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Mean Performance of Promising Genotypes of Cluster Bean (*Cyamopsis tetragonoloba* L. Taub.) for Yield and Yield Attributing Traits Over Three Locations

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ABSTRACT: Despite of huge demand for the crop, only limited breeding work has been done and very little attention has been given for its genetic improvement to enhance the productivity level. Before coming out with any superior variety with better yield there is need to periodically check the performance of available germplasm in comparison to best performing variety of that agro-climatic region, the purpose of this study is to identify the high yielding genotypes. A field investigation of twenty five genotypes of cluster bean including one check were evaluated in Randomized Block Design with three replications during *Kharif*, 2019 at three locations representing three agroclimatic Zones of Telangana *i.e.*, PG Research Block, College of Horticulture, Rajendranagar, Hyderabad (Southern Telangana Zone), JVR Horticultural Research Station, Malyal, Mahabubabad (Central Telangana Zone) and progressive farmers field at Vemulawada, Karimnagar (Northern Telangana Zone) for yield and yield attributing traits. Among the twenty four genotypes and check variety, three genotypes IC-103295 (119.74 cm), IC-200680 (118.45 cm) and IC-140774 (116.20 cm) were taller and genotype IC-28283 (43.9 cm) were shorter. Higher number of branches recorded in genotype IC-200680 (10.73). Genotype IC-200696 (30.16) found to be the earliest with respect to days to first flowering while late flowering were observed in IC-10520 (37.508). Genotype IC-103295 (103.15) showed highest number of pods per plant, while the genotype IC-13348 showed lowest number of pods per plant (37.03). In respect of pod yield per plant, the genotypes IC-103295 (187g) showed higher values, while the genotype IC-28283 (47.9 g) recorded the minimum pod yield per plant. Genotype IC-39989 (13.67 cm) recorded the highest pod length, while genotype IC-39989 (10.163mm) exhibited higher pod girth and genotype IC-39989 (2.47) recorded the higher pod weight. Therefore, these genotypes can be used as such or can further be subjected to selection or further breeding programmes to get the desirable variety of cluster bean suitable for rainfed conditions.

Keywords: Mean performance, Cluster bean genotypes, Pod yield.

INTRODUCTION

Cyamopsis tetragonoloba L. Taub., commonly known as guar, is a cluster bean with the diploid chromosome number 2n=14. It is a self-pollinated crop from the Fabaceae family. Guar is a short-day erect or bushy annual plant that originates in India and Pakistan (Purseglove, 1981). It is a drought-tolerant, warm-season legume crop with a deep and well-developed root system that is mostly grown as a rain-fed crop in dry and semi-arid areas during the rainy season for vegetable, galactomannan gum, fodder, and green manure. Guar increases soil productivity by fixing atmospheric nitrogen for its own needs as well as those of the subsequent crop (Bewal *et al*., 2009). Guar can be cultivated effectively in soils where no other crops can thrive. It may grow in salty and mildly alkaline soils with pH levels ranging from 7.5 to 8.0. (Venkataratnam, 1973). Crop is mainly grown in the dry habitats of Rajasthan, Haryana, Gujarat and Punjab and to a limited extent in Uttar Pradesh, Madhya Pradesh, Telangana, Andhra Pradesh, Tamil Nadu, Karnataka and Kerala. In India area under beans is 0.23 million ha with production of 2 million tonnes. Gujarat is the state with the largest area under beans cultivation with 0.07 million hac with 0.72 million tonnes of production. In Telangana, area under beans is 0.006 million hectares with production of 0.0063 million tonnes (NHB, 2018-19). Seeds contain gum mucilaginous substance called guar gum or galactomannan which is used in textiles, paper industry and cosmetic industry. Green pods are rich in vitamin A and iron. Although cluster bean is a minor crop but due

to its better and finer guar gum qualities, it is considered as an important cash crop for industrial gum production and for several pharmaceutical and nutraceutical products.

Considering the importance of cluster bean as a vegetable, there is prime need for its improvement. Despite of huge demand for the crop, only limited breeding work has been done and very little attention has been given for its genetic improvement to enhance the productivity level. Although several studies were conducted in *Cyamopsis tetragonoloba* L. Taub. for vegetable purpose, studies on cluster bean is limited in southern parts of India. Production of this crop in India mainly confined to the North-West part of India, however certain areas of Andhra Pradesh and Telangana state are highly suitable for cultivation of this crop as suggested by ICAR-high level expert committee report as an alternate crop for sustainability in scarce rainfall zones (CRIDA, 2012). As majority of the area in Telangana state is occupied with saline alkali soils with poor organic matter, the adoption of this crop in this region may be recommended to bring the poor and marginal lands under cultivation. Anandi and Oomen *et al.,* (2007); Rai *et al*., (2012); Girish *et al*., (2013); Jitender *et al.,* (2014); Vikas and Ram (2015); Goudar *et al*., (2017); Praveen *et al*., (2018); Yeswanth *et al*., (2019) evaluated cluster bean genotypes for growth, yield and quality attributing traits and reported some superior and high yielding genotypes and concluded that these germplasm can be utilized extensively in further breeding programmes for exploitation of desirable traits. After extensive yield trials should be released for commercial cultivation for yield. Hence, they may be recommended to farmers for cultivation after multilocational trials. However, due to limited information, farmers were unaware of the importance of this crop in many areas. Hence, to evaluate various cultivars of guar and identification of suitable cultivars for this region is highly warranted. But before coming out with any superior variety with better yield there is need to periodically check the performance of available germplasm in comparison to best performing variety of that agro-climatic region. Keeping the above in mind, the present investigation was taken up to study the mean performance of the genotypes for identification of high yielding genotypes.

MATERIALS AND METHODS

A set of 24 genotypes consisting of indigenous cluster bean collections augmented from the ICAR- National Bureau of Plant Genetic Resources, Regional Station, Jodhpur along with one check variety of cluster bean (Pusa Navbahar) from IARI, New Delhi were assessed in Randomized Block Design with three replications during *Kharif,* 2019 at three environments representing three agroclimatic Zones of Telangana *i.e*., PG Research Block, College of Horticulture, Rajendranagar, Hyderabad (Southern Telangana Zone), JVR Horticultural Research Station, Malyal, Mahabubabad (Central Telangana Zone) and progressive farmers field at Vemulawada, Karimnagar (Northern Telangana Zone).

