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EXPLOITATION OF CHICKPEA BREEDING LINES FOR GENETIC GAIN AND ASSESSMENT OF EXTENT OF GENETIC DIVERSITY

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ABSTRACT

Forty advance breeding lines developed at Regional Agricultural Research Station, Nandyal were evaluated for morphological and yield traits through principal component analysis and ward's clustering analysis for genetic gain and extent of genetic diversity. The PC1 accounted for maximum variability *i.e*., 37.94%, which reduced gradually to PC2 (26.56%), PC3 (15.05%), PC4 (9.50%), PC5 (7.07%) and PC6 (3.88%). The advance breeding lines of chickpea grouped into five different non-overlapping clusters using ward's cluster analysis. Genotypes in cluster I showed the highest seed yield and early maturing types whereas cluster III revealed the taller genotypes suitable for mechanical harvesting. The genotypes in cluster I (NBeG 924, NBeG 1610, NBeG 1614 and NBeG 1639) and cluster III (NBeG 1420, NBeG 1710, NBeG 1423, NBeG 1428, NBeG 1430, NBeG 1469, NBeG 1632 and NBeG 1923) could be utilized in future breeding programs for developing high yielding, early maturing types with machine harvestable genotypes suitable for scarce rainfall zone of Andhra Pradesh.

Key words : Genetic diversity, *Per se* performance, Principal component analysis, Ward's cluster analysis.

Introduction

Chickpea (*Cicer arietinum* L., 2n=14) is an important food legume crop in India, grown during *Rabi* season and occupies about 75% area of the world. Globally, it is grown in 13.71 m ha with 14.24 mt production, whereas in India, chickpea is grown in 11.91 m ha with production of 9.99 mt. Chickpea represents 36% and 46% of the national pulse acreage and production respectively. In India, total area is mainly contributed by Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Andhra Pradesh and Karnataka. Chickpea is highly nutritive and its seed contains 17-24% proteins, 41- 50.8% carbohydrates and high percentage of other mineral nutrients and unsaturated linoleic, oleic acid and also on account of its extensive adaptability, it became one of the most of the important crops for human consumption (Thakur *et al*., 2018). In Andhra Pradesh, chickpea is grown in 4.45 lakh ha with 4.56 lakh tonnes production mainly grown Kurnool, Nandyal, Prakasam, Anantapur, Kadapa, Palnadu, Bapatla and Guntur districts. RARS, Nandyal is the lead centre responsible for location specific research on chickpea in scarce rainfall zone of Andhra Pradesh with the objective of developing high yielding and short duration chickpea varieties with resistance/tolerance to biotic and abiotic stresses. Of late greater emphasis was laid on development of varieties suitable for machine harvest and also *kabuli* chickpeas suitable for export with improved nutritional value. Efforts in this direction have led to the development of several promising breeding lines at RARS, Nandyal both in *desi* and *kabuli* types of chickpea.

Genetic distance among the parents used in varietal development plays a vital role as it is expected to release more variability in segregating generations which can be exploited for improvement of crops (Nimbalkar *et al*., 2017). Genetic diversity studies using Ward's minimum variance (Rao, 1952) and similarity and dissimilarity coefficients will be generally employed to know the genetic distance among the parents. The present investigation was therefore designed to assess the *per se* performance and genetic diversity among advance breeding lines of *desi* and *kabuli* chickpea types.

Materials and Methods

Thirty three advanced breeding lines developed at Regional Agricultural Research Station, Scarce Rainfall Zone, Nandyal and eight released varieties (13 *kabuli* and 28 *desi* chickpea genotypes) were evaluated in a randomized block design with three replications. Sowing was done during *Rabi* 2022-23 with spacing of 30 cm between the rows and 10 cm between plants. Phenotypic data were recorded for various characters namely days to 50 per cent flowering, days to maturity, plant height (cm), number of pods per plant, 100 seed weight (g) and seed yield (kg/ha). The mean values of each replication were used to carry out the analysis of variance (ANOVA) using JMP statistical software (version 17). The genotypic (GCV), phenotypic (PCV) and environmental coefficients of variation (ECV) and their variances were calculated using as per Singh and Chaudhary (1985). The broad sense heritability was calculated on the genetic mean basis according to Allard (1999) as the ratio of the genotypic variance to the phenotypic variance. The mean of genetic advance (%) was estimated according to Johnson *et al*. (1955). In the multivariate analysis hierarchical clustering was carried out to find the pattern of similarity / dissimilarity among the accessions using the ward's minimum variance (Rao, 1952). Further, Principal component analysis (Sneath and Sokal, 1973) was carried out using a correlation matrix to define the pattern of variation among the genotypes.

