299	0.525*	0.552**	0.700**	1.000		
X_9	-0.464*	-0.425*	0.343	0.727**	0.772**	0.791**	0.419	0.186	1.000	
X_{10}	-0.540**	-0.710**	0.343	1.000	0.971**	0.856**	0.691**	0.240	0.939**	1.000

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Very late planting										
X_2	0.946**	1.000								
X_3	-0.081	0.001	1.000							
X_4	-0.682**	-0.764**	0.254	1.000						
X_5	-1.000	-0.975**	0.239	1.000	1.000					
X_6	-1.000	-0.892**	-0.057	0.957**	1.000	1.000				
X7	-0.679**	-0.565**	0.139	0.609**	0.863**	0.824**	1.000			
X_8	-0.563**	-0.154	0.359	0.374	0.645**	0.986**	0.870**	1.000		
X_9	-0.661**	-0.818**	0.212	0.937**	0.920**	0.808**	0.627**	0.423*	1.000	
X_{10}	-0.795**	-0.862**	0.123	1.000	1.000	0.830**	0.640**	0.539**	1.000	1.000

Table 5: Genotypic correlation coefficients between different yield components of chickpea under normal, late and very late planting conditions with pooled analysis during 2015-16.

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Normal planting										
X_2	0.832**	1.000								
X_3	0.317	0.461*	1.000							
X_4	-0.626**	-0.656**	-0.142	1.000						
X_5	-0.823**	-0.733**	-0.057	0.871**	1.000					
X_6	-0.727**	-0.774**	-0.070	0.871**	1.000	1.000				
X7	-0.740**	-0.802**	-0.074	0.624**	0.785**	0.718**	1.000			
X_8	-0.417	-0.359	0.159	0.253	0.514**	0.524*	0.706**	1.000		
X_9	-0.108	-0.202	0.549**	0.495*	0.460*	0.506*	0.093	0.130	1.000	
X_{10}	-0.570**	-0.574**	0.056	0.981**	0.847**	0.865**	0.532*	0.317	0.785**	1.000

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
				Late planting						
X_2	0.741**	1.000								
X_3	0.430*	0.244	1.000							
X_4	-0.523*	-0.610**	0.074	1.000						
X_5	-0.822**	-0.926**	-0.067	0.942**	1.000					
X_6	-0.774**	-0.838**	-0.011	1.000	1.000	1.000				
X7	-0.619**	-0.619**	-0.241	0.724**	0.649**	0.577**	1.000			
X_8	-0.402	-0.506*	-0.065	0.404	0.519*	0.592**	0.671**	1.000		
X_9	-0.293	-0.215	0.424*	0.666**	0.629**	0.650**	0.227	0.324	1.000	
X_{10}	-0.482*	-0.612**	0.096	1.000	0.886**	0.811**	0.553**	0.303	0.874**	1.000
Very late planting										
X_2	1.000	1.000								
X_3	0.123	0.270	1.000							
X_4	-0.652**	-0.786**	0.145	1.000						
X_5	-0.806**	-0.981**	-0.259	1.000	1.000					
X_6	-0.890**	-0.783**	-0.350	1.000	1.000	1.000				
X7	-0.708**	-0.728**	0.031	0.648**	0.777**	0.903**	1.000			
X_8	-0.240	-0.393	-0.170	0.420	0.870**	0.774**	0.568**	1.000		
X_9	-0.649**	-0.574**	0.352	0.772**	0.624**	0.681**	0.671**	0.703**	1.000	
X_{10}	-0.844**	-0.759**	0.180	1.000	1.000	1.000	0.797**	0.498*	0.964**	1.000

** - Significant at 1% probability level * - Significant at 5% probability level

X_1 - Days to 50% flowering X_2 - Days to maturity X_3 - Plant height (cm) X_4 – Plant biomass (g)

X_5 - Number of pods per plant X_6 - Number of effective pods per plant X_7 - Number of seeds per pod X_8 - 100 seed weight (g)

X_9 - Harvest index (%) X_{10} - Seed yield per plant (g).

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