Observations were recorded on five competitive plants in respect of twelve characters *viz*., plant height (cm), number of branches per plant, number of clusters per plant, number of pods per plant, pod length (cm), pod girth (mm), pod weight (g), number of seeds per pod, pod yield per plant (g) and pod yield per hectare (q/ha). Whereas days to first flowering and days to 50% flowering were recorded on plot basis.

RESULTS AND DISCUSSION

The results of Analysis of Variance for 24 genotypes and check variety in cluster bean are furnished in Table 1. The mean sum of squares for treatments (genotypes) was significant for all the twelve characters studied *viz*., *viz*., plant height (cm), number of branches per plant, days to first flowering, days to 50% flowering, number of clusters per plant, number of pods per plant, pod length (cm), pod girth (mm), pod weight (g), number of seeds per pod, pod yield per plant (g) and pod yield per hectare (q/ha).

Table 1: Analysis of Variance for 12 characters in 25 cluster bean genotypes.

Trait	Replication Mean Sum of Square (df=2)			Treatment Mean Sum of Square (df=24)			Error Mean Sum of Square (df=48)		
Environment	**HYD**	**KRNR**	**MLYL**	**HYD**	**KRNR**	**MLYL**	**HYD**	**KRNR**	**MLYL**
Plant height (cm)	1.95	14.95	0.70	1618	1641	1581	8.08	5.12	5.16
Number of branches per plant	0.06	0.27	0.15	21.52	21.45	18.54	0.076	0.18	0.16
Days to first flowering	0.84	1.87	0.72	15.68	14.1	14.76	0.61	0.49	0.32
Days to 50 % flowering	0.66	1.88	0.01	19.89	18.52	19.14	2.01	0.68	0.43
Number of clusters per plant	0.34	0.206	0.54	27.82	26.89	22.37	0.25	0.47	0.49
Number of pods per plant	0.42	13.95	40.97	1137	1030.4	995.9	7.65	16.34	13.49
Pod length (cm)	0.01	0.04	0.13	6.93	6.87	6.74	0.02	0.02	0.07
Pod girth (mm)	0.001	0.04	0.02	5.04	5.44	5.09	0.034	0.03	0.03
Pod weight (g)	0.005	0.0026	0.0057	0.27	0.28	0.283	0.018	0.0036	0.0040
Number of seeds per pod	0.042	0.09	0.017	3.97	3.65	4.46	0.041	0.04	0.04
Pod yield per plant (g)	15.12	31.78	180.07	4756	4325	3796.5	34.64	46.8	55.40
Pod yield per hectare (q/ha)	16.66	35.04	198.5	5243.2	4768.8	4185.7	38.19	51.6	61.18

HYD: Hyderabad, KRNR: Karimnagar, MLYL: Malyal

The analysis of variance revealed that genotypes differed significantly among themselves for all of the characters under study, indicating the presence of significant variability, whereas replications for all of the traits were non-significant, indicating that environmental error was sufficiently eliminated.

Plant height. The mean plant height values at the Hyderabad location (Table 2) ranged from 43.92 cm to 121.50 cm, with a general mean of 89.91 cm. The highest plant height (121.50 cm) was observed in IC-200680, while the lowest plant height (43.92 cm) was recorded in IC-28283. Thirteen genotypes and the check variety were significantly taller than the overall mean of 89.91 cm. Twelve genotypes had significantly higher values than the best check variety Pusa Navbahar (100.67 cm).

Entries at Karimnagar environment showed a general mean with 86.73 cm with range of 40.94 cm (IC-28283) to 120.40 cm (IC-103295). Among the genotypes, IC-103295 (120.4 cm) recorded highest plant height followed by IC-200680 (117.1) which were at par.

The genotypes at Malyal environment registered a general mean of 81.56 with a range of 43.27 cm to 117.83 cm. Significantly highest plant height was recorded in IC-103295 (117.83 cm) and lowest plant height (43.27 cm) was recorded in IC-28283 among the 25 genotypes. Five genotypes have significantly higher values than best check variety Pusa Navbahar (104.93 cm).

On the basis of mean performance of plant height pooled over three environments (Table 2), the plant height ranged from 43.9 cm (IC- 28283) to 119.744 cm (IC-103295) with general mean (86.26cm). Six genotypes were significantly higher than best check variety Pusa Navbahar (102.3 cm). These results are in consistent with the findings of those reported by Rajashekar *et al*., (2018); Shobiya *et al.,* (2019).

Table 2: Environmental wise mean performance of genotypes for plant height (cm) in cluster bean.

Genotype	Plant height (cm)			
	HYD	KRNR	MLYL	POOLED
IC-9052	84.67	79.97	74.03	79.55
IC- 9077-P1	101.97	97.98	85.40	95.11
IC-9229-P3	62.47	55.80	54.73	57.66
IC-9233-P3	90.67	93.00	87.97	90.54
IC-10323	104.97	99.33	84.54	96.281
IC-10333	106.40	105.53	103.87	105.26
IC-10520	110.80	105.95	106.03	107.59
IC-13348	54.95	65.77	61.63	60.78
IC-13365	57.20	54.53	50.53	54.08
IC-28269	70.97	63.67	63.03	65.88
IC-28283	43.92	40.97	43.27	43.90
IC-28286	75.50	73.17	65.77	71.47
IC-28287	106.27	101.10	86.28	97.88
IC-34344	78.47	73.50	68.33	73.43
IC-39989	101.50	100.67	81.00	94.38
IC-103295	121.00	120.40	117.83	119.74
IC-140774	119.67	114.50	114.43	116.20
IC-140777	108.77	65.03	97.67	105.12
IC-140791	60.73	55.38	55.81	57.310
IC-177844	65.71	70.33	56.72	63.03
IC-200679	115.67	114.47	113.47	114.53
IC-200680	121.50	117.10	116.77	118.45
IC-200696	105.33	65.10	82.38	93.33
IC-200715	74.67	100.67	62.70	72.18
Pusa Navbahar	100.67	102.90	104.93	102.83
General mean	89.91	86.73	81.56	86.26
S.E.	2.32	1.84	1.85	2.47
C.D. at 5%	4.66	3.718	3.731	7.15

HYD: Hyderabad, KRNR : Karimnagar, MLYL: Malyal

Number of branches per plant. For the number of branches, the genotypes in Hyderabad showed a general mean of 7.60, with a range of nil to 11.20. The genotype Pusa Navbahar had no branches, but the genotype IC-200680 had a maximum of 11.20 branches. Thirteen genotypes were considerably higher than the overall mean of 7.60.