Results and Discussion

The analysis of variance revealed highly significant mean squares due to genotypes for all traits, indicating the existence of genotypic variation among advance breeding lines and varieties for yield and yield attributing characters studied. The *per se* performance of genotypes are presented in Table 1.

Early maturing genotypes are preferred in chickpea as most of the crop in Andhra Pradesh is grown under rained conditions under receding soil moisture. Mean performance of genotypes for days to 50 per cent flowering ranged from 37 days (NBeG 1610, NBeG 1614, NBeG 1539, NBeG 924, NBeG 1639 and NBeG 1487 to 55.0 days (NBeG 1137). Kabuli genotypes *viz.,* NBeG 1610, NBeG 1614 and NBeG 1539 were early to flower and significantly superior to the best check of NBeG 119 (42 days) with respect to this trait. Desi genotypes *viz.,* NBeG 924, NBeG 1639 and NBeG 1487 were early to flowering and significantly superior to the best check NBeG 3 (42 days).

Days to maturity ranged from 92 days (NBeG 1539 and NBeG 1487) to 104 days (NBeG 810). In kabuli type of chickpea, the genotypes NBeG 1614 (93 days), NBeG 1610 (94 days), NBeG 1539 (92 days), NBeG 1509 (100 days) and NBeG 440 (94 days) had recorded shorter growing season and significantly superior to the best check NBeG 119 (102 days). Similarly, desi genotypes NBeG 924 (95 days), NBeG 1639 (93 days), NBeG 1267 (94 days), NBeG 1428 (94 days), NBeG 1430 (95 days), NBeG 1923 (96 days), NBeG 1487 (92 days), NBeG 1469 (94 days), NBeG 1146 (93 days), NBeG 1634 (95 days) and NBeG 1149 (95 days) and had recorded early maturity and significantly superior over the best check NBeG 452 and NBeG 857 (98 days).

Per se performance of plant height ranged from 32.5 cm (NBeG 1146) to 54.3 cm (NBeG 47). Chickpea genotypes with more than 45 cm are suitable for machine harvesting. In the present study, two *kabuli* genotypes NBeG 833 (46.8 cm) and NBeG 1554 (45.1 cm) were suitable for machine harvesting. Similarly, 13 desi genotypes *viz.*, NBeG 1423 (47.5cm), NBeG 1420 (49.8 cm), NBeG 1267 (48.2 cm), NBeG 1428 (47.9 cm), NBeG 1430 (46.3 cm), NBeG 1632 (46.4 cm), NBeG 1923 (46.5 cm), NBeG 779 (46.9 cm), NBeG 1710 (54.3 cm), NBeG 1469 (46.5 cm), NBeG 1634 (46.0 cm), NBeG 1327 (48.1 cm) and NBeG 1427 (46.9 cm) were suitable for machine harvesting.

Mean performance of genotypes for number of pods per plant ranged from 25.5 (NBeG 119) to 80.5 (NBeG 1923). In *kabuli* genotypes, NBeG 1610 (54.3) was significantly superior to the best check of NBeG 810 (32.7). Similarly, in *desi* genotypes NBeG 924 (62.1), NBeG 1430 (62.2), NBeG 1632 (67.1) and NBeG 857 (64.67) had recorded significantly higher pod number compared to grand mean (43.89).

In *desi* group of chickpeas, the preferred 100 seed weight will be in the range of 22-28 g. 100 seed weight ranged from 20.0 g (NBeG 1487) to 29.0 g (NBeG 1639). None of the genotypes were significantly superior to the best check NBeG 49. Similarly, in *kabuli* group of chickpeas, the preferred 100 seed weight will be more than 40 g. In 100 seed weight ranged from 33.7 g (NBeG 1539) to 44.3 g (NBeG 810, NBeG 833 and NBeG 1554). The genotypes *viz.*, NBeG 833, NBeG 1554, NBeG 844, NBeG 1010 and NBeG 810 had more than 40 g. None of the genotypes were significantly superior to the best check

Table 1 : Mean performance of forty genotypesof chickpea for yield and yield traits.

