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Morphological characterization of parental lines and cultivated genotypes of bottle gourd (*Lagenaria siceraria*)

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ABSTRACT

Genetic diversity and relatedness were assessed among fifteen most common commercial bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] genotypes of public sector institutes in India; the fifteen genotypes were grown in the field for two seasons under RCBD with three replications in New Delhi condition. Data were collected on morphological features of bottle gourd which include vine, leaf, flower, fruit and seed characteristics. A descriptor list with selected 32 morphological (qualitative and quantitative) characters were adopted from NBPGR guidelines and used for characterization. The data was used to calculate genetic similarity and to construct a dendrogram using the unweighted pair-group method with arithmetic average (UPGMA). Data on quantitative characters was subjected to ANOVA using SAS and effects declared significant at 5% level. The procedure PRINCOMP was then used to perform a principle component (PC) analysis using fourteen quantitative variables and genotypes plotted on two dimensions using the first two principle components (PC1 and PC2). The results of quantitative characters of Pusa Santusti, Pusa Sandesh and Arka Bahar demonstrated highly significant variation between genotypes. Results of the principle component analyses for the traits indicated that the first five PCs explained a total of 80% of the total variation. The high morphological diversity observed among public sector genotypes emphasizes the need to expand the genetic base of the cultivated bottle gourd in India.

Key words: Bottle gourd, Genotypes, Genetic diversity, Principle component, Quantitative characters, Qualitative characters

Cucurbitaceous vegetables are the largest family consisting of maximum number of edible species in vegetable kingdom. Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is one such important vegetable of this family with high genetic diversity for fruit shape and other fruit characteristics, resulting in a variety of uses (Bisognin 2002). It is vital for plant breeding programmes to have sufficient diversity available to allow for the production of new genotypes that are aimed towards the improvement of crop productivity and able to withstand damage from biotic and abiotic factors (Querol 1987).

Identification of genotypes based on morphological characteristics, viz. vine, leaf, flower, fruit and seed characteristics is the most widely used method. According to International Union for Protection of New Plant Genotypes (UPOV), any new characteristic used in varietal characterization should be clearly defined, accepted and should have standard method of observation, least or not affected by environment, accessible to breeders, associated with reasonable costs and efforts. For identification of genotypes through morphological characters and conduct of GOT, the plant and seed characters need to be studied and thoroughly documented. The National Test Guidelines are to be developed for conduct of DUS testing. Such characterization studies are lacking in bottle gourd.

The available information suggests that modern genotypes often lack additional characters which farmers consider important. Significant genetic variation may exist among bottle gourd genotypes. Some may be superior in certain traits but lacking in other aspects. Their morphological characteristics may also be different; hence there is a need for detailed study of genetic variation in cultivated bottle gourd genotypes in order to generate data. This data will be essential to validate suggested comparative advantages and may provide new options for crop improvement. Therefore, the present study was undertaken to characterize parental lines of Pusa Hybrid-3 and cultivated genotypes on the basis of morphological characters.

MATERIALS AND METHODS

A study on morphological characterization of bottle gourd 15 genotypes carried out at Centre for Protected

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Table 1 List of bottle gourd genotypes and their origin

Varieties/Hybrids	Institutes/universities
Pusa Naveen	Indian Agricultural Research Institute, New Delhi
Pusa Santhusti	Indian Agricultural Research Institute, New Delhi
Pusa Samridhi	Indian Agricultural Research Institute, New Delhi
Pusa Sandesh	Indian Agricultural Research Institute, New Delhi
Narendra Dharidar	Narendra Dev University of Agriculture & Technology, Faizabad (UP)
Narendra Jyoti	Narendra Dev University of Agriculture & Technology, Faizabad (UP)
Narendra Rashmi	Narendra Dev University of Agriculture & Technology, Faizabad (UP)
Punjab Long	Punjab Agricultural University, Ludhiana (Punjab)
Punjab Komal	Punjab Agricultural University, Ludhiana (Punjab)
PSPL	IARI, Regional Station, Karnal
Arka Bahar	Indian Institute of Horticulture Research, Bangaluru (Karnataka)
Kashi Ganga	Indian Vegetable Research Institute, Varanasi (UP)
Pant Sankar-1	GB Pant University of Agriculture & Technology, Pantnagar (Uttarakhand)
Pant Sankar-2	GB Pant University of Agriculture & Technology, Pantnagar (Uttarakhand)
Azad Kranti	Chandra Sehkar Azad University of Agriculture & Technology, Kanpur (UP)