The genotypes in Karimnagar had a general mean of 7.54 with a range of nil to 10.85 for the number of branches. Among the genotypes, Pusa Navbahar had the low branches (0), while IC-200680 had the most, with 10.85 branches.

The genotypes in the Malyal location (Table 3) had a general mean of 7.345 with a range of nil to 10.91 for the number of branches. The genotype Pusa Navbahar had the no branches (0), whereas the genotype IC-34344 had the most branches (10.91). Seven genotypes were recorded statistically at par values with the higher branches reported genotype IC-34344, namely IC-10323 (1.02), IC-200680 (10.15), IC-10333 (9.88), IC-140774 (9.45) and IC-9052 (9.43).

Table 3: Environmental wise mean performance of genotypes for number of branches per plant at (90 DAS), days to first flowering and days to 50% flowering in cluster bean.

Genotype	No. of branches per plant at (90 DAS)				Days to first flowering				Days to 50% flowering			
	HYD	KRNR	MLYL	POOLED	HYD	KRNR	MLYL	POOLED	HYD	KRNR	MLYL	POOLED
IC-9052	10.40	10.13	9.43	9.98	30.33	31.48	32.02	31.27	41.10	42.50	43.00	42.20
IC- 9077-P1	7.87	7.68	7.70	7.74	31.27	32.38	32.67	32.10	42.13	42.84	44.06	43.01
IC-9229-P3	4.97	4.31	4.63	4.63	35.57	36.03	36.87	36.15	40.70	40.77	43.39	41.61
IC-9233-P3	8.47	9.23	8.58	8.76	31.00	31.66	31.92	31.52	47.37	47.68	48.91	47.98
IC-10323	10.80	10.65	10.02	10.48	29.50	30.98	31.20	30.56	39.70	40.57	40.51	40.26
IC-10333	10.37	10.27	9.88	10.17	34.67	36.62	36.75	36.01	44.20	45.75	46.55	45.5
IC-10520	9.43	8.80	8.60	8.94	37.27	37.22	38.04	37.50	44.03	45.61	46.31	45.31
IC-13348	4.73	4.48	5.48	4.90	33.47	35.07	35.19	34.57	45.03	45.79	46.87	45.89
IC-13365	6.70	5.95	5.56	6.06	32.20	33.83	34.39	33.47	39.50	41.63	43.42	41.51
IC-28269	4.23	4.75	4.79	4.59	35.47	36.75	36.66	36.29	48.20	49.03	49.89	49.04
IC-28283	3.83	4.25	4.15	4.07	34.47	33.52	34.54	34.17	40.81	40.35	41.12	40.76
IC-28286	6.17	6.08	5.62	5.95	33.03	35.25	34.98	34.42	40.77	42.19	44.42	42.45
IC-28287	7.50	7.08	6.93	7.17	35.50	34.62	35.01	35.70	38.87	42.33	43.18	41.46
IC-34344	10.07	10.65	10.91	10.54	31.00	31.75	31.08	31.27	40.53	41.57	41.19	41.09
IC-39989	8.13	7.33	7.96	7.80	34.00	32.61	33.93	33.51	44.13	45.36	45.28	44.92
IC-103295	9.20	9.02	8.89	9.03	32.10	33.12	33.23	32.81	40.83	40.97	41.12	40.97
IC-140774	10.43	10.57	9.45	10.15	29.67	30.97	31.09	30.57	46.33	46.99	47.41	46.91
IC-140777	8.67	7.54	7.28	7.82	31.40	31.52	32.64	31.85	43.00	43.66	45.58	44.08
IC-140791	6.87	6.72	7.25	6.94	32.37	32.68	33.08	32.71	46.90	48.55	48.73	48.06
IC-177844	8.65	10.30	9.74	9.56	31.50	31.30	31.47	31.42	41.97	43.11	44.12	43.06
IC-200679	8.75	8.62	8.49	8.62	31.50	34.42	32.83	32.91	43.83	44.52	45.43	44.59
IC-200680	11.20	10.85	10.15	10.73	32.27	33.45	33.42	33.04	45.00	44.70	46.92	45.54
IC-200696	4.97	6.32	5.27	5.51	28.77	30.75	30.97	30.16	38.87	42.77	44.97	43.26
IC-200715	7.80	7.01	6.85	7.21	31.37	31.85	31.86	31.69	44.10	43.57	46.41	44.69
Pusa Navabahar	0.00	0.00	0.00	00	31.47	31.35	32.18	31.66	43.73	43.39	46.09	44.40
General mean	7.60	7.54	7.34	7.49	32.52	33.36	33.64	33.17	42.99	43.84	44.99	43.94
S.E.(m)	0.22	0.34	0.33	0.29	0.64	0.57	0.46	0.35	1.159	0.67	0.54	0.42
C.D. at 5%	0.45	0.70	0.66	0.70	1.28	1.16	0.94	0.83	3.11	1.80	1.44	1.01

HYD: Hyderabad, KRNR: Karimnagar, MLYL: Malyal

The overall mean for pooled data across three locations was 7.49, with a range of zero to 10.73. The genotype IC-200680 had the most branches per plant (10.73), while the genotype Pusa Navbahar had no branches. The genotypes IC-9052, IC-9077-P1, IC-9233-P3, IC-10323, IC-10333, IC-10520, IC-34344, IC-39989, IC-103295, IC-140774, IC-140777, IC-177844 and IC-200680 had a high mean value for the number of branches per plant (Table 3). The findings for this feature are consistent with the findings of Ravish *et al*., (2017); Praveen *et al*., (2018).

Days to first flowering. The mean days to first flowering in Hyderabad varied from 28.77 days to 37.50 days, with a mean of 32.52. Early flowering was seen in genotype IC-200696 (28.77), whereas late flowering was detected in genotypes IC-10520 (37.27) and IC-28287 (38.50). Nine genotypes flowered later than the grand mean of 32.52 days. Twelve genotypes had earlier flowering than the best check variety, Pusa Navbahar (31.47) days.