S. no.	Genotype	Type of chickpea	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	No. of pods per plant	100 Seed weight (g)	Seed yield (kg/ha)
Advance Breeding lines								
1	NBeG 1610	Kabuli	37	94	38.9	54.3	36.7	3443
2	NBeG 1614	Kabuli	37	93	38.1	40.2	34.3	3377
3	NBeG 1532	Kabuli	46	103	44.3	35.5	36.7	2777
4	NBeG 1539	Kabuli	37	92	37.9	31.9	33.7	2693
5	NBeG 833	Kabuli	47	102	46.8	29.1	44.3	2590
6	NBeG 1529	Kabuli	46	102	40.1	37.7	36.0	2583
7	NBeG 1509	Kabuli	45	100	40.0	30.6	36.3	2543
8	NBeG 1554	Kabuli	44	101	45.1	31.9	44.3	2367
9	NBeG 440	Kabuli	44	94	43.1	44.1	39.7	2297
10	NBeG 844	Kabuli	45	101	43.4	27.6	44.0	2290
11	NBeG 1010	Kabuli	45	103	42.5	32.9	43.7	2263
12	NBeG 924	Desi	37	95	36.5	62.1	24.0	3627
13	NBeG 1639	Desi	37	93	43.5	36.4	29.0	3520
14	NBeG 1423	Desi	44	98	47.5	37.9	25.0	3553
15	NBeG 1328	Desi	43	98	36.6	46.1	27.3	3307
16	NBeG 1420	Desi	53	98	49.8	50.3	24.0	3253
17	NBeG 1267	Desi	45	94	48.2	43.7	23.7	3157
18	NBeG 1174	Desi	45	96	33.7	34.0	23.7	2997
19	NBeG 1428	Desi	46	94	47.9	59.0	21.7	2983
20	NBeG 1137	Desi	55	98	39.3	49.5	26.3	2973
21	NBeG 1430	Desi	46	95	46.3	62.2	23.0	2970
22	NBeG 1632	Desi	45	98	46.4	67.1	24.0	2960
23	NBeG 1923	Desi	45	96	46.5	80.5	20.0	2960
24	NBeG 779	Desi	46	99	46.9	41.9	28.3	2750
25	NBeG 1487	Desi	37	92	35.3	38.6	20.0	2660
26	NBeG 1710	Desi	52	98	54.3	52.3	23.7	2637
27	NBeG 1469	Desi	47	94	46.5	58.4	20.7	2620
28	NBeG 1146	Desi	45	93	32.5	36.5	24.7	2440
29	NBeG 1634	Desi	47	95	46.0	45.5	23.0	2247
30	NBeG 1327	Desi	47	100	48.1	34.7	23.7	2203
31	NBeG 1149	Desi	46	95	34.3	43.3	25.3	2187
32	NBeG 1427	Desi	43	99	46.9	55.9	25.3	2170
Released varieties								
33	NBeG 810	Kabuli	48	104	49.0	32.7	44.3	3240
34	NBeG 119	Kabuli	42	102	42.8	25.5	39.3	2603
35	NBeG 452	Desi	43	98	33.8	41.7	25.0	3127
36	NBeG 857	Desi	45	98	33.2	64.7	23.7	2813
37	NBeG 776	Desi	46	100	44.0	39.0	27.3	2767
38	NBeG 49	Desi	44	100	41.4	42.8	30.7	2657
39	NBeG 47	Desi	46	99	54.4	31.7	30.0	2467
40	NBeG 3	Desi	42	100	35.5	45.9	28.0	2070
Mean		**44**	**98**	**42.7**	**43.9**	**29.6**	**2779**	
CV%		**1.9**	**0.9**	**3.4**	**26.4**	**3.6**	**12.4**	
Sem		**0.5**	**0.5**	**0.8**	**6.7**	**0.6**	**200.9**	
C.D. 5%		**1.4**	**1.4**	**2.3**	**18.9**	**1.7**	**565.4**	

Table 2 : Estimation of variability and genetic parameters for yield and yield traits in chickpea.