Cultivation Technology (CPCT), IARI, New Delhi. The investigated seed materials were collected from different institutes of public sector across India (Table 1).

A NBPGR descriptor list with 32 morphological characters was used for characterization (Table 2). Each qualitative descriptor was scored by observing five tagged plants per genotypes taking one plant from every block (replicate). Quantitative descriptors were taken as the mean value of three measurements made on five plants per replication.

Statistical analysis were carried out on 14 quantitative characters (Table 2) by employing SAS (9.2). First, descriptive statistics (mean, standard deviation, and coefficient of variation), were generated. The procedure PRINCOMP was then used to perform a principle component (PC) analysis using the 14 quantitative variables. In this procedure, first a similarity matrix was calculated and was used to calculate eigen values and scores for the genotypes. The genotypes were then plotted on two dimensions using the first two principle components (PC1 and PC2). Dendrograms and genetic similarity among the accessions were also generated and expressed as euclidean genetic distances. The fourteen quantitative characters were also subjected to ANOVA and Least Significant Difference ($LSD_{5\%}$) was used to separate the means.

Table 2 NBPGR-Descriptors used for characterizing the bottle gourd genotypes

Qualitative descriptors	
Early plant vigour	3-poor, 5-good, 7-very good and 99-others
Plant growth habit	3-short vine, 5-medium vine, 7-long vine and 99-others
Stem pubescence	0-absent, 3-sparse, 5-medium, 7-dense and 99-others
Stem shape	1-rounded, 2-angular and 99-others
Tendril	0-absent and 1-present
Tendril type	1-coiled, 2-straight and 99-others
Tendril branching	1-unbranched and 2-branched
Leaf margin	1-entire, 2 serrate, 3-multifid and 99-others
Leaf shape	1-cordate, 2-oblong, 3-ovate, 4-obovate, 5-orbicular, 6-reniform and 99-others
Leaf size	3-small, 5-medium 7-large and 99-others
Sex type	1-monoecious, 2-gynomonoecious, 3-andromonoecious, 4-androgynomonoecious, 5-hermophrodite, 6-androecious and 99-others
Flower colour	1-white, 2-cream and 99-others
Peduncle separation from fruit	3-easy, 5-intermediate, 7-difficult and 99 others
Fruit shape	1-elliptical, 2-elongate, 3-pyriform, 4-oblong, 5-club shaped, 6-top shaped, 7-globular, 8-dumbelled shaped, 9-kamandal shaped 10-lengthened shaped and 99-others
Blossom end fruit shape	1-semi blunt, 2-blunt, 3-acute and 99-others
Fruit skin colour	1-light green, 2-green, 3-dark green, 4-patchy green and 99-others
Fruit taste	1-sweet, 2-bitter and 99-others
Fruit pubescence	0-absent and 1-prenet
Quantitative descriptors	
Internodal length (cm)	
Petiole length (cm)	
Nodes at which first female flower appeared	
Days to 50% flowering	
Peduncle length (cm)	
Seed length breadth ratio	
Vine length (m)	
Number of primary branch	
Number of fruit per plant	
Fruit length (cm)	
Fruit width (cm)	
Fruit weight (kg)	
Number of seed per fruit	
100 seed weight (g)	