At Karimnagar, the genotypes had a general mean of 33.367 days to first flowering, with a range of 30.75 to 37.62. Early flowering was seen in genotype IC-200696 (30.75), whereas late flowering was observed in genotypes IC-10520 (37.22) and IC-28287 (37.62). Four genotypes flowered earlier than the best check variety, Pusa Navbahar (31.35) days.

The genotypes at the Malyal location had a general mean of 33.64 days to first flowering, with a range of 30 to 38 days. Early flowering was reported by genotype IC-200696 (30.97), whereas late flowering was recorded in genotypes IC-10520 (38.04) and IC-28287 (38.01). Seven genotypes bloomed sooner than the best control variety, Pusa Navbahar (32.18) days.

The genotype means of the pooled data varied from 30.161 (IC-200696) to 37.508. (IC-10520). The genotype IC-200696 (30.16) took less days to blossom throughout three environments, followed by IC-10323 (30.561) and IC-140774 (30.574), and took considerably fewer days to flower than the overall mean (33.178). These findings are consistent with those of Santhosha *et al.,* (2017); Rajashekar *et al.,* (2018).

Days to 50 per cent flowering. The mean values for days to 50% flowering at the Hyderabad location varied from 38.87 days to 48.20 days, with a grand mean of 42.99. The genotype IC-200696 reached 50% flowering in 38.87 days, whereas the genotypes IC-9233-P3 and IC-28283 reached 50% flowering in 47.37 and 48.20 days, respectively. Thirteen genotypes flowered earlier than the grand mean of 42.99 days.

Entries in the Karimnagar location had a general mean of 43.84, with a range of 40.57 to 49.03 for days to 50% flowering. Genotype IC-10323 (40.57) had the earliest flowering, but genotype IC-28269 (49.03) had late days to 50% flowering. Ten genotypes flowered 50% earlier than the best check variety, Pusa Navbahar (43.39) days.

The genotypes at the Malyal environment had a general mean of 44.99 days to 50% flowering, with a range of 40.51 to 49.89 days. Genotype IC-10323 (40.51) had the earliest flowering, whereas genotype IC-28269 (49.89) had the most days to 50% flowering. Fifteen genotypes flowered 50% earlier than the best check variety, Pusa Navbahar (46.09) days.

The population mean for days to 50% flowering varied from 40.26 (IC-10323) to 49.04 days (IC-28269), with a population mean of 43.945. Twelve genotypes, namely IC-9052, IC-9077-P1, IC-9229-P3, IC-10323, IC-13365, IC-28283, IC-28286, IC-28287, IC-34344, IC-103295, IC-177844 and IC-200696, required fewer days to reach 50% flowering than the population mean. These findings are consistent with those of Rai *et al.*, (2012); Praveen *et al*., (2018); Rishitha *et al.*, (2019).

Number of clusters per plant. The number of clusters per plant at the Hyderabad location ranged from 9.77 to 22.34, with a grand mean of 16.09 (Table 4). The genotype IC-200680 had the highest number of clusters per plant at 22.34, whereas the genotype IC-28269 had the lowest number of clusters per plant at 9.77. Twelve genotypes and a control variety produced more clusters per plant than the grand mean of 16.09. Twelve genotypes had more clusters per plant than the best check variety, Pusa Navbahar (16.10).

The number of clusters per plant ranged from 8.40 to 21.47 in Karimnagar, with a mean of 14.92. Among all genotypes, IC-200680 had the highest number of clusters per plant (21.47), whereas IC-28269 had the lowest number of clusters per plant (21.47). (8.40). Thirteen genotypes were found to have more clusters per plant than the best check variety Pusa Navbahar (15.19).

Entries in the Malyal environment had a general mean of 13.19 clusters per plant, with a range of 8.48 to 19.10. The genotype IC-200680 had the most clusters per plant, while the genotype IC-28269 had the fewest clusters per plant. Eight genotypes had more clusters per plant than the best check variety Pusa Navbahar (14.18).

When comparing genotype performance in pooled environments thirteen genotypes, namely IC-9052, IC-9229-P3, IC-10323, IC-10520, IC-34344, IC-103295, IC-140774, IC-140777, IC-177844, IC-200679, IC-200680, IC-200715 and Pusa Navbahar, had significantly more clusters per plant than (14.73). More number of clusters per plant were found in genotype IC-200680 (20.968), followed by IC-103295 (18.47), IC-10323 (17.61) and IC-200679 (17.596). The genotype IC-28269 (8.8) has the fewest clusters per plant. These findings are consistent with those by Vir and Singh (2015); Vikas Kumar and Ram (2015); Praveen *et al*., (2018).

Number of pods per plant. The number of pods per plant ranged from 43.21 to 112.69 at the Hyderabad location (Table 4), with a grand mean of 68.52. The genotype IC-103295 had the most pods per plant (112.69), whereas the genotype IC-13348 had the fewest pods per plant (43.21). IC-34344 (107.57), IC-10323 (95.90) and IC-200680 (95.63) genotypes were statistically equal to IC-103295 (112.69). Thirteen genotypes produced more pods per plant than the mean value (72.77) as well as more pods than the check variety Pusa Navbahar (68.52).

Table 4: Environmental wise mean performance of genotypes for number of clusters per plant, number of pods per plant and days to maturity in cluster bean.