Parameters	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	No. of pods per plant	100 Seed weight (g)	Seed yield (kg/ha)
PCV	9.78	3.55	13.44	28.00	25.91	15.55
GCV	9.72	3.51	13.30	23.47	25.83	13.79
ECV	1.91	0.90	3.37	26.43	3.56	12.45
Heritability in Broad Sense (%)	99.0	98.0	98.0	70.0	99.0	79.0
Genetic advance	8.80	6.97	11.55	17.89	15.62	704.51
Genetic advance as per cent mean	19.90	7.15	27.11	40.54	53.04	25.20

NBeG 810. In *kabuli* chickpeas three distinct seed shapes have been recognized ram-headed, owl-headed and pea-shaped and chickpeas with ram-head-shaped seeds generally have the largest seed size, as high as 45 g e" per 100-seed weight (Pundir *et al*., 1988). Farmers prefer to produce large-seeded chickpeas due to consumer preference, since a larger seed size commands a higher price in regional and international markets. In addition to a higher price, a large seed size confers an advantage during germination, higher seedling vigor, allowing deeper sowing than that of small seeds in order to escape drought. Large seed size has therefore been considered to be a noteworthy trait in breeding programs (Upadhyaya *et al*., 2006).

Among the genotypes seed yield ranged from 2077 g (NBeG 3) to 3627 g (NBeG 924). Two *kabuli* genotypes NBeG 1610 (3443 g) and NBeG 1614 (3377 g) were superior to the best check NBeG 810 (3240 g). In desi genotypes NBeG 924 (3627 g), NBeG 1639 (3520 g), NBeG 1423 (3553 g), NBeG 1328 (3307 g), NBeG 1420 (3253 g) and NBeG 1267 (3157 g) were superior to the best check of NBeG 452 (3127 g).

Apart from *per se* performance, the genetic gain in any breeding programmes can be assessed by estimating phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), environmental coefficient of variation (ECV), heritability, genetic advance and genetic advance as per cent mean for yield and yield attributing traits (Table 2). In the present study, higher PCV compared to GCV were noticed for number of pods per plant and seed yield, indicating the influence of environment on the expression of the traits. A negligible difference between GCV and PCV was noticed in case of days to 50 per cent flowering, days to maturity, plant height and 100 seed weight specifying less environmental influence on the expression of these traits.

The high PCV and GCV together with high heritability and high genetic advance as per cent mean indicate the worth of the traits during selection exercised in crop improvement programmes. In the present study, number of pods per plant, 100 seed weight, plant height and seed yield had recorded high to moderate PCV and GCV coupled with high heritability and high genetic advance as per cent mean indicating the pre-ponderance of additive gene action and therefore, ample scope for improvement of these traits through selection. Similar, results were reported by Krishnaiah *et al.* (2002) for plant height, number of pods per plant, 100 seed weight and seed yield. However, days to 50 per cent flowering and days to maturity had recorded low PCV and GCV coupled with high heritability and moderate to low genetic advance as per cent mean indicating the role of both additive and non-additive gene effects for control of these characters. Sreelakshmi *et al.* (2010) reported high heritability with moderate to low genetic advance as per cent mean for days 50 per cent flowering and days to maturity.

Principal component analysis

In the present investigation, principal component analysis was performed for six quantitative traits of advance breeding lines of chickpea. The objective of principal component analysis is to identify the minimum number of components, which can explain maximum variability out of the total variability and also to rank advance breeding lines on the basis of PC scores. Two PCs exhibited more than 1.0 Eigen value and showed about 64.50% variability. Therefore, these two PCs were given due important for the further explanation. Four principal components having Eigen values greater than 0.5 altogether explained 89.05% of the total variation among the 40 advance breeding lines. Individually, the PC1 accounted for maximum proportion of variability

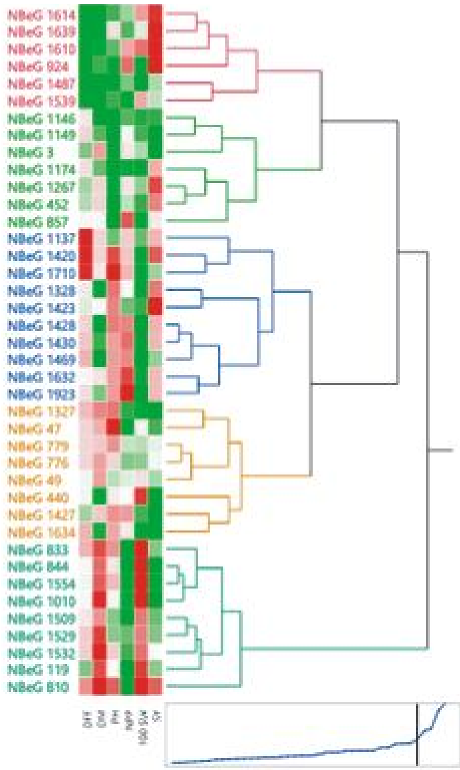

Fig. 1 : Dendrogram of 40 advance breeding lines of chickpea (*Cicer arietinum* L.) derived from the Ward's minimum variance cluster analysis.