RESULTS AND DISCUSSION

Assessment of genotypes with qualitative characters

A total of 15 public sector genotypes under study portrayed a wide range of diversity in qualitative characters including early plant vigour, stem pubescence, leaf size, fruit shape, peduncle separation from fruit, blossom end fruit shape, fruit skin colour and fruit pubescence. However

Table 3 Variation in qualitative characters of bottle gourd genotypes from different public sector institutes

Genotype	Characters								
	Early plant vigour	Plant growth habit	Stem pubescence	Stem shape	Tendril	Tendril type	Tendril branching	Leaf margin	Leaf shape
Pusa Naveen	Good	Medium vine	Sparse	Angular	Present	Coiled	Branched	Entire	Cordate
Pusa Santhusti	Good	Medium vine	Medium	Angular	Present	Coiled	Branched	Entire	Cordate
Pusa Samridhi	Good	Medium vine	Medium	Angular	Present	Coiled	Branched	Entire	Cordate
Pusa Sandesh	Poor	Medium vine	Dense	Angular	Present	Coiled	Branched	Entire	Cordate
Narendra Dharidar	Good	Medium vine	Sparse	Angular	Present	Coiled	Branched	Entire	Cordate
Narendra Jyoti	Poor	Medium vine	Absent	Angular	Present	Coiled	Branched	Entire	Cordate
Narendra Rashmi	Good	Medium vine	Sparse	Angular	Present	Coiled	Branched	Entire	Cordate
Punjab Long	Poor	Medium vine	Sparse	Angular	Present	Coiled	Branched	Entire	Cordate
Punjab Komal	Poor	Medium vine	Sparse	Angular	Present	Coiled	Branched	Entire	Cordate
PSPL	V. good	Long vine	Sparse	Angular	Present	Coiled	Branched	Entire	Cordate
Arka Bahar	V. good	Long vine	Medium	Angular	Present	Coiled	Branched	Entire	Cordate
Kashi Ganga	Good	Medium vine	Sparse	Angular	Present	Coiled	Branched	Entire	Cordate
Pant Sankar-1	Poor	Short vine	Medium	Angular	Present	Coiled	Branched	Entire	Cordate
Pant Sankar-2	Good	Medium vine	Medium	Angular	Present	Coiled	Branched	Entire	Cordate
Azad Kranti	Good	Medium vine	Dense	Angular	Present	Coiled	Branched	Entire	Cordate
	Leaf size	*Sex Type*	*Flower colour*	*Fruit shape*	*Peduncle separation from fruit*	*Blossom end fruit shape*	*Fruit skin colour*	*Fruit taste*	*Fruit pube-scence*
Pusa Naveen	Medium	Monoecious	Cream	Cylindrical	Intermediate	Semi blunt	Dark green	Sweet	Present
Pusa Santhusti	Medium	Monoecious	Cream	Pear	Easy	Semi blunt	Dark green	Sweet	Present
Pusa Samridhi	Large	Monoecious	Cream	Club	Difficult	Blunt	Dark green	Sweet	Present
Pusa Sandesh	Medium	Monoecious	Cream	Round	Difficult	Blunt	Light green	Sweet	Present
Narendra Dharidar	Medium	Monoecious	Cream	Club	Easy	Blunt	Patchy green	Sweet	Absesnt
Narendra Jyoti	Medium	Monoecious	Cream	Cylindrical	Easy	Semi blunt	Green	Sweet	Absesnt
Narendra Rashmi	Medium	Monoecious	Cream	Club	Easy	Semi blunt	Green	Sweet	Absesnt
Punjab Long	Small	Monoecious	Cream	Cylindrical	Intermediate	Semi blunt	Light green	Sweet	Absesnt
Punjab Komal	Small	Monoecious	Cream	Pear	Difficult	Blunt	Light green	Sweet	Absesnt
PSPL	Large	Monoecious	Cream	Oblong	Difficult	Acute	Green	Sweet	Absesnt
Arka Bahar	Large	Monoecious	Cream	Club	Easy	Blunt	Green	Sweet	Present
Kashi Ganga	Medium	Monoecious	Cream	Club	Easy	Acute	Green	Sweet	Absesnt
Pant Sankar-1	Medium	Monoecious	Cream	Club	Intermediate	Semi blunt	Green	Sweet	Absesnt
Pant Sankar-2	Large	Monoecious	Cream	Club	Easy	Acute	Green	Sweet	Absesnt
Azad Kranti	Medium	Monoecious	Cream	Club	Easy	Semi blunt	Green	Sweet	Absesnt