Genotype	Number of clusters per plant				Number of pods per plant			
	HYD	KRNR	MLYL	POOLED	HYD	KRNR	MLYL	POOLED
IC-9052	18.37	17.30	15.60	17.08	92.69	86.47	76.47	85.20
IC- 9077-P1	15.74	15.57	11.60	14.30	62.19	58.86	43.78	54.94
IC-9229-P3	17.19	16.13	13.55	15.62	82.51	68.81	55.42	68.91
IC-9233-P3	12.20	10.97	9.80	10.89	57.03	48.19	41.65	48.95
IC-10323	18.47	18.27	16.10	17.61	95.95	88.60	78.50	87.68
IC-10333	15.56	14.58	13.48	14.54	73.48	65.98	59.30	66.25
IC-10520	17.00	16.17	14.80	15.9	72.94	61.12	54.23	62.76
IC-13348	12.65	11.67	10.19	11.50	43.21	36.22	31.67	37.03
IC-13365	12.33	11.67	11.02	11.67	54.74	42.72	38.74	45.39
IC-28269	9.77	8.40	8.48	8.88	45.06	37.40	36.69	39.71
IC-28283	13.98	12.64	10.45	12.35	50.19	42.65	36.14	42.99
IC-28286	13.37	12.30	10.40	12.02	55.26	44.79	34.36	44.08
IC-28287	11.23	10.89	8.75	10.29	46.92	46.56	34.93	42.80
IC-34344	18.43	16.50	16.07	17.08	107.57	89.65	91.20	96.14
IC-39989	14.13	14.30	12.35	13.59	66.04	65.52	53.42	61.66
IC-103295	19.73	18.27	17.43	18.47	112.69	100.51	96.28	103.15
IC-140774	18.62	17.41	13.50	16.51	90.32	80.11	64.46	78.29
IC-140777	17.71	16.87	15.03	16.54	79.69	75.61	68.05	74.45
IC-140791	16.00	14.17	13.27	14.48	58.40	49.79	47.62	51.93
IC-177844	17.25	15.54	13.35	15.37	80.95	71.66	60.39	71.0
IC-200679	20.22	17.94	14.55	17.59	85.69	74.89	65.04	75.20
IC-200680	22.34	21.47	19.10	20.96	95.63	89.67	80.33	88.57
IC-200696	15.98	12.27	11.32	13.18	65.16	45.93	40.34	50.47
IC-200715	18.00	16.69	15.45	16.71	76.45	61.21	55.66	64.43
Pusa Navbahar	16.10	15.19	14.18	15.15	68.52	63.18	59.16	64.62
General mean	16.09	14.92	13.19	14.73	72.77	63.84	56.153	64.25
S.E.(m)	0.40	0.56	0.57	0.385	2.25	3.301	2.99	2.11
C.D. at 5%	0.821	1.136	1.154	0.961	4.54	6.63	6.03	5.03

HYD: Hyderabad, KRNR: Karimnagar, MLYL: Malyal

The number of pods per plant of genotypes ranged from 36.22 to 100.51 in Karimnagar, with a mean of 63.84. The genotype IC-103295 had the most pods per plant (100.51), whereas the genotype IC-13348 had the fewest (100.51). (36.22). Following that, three genotypes, IC-34344 (89.65), IC-10323 (88.60) and IC-200680 (89.62) were statistically equal. Twelve genotypes produced more pods per plant than the mean value (63.84) and also outperformed the check variety Pusa Navbahar (63.18).

The genotypes in the Malyal environment had a general mean of 56.153 pods per plant, with a range of 31.67 to 96.28. The genotype IC-103295 produced the most pods per plant (96.28), whereas the genotype IC-13348 produced the fewest pods per plant (31.67). IC-34344 (91.2) was statistically equivalent to IC-103295 (96.28). Eleven genotypes and the check variety Pusa Navbahar produced more pods per plant than the mean value (56.13). Pusa Navbahar, the check variety, produced 59.16 pods per plant.

The mean performance of genotypes for number of pods per plant varied from 37.03 (IC-13348) to 103.15 (IC-103295), with an overall mean number of pods per plant of 37.03 (IC-13348) (64.25). 13 genotypes, namely IC-9052, IC-9229-P3, IC-10323, IC-10333, IC-34344, IC-103295, IC-140774, IC-140777, IC-177844, IC-200679, IC-200680, IC-200715 and Pusa Navbahar, out of 25 genotypes, reported a more number of green pods per plant than the general mean.

The data pertaining to this trait are in accord with the studies conducted by Jitender *et al.,* (2014); Rajashekar *et al.,* (2018); Yeswanth *et al.,* (2019).

Pod length (cm). The mean pod length values at the Hyderabad site (Table 5) ranged from 6.30 cm to 13.77 cm, with a grand mean of 7.625 cm. The genotype IC-39989 had the longest pods at 13.77 cm, whereas the genotypes IC-200679 and IC-140791 had the shortest pods (6.30 cm). There was no genotype that was statistically equivalent to the value of IC- IC-39989 (13.77 cm). Eight genotypes and the control variety Pusa Navbahar generated considerably longer pods than the grand mean (7.625 cm).

The genotypes at Karimnagar had a general mean of 7.536 with a range of 6.24 cm to 13.72 cm for pod length. The genotype IC-39989 had the longest pod (13.72 cm), whereas the genotypes IC-200679 (6.24 cm) and IC-140791 (6.24 cm) had the shortest pods. No genotype was statistically equivalent to IC-39989 (13.72 cm). Seven genotypes and the check variety Pusa Navbahar produced considerably longer pods than the grand mean of 7.536 cm.

The genotypes in the Malyal location had a general mean pod length of 7.87 cm, with a range of 6.23 to 13.55 cm. The genotype IC-39989 had the longest pod length (13.55 cm), whereas the genotypes IC-9233-P3 (6.23 cm) and IC-140791 (6.26 cm) had the shortest pod length. No genotype was statistically equivalent to IC- IC-39989 (13.55 cm). Five genotypes and the control variety Pusa Navbahar produced considerably longer pods than the grand mean of 7.87 cm.

Taking into account the pooled performance of genotypes across three settings, it was discovered that seven genotypes, namely IC-10333, IC-28283, IC-28287, IC-39989, IC-103295, IC-177844, IC-200696 and Pusa Navbahar, had considerably longer pod length than the general mean (7.518 cm). IC-39989 (13.67 cm) genotype had the longest pod length, followed by IC-28283 (8.85 cm) and Pusa Navbahar (8.711 cm). These findings are comparable to those of Praveen *et al.,* (2018); Rajashekar *et al*., (2018).

Pod girth (mm). Pod girth ranged from 4.87 mm to 10.33 mm in Hyderabad (Table 5), with a mean of 8.68 mm. The genotype IC-39989 had the largest pod girth (10.33 mm), while the genotype IC-10333 had the smallest pod girth (10.33 mm) (4.87 mm). Two genotypes, IC-140774 (9.90 mm) and IC-200680 (9.50 mm), had pod girths comparable to IC-39989 (10.33 mm). Eleven genotypes and one check variety had considerably higher values than the overall mean of 7.949 mm. Nine genotypes had considerably higher values than the check variety Pusa Navbahar (8.68 mm).