(37.94%) in the set of all variables and the remaining components accounted for progressively lesser and lesser amount of variation. The PC2 accounted for variability (26.56%), which reduced gradually to PC3 (15.05%), PC4 (9.50%), PC5 (7.07%) and PC6 (3.88%). It can be concluded from the above results that yield contributing traits were having the highest variation in PC1 followed by PC2 and PC3. Thus, PC1 was constituted by days to 50 per cent flowering, days to maturity, plant height and 100 seed weight. The PC1 was dominated by most of the yield attributing traits, a intensive selection procedure can be designed to bring out rapid improvement of dependent traits *i.e.*, yield by selecting the lines of PC1. Similar findings were reported by Mahendran *et al.* (2015). The PC2 dominated by days to 50 per cent flowering, plant height and number of pods per plant. The main variables of PC3 were days to maturity, plant height, 100 seed weight and seed yield. Thus, PC1 and PC3 allowed for simultaneous selection of yield related traits and it can be regarded as yield factor from this study it was clear that PC1 and PC3 were mostly related to seed yield traits. The traits which show positive values will contribute maximum towards genetic diversity. The greater diversity in the genotypes due to those traits will offer good scope for the improvement of yield by selection of parents. Similar findings were reported by Singh *et al.* (2021) and Mahmood *et al.* (2022).

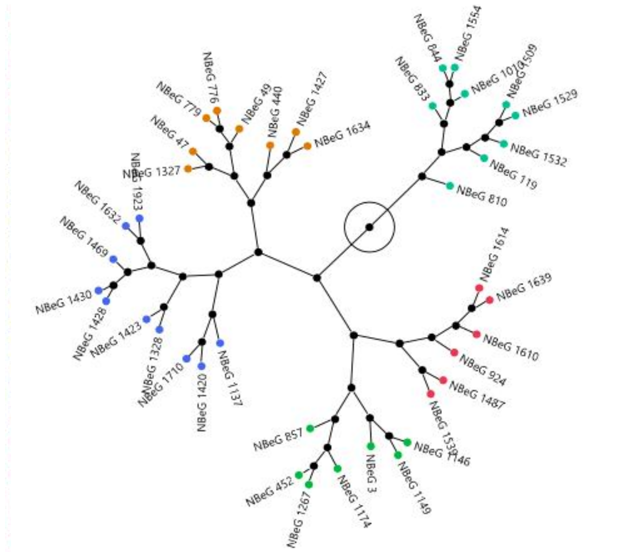

Fig. 2 : Constellation plot of 40 advance breeding lines of chickpea.

Ward's clustering

The clustering based on Ward's minimum variance grouped forty advance breeding lines into five different non-overlapping clusters (Figs. 1, 2 and Table 4). Ambilwade *et al.* (2018) also studied genetic diversity in chickpea genotypes and reported six clusters using 35 genotypes. In cluster I had six genotypes were characterized by higher seed yield (3220.0 kg/ha) and the lowest for days to 50 per cent flowering (36.84 days) and days to maturity (93.22 days) *i.e.*, early maturing types. In cluster I the genotype NBeG 924 (3627 kg/ha) showed highest seed yield followed by NBeG 1610 (3443 kg/ha), NBeG 1614 (3377 kg/ha) and NBeG 1639 (3520 kg/ha) due to the higher number of pods per plant. Based on yield traits, cluster I had the high yielding, early maturing types and upright-growing chickpea genotypes. The traits *viz.*, number of pods per plant and 100-seed weight revealed the foremost traits that directly affect plant productivity and incise the genetic diversity of chickpeas.