stem shape, tendril, tendril branching, leaf margin, leaf shape, sex type, flower colour and fruit taste were constant for all cultivated accessions. This was consistent with the results of Huh *et al.* (2008) on Korean and Turkish watermelon populations and Aruah *et al.* (2010) on variations among some Nigerian *Cucurbita* landraces. The greatest diversity was in fruit characters especially fruit shape, fruit skin colour and blossom end fruit shape. This concurs to the findings of Bisognin (2002) who reported that cucurbits are very similar in above ground development but have high genetic diversity for fruit shape and other fruit characteristics.

Assessment of genotypes with quantitative characters

The results showed significant variation among the genotypes in most of the traits measured. The genotypes, Azad Kranti and Arka Bahar were measured the higher internodal length (cm) than the other genotypes. The petiole length (cm) was significantly higher in Arka Bahar (24.10 cm) and Narendra Rashmi (20.67 cm), while minimum was observed in Narendra Jyoti (9.61 cm). Significantly minimum days to 50% flowering were observed in Pusa Samridhi, Narendra Rashmi and Pusa Naveen while 11 days delayed in Narendra Jyoti and PSPL and 27 days delayed in Arka Bahar. The variation observed on the days to 50% flowering was largely due to varietal differences among the public sector genotypes evaluated. This result was in agreement with that reported by Agbagwa and Ndukwu (2004) in *C. moschata*. The genotypes differed in peduncle length (cm). The significantly higher length was shown in Pusa Samridhi and Arka Bahar than the other genotypes. The seed length breadth ratio was maximum in Pusa Santusti fallowed by Pusa Samridhi, Punjab Long, Narendra Dharidar. The variations among the genotypes in number of seeds per

Table 4 Variation in quantitative characters of bottle gourd genotypes from different public sector institutes