Entries in the Karimnagar location had a general mean of 7.529 with a range of 4.43 mm to 9.95 mm for pod girth. The genotype IC-39989 had the largest pod girth (9.95 mm), whereas the genotype IC-10333 had the smallest pod girth (4.43 mm). Two genotypes, IC-140774 (9.52 mm) and IC-200680 (9.41 mm), produced results comparable to IC-39989 (9.95 mm). Nine genotypes and one control variety had considerably higher values than the overall mean of 7.529 mm. Seven genotypes scored considerably higher than the check cultivar Pusa Navbahar (8.68 mm).

The genotypes in the Malyal location had a general mean pod girth of 7.70 mm, with a range of 4.73 mm to 10.20 mm. The genotype IC-39989 had the largest pod girth of 10.20 mm, whereas the genotype IC-10333 had the smallest pod girth of 10.20 mm (4.73 mm). Ten genotypes and a control variety had considerably higher values than the grand mean of 7.704 mm. Seven genotypes outperformed the check variety Pusa Navbahar (8.54 mm).

For pod girth, the overall mean of genotypes across three environments (Table 5) was 7.727 mm. The genotypes' mean performance ranged from 5.73 mm (IC-10520, IC-13348) to 10.163 cm (IC-39989). Twelve genotypes, namely IC-9052, IC-10323, IC-13365, IC-28269, IC-28287, IC-34344, IC-39989, IC-103295, IC-140774, IC-200680 and Pusa Navbahar, outperformed the overall mean value in terms of pod girth (7.727 mm).

The data on this feature are consistent with the findings of Rai *et al.,* (2012); Malaghan *et al.,* (2013); Rajashekar *et al.,* (2018); Yeswanth *et al*., (2019).

Pod weight (g). The average pod weight at the Hyderabad location ranged from 1.13 g to 2.54 g, with a grand mean of 1.58 g (Table 5). The genotype IC-39989 (2.54 g) had the highest average pod weight, whereas genotype IC-10520 (1.13 g) had the lowest average pod weight. In comparison to IC-39989, genotypes IC-9052, IC-13365 and IC-103295 had pod weights of 1.89 g, 1.85 g and 1.86 g, respectively. Eleven genotypes and a control variety had considerably higher values than the grand mean of 1.58 g. Nine genotypes outperformed the control variety Pusa Navbahar in terms of value (1.65 g).

Table 5: Environmental wise mean performance of genotypes for pod length (cm), pod girth (mm) and pod weight (g) in cluster bean.

Genotype	Pod length (cm)				Pod girth (mm)				Pod weight (g)			
	HYD	KRNR	MLYL	POOLED	HYD	KRNR	MLYL	POOLED	HYD	KRNR	MLYL	POOLED
IC-9052	7.15	7.06	6.89	7.03	9.05	8.96	8.81	8.94	1.89	1.84	1.79	1.84
IC- 9077-P1	7.07	7.26	6.75	7.02	7.53	7.25	7.40	7.39	1.39	1.31	1.35	1.35
IC-9229-P3	6.87	6.87	6.57	6.77	7.48	7.10	7.34	7.30	1.41	1.33	1.33	1.35
IC-9233-P3	6.53	6.40	6.23	6.39	8.93	7.48	7.90	8.10	1.38	1.28	1.36	1.34
IC-10323	7.20	7.30	7.11	7.20	9.03	8.65	8.90	8.86	1.59	1.55	1.54	1.56
IC-10333	8.17	8.17	8.00	8.11	4.87	4.43	4.73	4.67	1.72	1.73	1.67	1.70
IC-10520	7.47	6.97	7.15	7.19	5.90	5.52	5.77	5.73	1.13	1.07	1.04	1.07
IC-13348	7.17	7.26	7.04	7.15	5.90	5.52	5.77	5.73	1.49	1.26	1.35	1.36
IC-13365	7.98	7.43	7.68	7.69	7.43	6.80	6.96	7.87	1.86	1.75	1.74	1.78
IC-28269	6.80	7.09	6.52	6.80	8.43	7.78	7.40	8.69	1.45	1.40	1.33	1.39
IC-28283	9.00	8.94	8.62	8.85	8.63	8.76	8.69	7.19	1.19	1.11	1.03	1.10
IC-28286	6.83	6.75	6.58	6.72	7.37	6.99	7.23	7.19	1.39	1.36	1.31	1.35
IC-28287	8.83	8.70	8.23	8.58	7.63	7.09	7.16	7.79	1.78	1.34	1.26	1.46
IC-34344	6.53	6.41	6.44	6.46	8.93	8.63	8.80	8.78	1.41	1.33	1.35	1.364
IC-39989	13.77	13.72	13.55	13.67	10.33	9.95	10.20	10.16	2.54	2.43	2.45	2.47
IC-103295	8.47	8.37	8.65	8.84	8.90	8.52	8.77	8.73	1.85	1.79	1.80	1.81
IC-140774	6.63	6.55	6.38	6.52	9.90	9.52	9.77	9.73	1.47	1.23	1.21	1.30
IC-140777	6.73	7.05	6.54	6.77	7.60	6.49	6.94	7.01	1.51	1.38	1.40	1.43
IC-140791	6.30	6.24	6.26	6.26	7.83	7.45	7.70	7.66	1.28	1.33	1.19	1.26
IC-177844	7.97	8.03	7.45	7.81	6.50	6.12	6.37	6.33	1.81	1.75	1.73	1.76
IC-200679	6.30	6.34	6.27	6.30	7.52	7.33	7.38	7.41	1.18	1.16	1.19	1.17
IC-200680	7.13	6.73	6.94	6.93	9.50	9.41	9.43	9.44	1.76	1.62	1.58	1.65
IC-200696	7.87	7.77	7.60	7.74	7.30	6.92	7.17	7.13	1.83	1.75	1.81	1.79
IC-200715	6.90	6.38	6.62	6.63	7.54	7.28	7.40	7.40	1.54	1.43	1.51	1.49
Pusa Navbahar	8.97	8.60	8.57	8.71	8.68	8.30	8.54	8.50	1.65	1.75	1.64	1.68
General mean	7.625	7.536	7.87	7.51	7.94	7.529	7.704	7.727	1.58	1.49	1.47	1.517
S.E.(m)	0.13	0.14	0.21	0.12	0.15	0.16	0.14	0.09	0.035	0.04	0.05	0.03
C.D. at 5%	0.278	0.283	0.437	0.304	0.304	0.327	0.299	0.218	0.071	0.099	0.105	0.073