Cluster II had seven genotypes, classified by the lowest values of plant height (34.22 cm), yet having moderate values for all the other traits. Cluster III had ten genotypes, classified by higher mean values of plant height (47.28 cm), number of pods per plant (56.11) and days to 50 per cent flowering (47.80 days) and lowest values for 100 seed weight (23.20 g). Despite the small seed, the plants were taller (47.28 cm) (Table 5). In cluster III the genotypes NBeG 1420 (49.8 cm), NBeG 1710 (54.3 cm), NBeG 1423 (47.5 cm), NBeG 1428 (47.9 cm), NBeG 1430 (46.3 cm), NBeG 1469 (46.5 cm), NBeG 1632 (46.4 cm) and NBeG 1923 (46.5 cm) plants with a

Table 3 : Principal components, Eigen values, proportion of variation (%) and Cumulative variance of the six most important characters from principal component analysis

S. no.	Characters	PC1	PC2	PC3	PC4	PC5	PC6
1	Days to 50 per cent flowering	0.27	0.62	-0.15	0.36	-0.43	0.45
2	Days to maturity	056	0.12	0.16	0.48	0.29	-0.57
3	Plant height	0.23	0.53	0.38	-0.70	0.07	-0.11
4	No. of pods per plant	-0.44	0.42	-0.02	0.20	0.73	0.20
5	100 Seed weight	0.50	-0.36	0.28	-0.02	0.35	0.64
6	Seed yield (kg/ha)	-0.34	-0.03	0.85	0.29	-0.26	0.03
Eigen value		**2.28**	**1.59**	**0.90**	**0.57**	**0.42**	**0.23**
Proportion of variation (%)		**37.94**	**26.56**	**15.05**	**9.50**	**7.07**	**3.88**
Cumulative variance (%)		**37.94**	**64.50**	**79.55**	**89.05**	**96.12**	**100.00**

Table 4 : Distribution of 40chickpeaaccessions into five different clusters.

Cluster No.	No. of genotypes	Name of the genotypes
I	6	NBeG 1614, NBeG 1639, NBeG 1610, NBeG 924, NBeG1487, NBeG 1539
II	7	NBeG 1146, NBeG 1149, NBeG 3, NBeG 1174, NBeG1267, NBeG 452, NBeG 857
III	10	NBeG 1137, NBeG 1420, NBeG 1710, NBeG 1328, NBeG 1423, NBeG 1428, NBeG 1430, NBeG 1469, NBeG 1632, NBeG 1923
IV	8	NBeG 1327, NBeG 47, NBeG 779, NBeG 776, NBeG 49, NBeG 440, NBeG 1427, NBeG 1634,
V	9	NBeG 833, NBeG 844, NBeG 1554, NBeG 1010, NBeG 1509, NBeG 1529, NBeG 1532, NBeG 119, NBeG 810

Table 5 : Cluster means of traits in different clusters and distribution of genotypes among five clusters.

Cluster number	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	No. of pods per plant	100 Seed weight (g)	Seed yield (kg/ha)
I	36.84*	93.22*	38.38	43.90	29.61	3220.00**
II	44.19	96.81	34.22*	44.60	25.38	2705.72
III	47.80**	96.37	47.28**	56.11**	23.20*	3006.67
IV	45.29	98.13	46.37	41.95	28.50	2444.59*
V	45.37	101.96**	43.77	31.50*	41.00**	2584.07

* indicate low and ** indicate higher value.

height of more than 45 cm are suitable for machine harvesting. Cluster IV had eight genotypes, classified by the lowest values for seed yield (2444.59 kg/ha) and moderate mean values for all other traits. In Cluster IV, the decreased seed yield in advance breeding lines may have resulted in a low number of pods per plant. Cluster V had nine genotypes were characterized by higher mean values for 100 seed weight (41.00 g) with large seed kabuli varieties *viz.*, NBeG 833, NBeG 844, NBeG 810 and NBeG 119 and days to maturity (101.96 days) *i.e.*, late maturing types and lowest values for number of pods per plant (31.50).

Conclusion

Characterizing the present advance breeding lines in chickpea (*Cicer arietinum* L.) revealed better genetic variability among the yield traits. According to the principal component, number of pods per plant and 100 seed weight appeared as the main yield components that manage and improve the seed yield. Cluster analysis of chickpea genotypes indicated that genotypes in each cluster had some specific traits. Cluster I had high yielding and early maturing genotypes *viz.*, NBeG 924, NBeG 1610, NBeG 1614 and NBeG 1639. Cluster III had genotypes *viz.*, NBeG 1420, NBeG 1710, NBeG 1423, NBeG 1428, NBeG 1430, NBeG 1469, NBeG 1632 and NBeG 1923 with plant height of more than 45 cm were suitable for machine harvesting. The genotypes in Cluster I and III could be utilized in future breeding programs for selecting high yielding, early maturing types with machine harvestable genotypes suitable for scarce rainfall zone of Andhra Pradesh.

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