Genotype	Internode length (cm)	Petilole length (cm)	Node No. first @& flower appears	Days to 50% flowering	Peduncle length (cm)	Seed length-breadth ratio	Vine length (m)
Pusa Naveen	11.22	13.59	14.63	51	15.33	2.25	4.78
Pusa Santusti	11.24	14.6	20.75	57.16	12.63	3.43	4.26
Pusa Samridhi	17.56	11.62	23.48	50.66	24.43	2.91	6.34
Pusa Sandesh	15.47	14.31	22.84	57.33	20.27	1.89	5.79
Narendra Dharidhar	17.68	13.51	29.64	54.5	14.95	2.52	6.63
Narndra Jyoti	12.43	9.61	28.24	61.5	11.7	2.1	5.66
Narendra Rashmi	11.39	20.67	13.89	50.5	16	2.35	5.48
Punjab Long	15.82	12.07	21.07	52.83	10.78	2.58	6.28
PSPL	17.99	15.78	19.19	61.66	12.38	1.72	7.72
Arka Bahar	20.79	24.1	24.54	78	20.46	2.07	9.07
Punjab Komal	17.64	15.12	17.29	54.33	15.89	2.46	5.89
Kashi Ganga	17.52	15.96	15.97	57.33	13.78	1.53	6.59
Pant Sankar-1	12.81	14	12.76	55.5	13.44	2.11	3.62
Pant Sankar-2	17.75	17.46	17.77	57.16	15.19	2.45	5.76
Azad Kranti	22.85	15.64	22.91	58.16	15.46	1.68	6.31
Mean	16.01	15.2	20.33	57.17	15.51	2.27	6.01
SE(d)	0.194	0.06	0.113	0.676	0.257	0.065	0.119
CV	4.674	0.472	0.681	1.449	2.035	3.54	2.411
LSD (P=0.05)	0.722	0.127	0.419	2.509	0.955	0.243	0.442
	No. of primary branches	*Number of fruits / plant*	*Fruit length (cm)*	*Fruit width (cm)*	*Fruit weight (kg)*	*No. of seed / fruit*	*100 seed weight (g)*
Pusa Naveen	6.13	4.2	50.99	10.19	2.1	743.08	14.94
Pusa Santusti	5.15	4.76	37.96	22.31	5.08	914.66	19.31
Pusa Samridhi	7.23	4.55	48.91	12.62	2.36	419.69	16.71
Pusa Sandesh	5.05	6	14.29	24.13	1.92	422.93	18.48
Narendra Dharidhar	6.4	3.76	44.92	9.54	1.95	622.96	12.67
Narndra Jyoti	5.5	3.2	65.81	8.13	1.67	529.8	14.41
Narendra Rashmi	7.98	3.38	53.86	7.63	1.35	312.6	14.36
Punjab Long	7.16	4.45	42.84	10.89	2.47	710.78	15.43
PSPL	7.4	5.36	83.61	7.3	2.2	358.13	16.2
Arka Bahar	7.91	1.43	45.33	10.14	2.18	675.8	17.82
Punjab Komal	7.38	3.26	19.58	15.76	1.61	42310	13.94
Kashi Ganga	7.18	4.5	55.67	9.65	2.41	726.85	15.7
Pant Sankar-1	5.4	4.46	47.85	8.84	1.59	497.05	13.71
Pant Sankar-2	4.36	5.56	59.96	9.39	1.66	502.53	15.45
Azad Kranti	6.43	3.78	66.88	8.23	2.06	486.25	20.23
Mean	6.44	4.18	49.23	11.65	2.17	556.41	15.96
SE(d)	0.121	0.102	0.285	0.052	0.018	4.227	0.062
CV	2.3	3.007	0.709	0.552	1.054	0.93	1.518
LSD (P=0.05)	0.45	0.38	1.06	0.195	0.069	15.672	0.733

fruit, seed length, seed width and 100-seed weight indicate that the characteristics are genetically controlled as reported earlier by Stephenson *et al*. (1988) and Mondal *et al*. (1989). It is evident that fruits containing more seeds achieved greater size. The vine length (m) was significantly higher in Arka Bahar (9.07m), however lowest fruit per plant was also seen in Arka Bahar (1.43m). The PSPL having the highest fruit length (83.61 cm) than the others, while it shown significantly lowest fruit width (7.30 cm). The genotypes Pusa Santusti, Pusa Naveen and Kashi Ganga produce maximum number of seed per fruit then the other genotypes. The 100 seed weight (g) varied from 12.67 g Narendra Dharidar to 20.23 g in Azad Kranti. The variation on the fruit length, fruit diameter and number of fruits per plant could be attributed to genetic differences existing among the genotypes. Nee (1990) and Abdullah *et al*. (2003) reported that *Cucurbita* genotypes produce fruits of various sizes as dictated by the genetic constitution.

Table 5 Eigen values of the correlation matrix of bottle gourd genotypes

	Eigen values of the Correlation Matrix			
Variables	Eigen value	Difference	Proportion	Cumulative
PCA 1	3.89690906	1.14030370	0.2784	0.2784
PCA 2	2.75660536	1.00629079	0.1969	0.4753
PCA 3	1.75031457	0.27670393	0.1250	0.6003
PCA 4	1.47361064	0.11242700	0.1053	0.7055
PCA 5	1.36118364	0.48944664	0.0972	0.8028

Table 6 Eigen vectors and the total percentage variations for the first five principal components of the fifteen selectedbottle gourd genotypes