HYD: Hyderabad, KRNR: Karimnagar, MLYL: Malyal

The pod weight ranged from 1.07 g to 2.43 g in the Karimnagar location, with an overall mean of 1.49 g. The genotype IC-39989 (2.43 g) had the highest average pod weight, whereas genotype IC-10520 (1.07 g) had the lowest average pod weight. IC-9052, IC-103295 and IC-13365 had pod weights of 1.84 g, 1.79 g and 1.75 g, respectively, next to the IC-39989 genotype. Ten genotypes and a control variety had considerably higher values than the grand mean of 1.58 g. Six genotypes scored considerably higher than the check cultivar Pusa Navbahar (1.75 g).

Entries in the Malyal location had a general mean of 1.47g and a pod weight range of 1.04g to 2.45g. The genotype IC-39989 (2.45g) had the greatest average pod weight, whereas the genotype IC-10520 (1.04 g) had the lowest. In comparison to IC-39989, IC-103295, IC-9052 and IC-13365 had pod weights of 1.80g, 1.79g and 1.74g respectively. Eleven genotypes and a control variety had considerably higher values than the grand mean of 1.47g. Seven genotypes outperformed the check variety Pusa Navbahar in terms of value (1.64g).

A review of pooled data from three environments found that the mean pod weight ranged from 1.07 g in IC-10520 to 2.474 g in IC-39989. IC-9052, IC-10323, IC-10333, IC-13365, IC-39989, IC-103295, IC-177844, IC-200680, IC-200696 and Pusa Navbahar were the ten genotypes with greater pod weight than the overall mean (1.517g). Seven genotypes outperformed the check variety Pusa Navbahar in terms of value (1.68g).

These findings are comparable to those of Anandhi and Oomen (2007); Rajashekar *et al.*, (2018).

Number of seeds per pod. The number of seeds per pod in Hyderabad ranged from 5.67 to 10.97, with a grand mean of 7.45. The genotype IC-39989 (10.97) had a substantially more number of seeds per pod, while the genotype IC-200715 (5.67) had a significantly lower number of seeds per pod. No genotype was statistically equivalent to IC-39989 (10.97). Twelve genotypes had considerably more seeds per pod than the grand mean of 7.45. Nine genotypes produced considerably more seeds per pod than the check variety Pusa Navbahar (7.59).

The number of seeds per pod ranged from 5.40 to 10.72 in the Karimnagar location, with mean of 7.25. The genotype IC-39989 (10.72) had a substantially more number of seeds per pod, while the genotype IC-200715 (5.40) had a significantly less number of seeds per pod. No genotype was statistically equivalent to IC-39989 (10.72).

For number of seeds per pod, the genotypes at Malyal had a general mean of 7.354 with a range of 5.07 to 10.93. The genotype IC-39989 (10.93) had a considerably more number of seeds per pod, whereas the genotype IC-200715 (5.07) had a significantly less number of seeds per pod. No genotype was statistically equivalent to IC-39989 (10.93). Fifteen genotypes reported more seeds per pod than the check variety Pusa Navbahar (7.05).

Based on the mean performance of genotypes in a pooled analysis of various environments, it was found that 12 genotypes, namely IC-9052, IC-9077-P1, IC-10323, IC-10333, IC-10520, IC-28283, IC-34344, IC-39989, IC-103295, IC-177844, IC-200680, and Pusa Navbahar, had significantly higher mean than the general (7.35). The most seeds per pod were found in genotypes IC-39989 (10.87), IC-28283 (9.17) and IC-10333 (8.42). The findings of this study agree with those of Vir and Singh (2015); Rajashekar *et al.*, (2018); Shobiya *et al.*, (2019); Yeswanth *et al.*, (2019).

Pod yield per plant (g). The mean value (Table 6) for pod yield per plant at the Hyderabad location ranged from 59.53 g to 208.52 g, with a grand mean of 113.26 g. The genotype IC-103295 (208.52 g) had the highest pod yield per plant, whereas the genotype IC-28283 (59.53 g) had the lowest. No genotype was statistically equivalent to IC-103295 (208.52 g). Thirteen genotypes produced considerably more pods per plant than the grand mean (115.65 g) of the check variety Pusa Navbahar (113.26 g).

Entries in the Karimnagar site had a general mean of 96.48 g with a range of 47.04 g to 179.92 g for pod production per plant. The genotype IC-103295 (179.92 g) had the highest pod yield per plant, whereas the genotype IC-28283 (47.04 g) had the lowest. No genotype was statistically equivalent to IC-103295 (179.92 g). Eight genotypes had greater values than the control cultivar Pusa Navbahar (110.32 g).

The average performance of genotypes in the Malyal location was 84.39 g, with a range of 37.18 g to 173.60 g. The genotype IC-103295 had the highest pod production per plant at 173 g per plant, whereas genotype IC-28283 had the lowest output per plant at 37.18 g per plant. Seven genotypes out of 25 had greater values than the control variety Pusa Navbahar (96.97 g).

The pooled analysis of mean genotype performance across environments (Table 6) revealed that mean pod production per plant ranged from 47.9 g in IC-28283 to 187g in IC-103295. IC-9052, IC-10323, IC-10333, IC-34344, IC-39989, IC-103295, IC-140774, IC-140777, IC-177844, IC-200680 and Pusa Navbahar had greater pod production per plant than the overall mean (98.84). Seven genotypes had greater values than the control cultivar Pusa Navbahar (106.8 g). These findings are comparable to those of Goudar *et al.,* (2017); Praveen *et al.,* (2018); Rishitha *et al.,* (2019).

Table 6 : Environmental wise mean performance of genotypes for no. of seeds per pods, pod yield per plant (g) and pod yield per ha (q/ha) in cluster bean.