Variable	Eigen vectors				
	PC1	PC2	PC3	PC4	PC5
Internodal length	0.35	0.14	-0.09	0.29	-0.01
Petiole length	0.31	0.15	0.04	-0.32	0.42
Node at which first female flower	0.12	0.27	0.01	0.26	-0.67
Days to 50% flower	0.33	0.28	0.24	0.09	-0.04
Peduncle length	0.13	0.24	-0.54	-0.13	-0.01
Seed length breadth ratio	-0.32	0.20	0.11	-0.34	-0.13
Vine length	0.44	0.16	0.00	0.05	-0.13
Number of primary branch	0.32	-0.01	0.01	-0.38	0.13
Number of fruits per plant	-0.25	-0.09	-0.22	0.51	0.27
Fruit length	0.18	-0.29	0.40	0.32	0.15
Fruit width	-0.26	0.43	-0.29	0.02	0.05
Fruit weight	-0.22	0.40	0.33	0.03	0.21
Number of seed per fruit	-0.18	0.27	0.49	-0.06	-0.10

Similarly, Mondal *et al.* (1989) and Aruah *et al.* (2010) reported wide range of variability in watermelon for fruit length, fruit diameter and number of fruits per plant.

The results of the PCA of the 14 quantitative traits measured are presented in Table 5 and 6. The results showed that the first five components contributed 80.28% of the variability among the 15 genotypes evaluated. The PC1, PC2, PC3, PC4 and PC5 accounted for 27.84, 19.69, 12.50, 10.53 and 9.72% of the total variation, respectively. The first principal component axis had high loading for vine length, intermodal length, petiole length and days to 50% flowering. On the other hand, fruit weight, fruit width number of seed per fruit and node at which first female flower appears were the biggest contribution to PC2. The two dimensional presentation of all genotypes grouped and is presented in Fig 1. The Arka Bahar (G10) separated clearly from the other genotypes and was located on the right side of upper part of the PCA graph while the Pusa Santusti were on the left side of upper part also separated from the rest of genotypes and was located on the lower side of the PCA graph Fig 1.

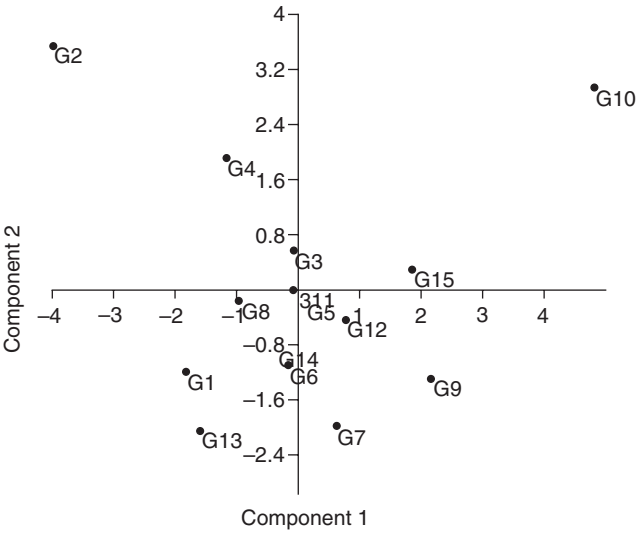

Fig 1 Principle component (PC) analysis plot of first two principle components, depicting relationship among bottle gourd genotypes

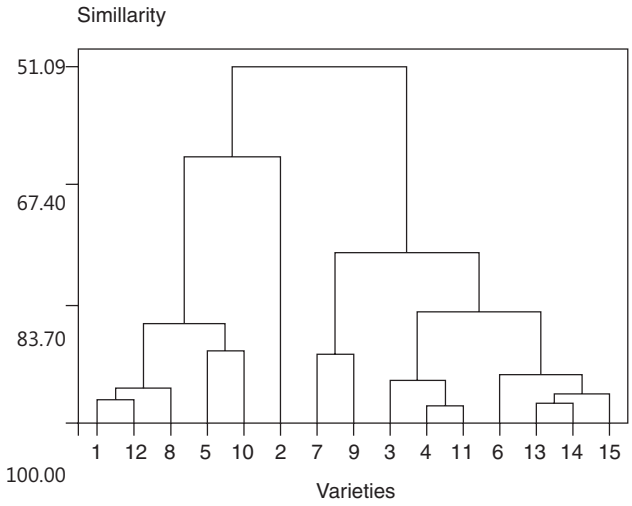

Fig 2 Dendrogram of 15 bottle gourd genotypes based on quantitative characters.1. Pusa Naveen, 2. Pusa Santhusti, 3. Pusa Samridhi, 4. Pusa Sandesh, 5. Narendra Dharidhar, 6. Narendra Jyothi, 7. Narendra Rashmi, 8. Punjab Long, 9. PSPL, 10. Arka Bahar, 11. Punjab Komal, 12. Kashi Ganga, 13. Pant Sankar-1, 14. Pant Sankar-2, 15. Azad Kranthi.

The genotypes variability evaluated by hierarchical cluster analysis (dendrogram) conducted on the quantitative traits, grouped the genotypes into three clusters (Fig 2). Cluster I comprised the genotypes 1 (Pusa Naveen), 12 (Kashi Ganga), 8 (Punjab Long), 5 (Narendra Dharidar) and 10 (Arka Bahar), while cluster II consist of only (Pusa Santusti) genotype. The cluster III consist of genotypes, 7 (Narendra Rashmi), 9 (PSPL), 3 (Pusa Samridhi), 4 (Pusa Sandesh), 11 (Punjab Komal), 6 (Narendra Jyoti), 13 (Pant Sankar-1), 14 (Pant Sankar-2) and 15 (Azad Kranti). The three clusters have appeared to maintain some level of distance from each other.

Table 7 Clusters means for 14 quantitative traits of fifteen bottle gourd genotypes.

Parameter	Cluster means		
	I	II	III
Internodal length (cm)	16.60	11.24	16.21
Petiole length (cm)	15.84	14.60	14.91
Node at which first female flower	21.17	20.76	19.82
Days to 50% flower	58.73	57.17	56.31
Peduncle length (cm)	15.06	12.64	16.08
Seed length breadth ratio	2.19	3.43	2.18
Vine length (m)	6.67	4.27	5.84
Number of primary branch	6.96	5.15	6.30
Number of fruits per plant	3.67	4.77	4.39
Fruit length (cm)	47.95	37.96	51.19
Fruit width (cm)	10.08	22.31	11.33
Fruit weight (kg)	2.22	5.08	1.82
Number of seed per fruit	695.89	914.67	439.12
100 seed weight (g)	15.31	19.31	15.94

Genotypes variability evaluated by hierarchical cluster analysis conducted on the quantitative traits, grouped the accessions into three clusters, indicating sufficient heritable variation that could warrant rational selection. Cluster I, II and cluster III had five one and nine genotypes, respectively (Table 7). The cluster I comprise of medium vine length genotypes with high petiole length, less fruit width. The variety in cluster II is essentially high seed length and breadth ratio, fruit width, fruit weight, number of seeds per fruit and 100 seed weight with low vine length. The cluster III is essentially lowers fruit weight and higher fruit length. It could be concluded that the genotypes in cluster I and III are promising in the production of more vegetative growth. The cluster II Pusa Santusti has more seed yielding parameters. Therefore, this genotypes could be recommended for selection and for further breeding program and also in seed production programme.

The multivariate techniques applied for morphological data sets demonstrate that introducing a component of morphological characters of bottle gourd cultivar. A morphometric analysis of quantitative traits showed that variation was relatively high among the bottle gourd genotypes studied. Bottle gourd cultivars were classified into three groups and the number of cultivar per group varied considerably. These cultivars are an important source of diversity which could be used in future breeding programs. This study may also find application in helping identify described bottle gourd populations during seed certification and testing.

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