Genotype	No. of seeds per pod				Pod yield per plant (g)				Pod yield per ha (q/ha)			
	HYD	KRNR	MLYL	POOLED	HYD	KRNR	MLYL	POOLED	HYD	KRNR	MLYL	POOLED
IC-9052	7.87	7.62	7.77	7.75	175.15	159.26	136.79	157.06	183.91	167.23	143.63	164.92
IC- 9077-P1	7.97	7.72	7.93	7.87	86.28	77.22	59.44	74.31	90.59	81.08	62.42	78.03
IC-9229-P3	6.93	6.69	6.90	6.84	116.05	91.20	73.78	93.6	121.86	95.77	77.47	98.36
IC-9233-P3	7.30	7.06	7.26	7.20	78.83	61.68	56.71	65.74	82.77	64.76	59.54	69.02
IC-10323	7.80	7.56	7.76	7.70	152.86	137.37	121.24	137.15	160.51	144.23	127.30	144.1
IC-10333	8.53	8.29	8.50	8.44	126.16	114.27	98.95	113.12	132.47	119.98	103.90	118.7
IC-10520	7.50	7.26	7.46	7.40	82.47	65.36	56.25	68.02	86.59	68.62	59.06	71.4
IC-13348	7.33	7.09	7.30	7.24	64.38	45.53	42.86	50.92	67.60	47.80	45.01	53.47
IC-13365	7.33	7.09	7.30	7.24	101.85	74.81	67.30	81.31	106.94	78.55	70.66	85.38
IC-28269	6.68	6.59	6.73	6.66	65.19	52.35	48.72	55.4	68.45	54.97	51.16	58.19
IC-28283	9.27	9.02	9.23	9.17	59.50	47.04	37.18	47.9	62.48	49.40	39.04	50.03
IC-28286	7.27	7.02	7.23	7.17	77.01	61.03	45.31	61.1	80.86	64.08	47.58	64.17
IC-28287	5.73	6.11	5.69	5.84	83.66	62.53	44.23	63.47	87.85	65.66	46.44	66.64
IC-34344	7.97	7.72	7.93	7.87	152.08	119.29	123.47	131.61	159.68	125.26	129.64	138.19
IC-39989	10.97	10.72	10.93	10.87	168.06	159.43	130.86	152.7	176.46	167.40	137.41	160.42
IC-103295	8.43	8.19	8.40	8.34	208.52	179.92	173.60	187.00	218.95	188.92	182.28	196.78
IC-140774	5.75	5.71	5.30	5.58	133.10	98.35	78.03	103.15	139.75	103.26	81.93	108.38
IC-140777	7.07	6.82	7.03	6.97	120.07	104.23	95.53	106.6	126.07	109.44	100.31	111.9
IC-140791	6.81	6.58	6.67	6.68	74.84	66.16	56.63	65.8	78.58	69.46	59.46	69.16
IC-177844	7.47	7.22	7.43	7.37	146.51	125.27	104.69	125.4	153.84	131.53	109.92	131.7
IC-200679	6.30	6.06	6.26	6.20	100.80	86.92	77.46	88.39	105.84	91.26	81.34	92.8
IC-200680	8.17	7.92	8.13	8.07	168.36	144.93	126.54	146.6	176.77	152.18	132.87	153.98
IC-200696	6.57	6.32	6.53	6.47	119.02	80.55	72.91	90.8	124.97	84.57	76.56	95.3
IC-200715	5.67	5.40	5.07	5.38	117.44	87.16	84.36	96.32	123.31	91.52	88.57	101
Pusa Navbahar	7.59	7.41	7.05	7.35	113.26	110.32	96.97	106.80	118.92	115.83	101.82	112.19
General mean	7.45	7.25	7.35	7.35	115.65	96.48	84.39	98.84	121.44	101.31	88.612	103.78
S.E.(m)	0.166	0.331	0.329	0.102	4.806	5.586	6.08	0.23	5.04	5.88	6.38	3.90
C.D. at 5%	0.445	0.441	0.439	0.243	9.66	11.231	12.229	8.75	10.145	11.79	12.84	9.19

HYD: Hyderabad, KRNR: Karimnagar, MLYL: Malyal

Pod yield per hectare (q/ha). In Hyderabad environment, the mean pod yield per hectare varied from 62.48 q/ha to 218.95 q/ha, with a normal mean of 121.44 q. Genotype IC-103295 had the highest pod yield per hectare (218.95 q/ha), whereas genotype IC-28283 had the lowest pod yield per hectare (62.48 q/ha). Thirteen genotypes exceeded the check variety (118.92 q/ha), Pusa Navbahar.

At Karimnagar location, the average mean pod yield per hectare (Table 6) was 101.31 q/ha, with a range of 49.40 q/ha to 188.92 q/ha. The greatest pod yield per hectare was obtained by genotype IC-103295 (188.92 q/ha), whereas the lowest pod yield per hectare was reported by genotype IC-28283 (49.40 q/ha. Eight genotypes outperformed the check variety Pusa Navbahar (115.31 q/ha).

For pod yield per hectare, the genotypes at Malyal showed a general mean of 88.61q/ha with a range of 45.01 q/ha to 182.28 q/ha. The genotype IC-103295 had the highest pod yield per hectare (182.28 q/ha), whereas the genotype IC-28283 had the lowest pod yield per hectare (45.01 q/ha). No genotype was significantly at par with IC-103295 (182.28 q/ha).

The mean performance of the genotypes across three environments was 196.7 q/ha in IC-103295 and 50.03 q/ha in IC-28283, with a population general mean of 103.78 q/ha (Table 6). Eleven genotypes, namely IC-9052, IC-10323, IC-10333, IC-34344, IC-200680, IC-

140777, IC-140774, IC-177844, IC-103295, IC-39989 and Pusa Navbahar, outperformed the overall mean (103.78 q/ha). Eight genotypes had greater values than the check variety Pusa Navbahar (112.19 q/ha). These results are similar with reports of Rajashekar *et al*., (2018); Rishitha *et al*., (2019); Yeswanth *et al*., (2019).

CONCLUSION

The mean performance of the genotypes for individual character is an essential criterion for rejecting undesired types in any selection programme. This showed that the germplasm analyzed might serve as a prospective source and provide opportunities for the development of high yielding varieties with desired horticultural characteristics.

FUTURE SCOPE

The present findings would be helpful for formulation of selection strategy for identification of parent materials in a set of germplasm as well as selection of elite plant types in cluster bean breeding programme under various environmental conditions.

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