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Study of variability and morphological characterization of cultivated genotypes of bottle gourd [*Lagenaria siceraria* (Mol.) Stdl.]

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Abstract
A field experiment was conducted to assess the variability and morphological characterization of bottle gourd genotypes which comprises of 37 genotypes at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during summer. The genotypes were planted in randomized block design with three replications. The data recorded were subjected to statistical analysis. Considerable amount of variability was noticed for the 16 quantitative traits as indicated by the analysis of variance. High estimates of GCV and PCV were recorded for diameter of fruit, length of fruit, weight of 100 seeds, no. of fruits per vine, number of primary branches, nodes to first male flower, fruit yield per vine, leaf length, nodes to first female flower and fruit yield per vine. High heritability coupled with high genetic advance as percent of mean was observed for diameter of fruit, length of fruit and weight of hundred seed that these traits were under the strong influence of additive gene action.

Keywords: Bottle gourd, GCV, PCV and Heritability

1. Introduction
Cucurbitaceous vegetables are the largest family comprising of 850 sps. and 200 genus in the vegetable kingdom. Bottle gourd (*Lagenaria siceraria* (mol.) Standl.) is one of the important vegetable of this family. It has high genetic diversity in terms of its shape, size and colour. From the ancient time period it has immense value starting from musical instrument to its used in edible purpose. Good quality bottle gourd based blend juice could be prepared without adding any chemical preservative in it with minimal thermal processing since during thermal processing, the minimum and maximum loss of ascorbic acid blend juice have been recorded 22.97% at 80ºC for 5 minutes and 47.70% at 95ºC for 30 minutes, respectively Gajera and Joshi [4]. Likewise its seeds are the potential source of protein, lipid, macro and micronutrients, and if utilized properly, it can solve the problem of malnutrition and serve as raw material for agro-based industries Hassan *et al*. [6]. The bitter fruits are poisonous and are used as a strong purgative Joshi and Gaur [7]. But still its development is in infancy stage so breeders now show keen interest for improvement of this crop by utilizing its genetic diversity. The genotypes which developed by the breeder have high crop productivity and able to withstand damage from biotic and abiotic factor. Morphological characterization of bottle gourd genotypes by visual observation is the most commonly used method for identification of genotypes. According to International Union for protection of New Plant Genotypes (UPOV), any new characteristics used in characterization of variety 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. The National Test Guidelines are to be developed for conduct of DUS testing of varieties. Such Characterization studies are found in bottle gourd in less as compared to other cucurbits like cucumber, bitter gourd and squashes etc. Significant genetic variation found in cultivated varieties of bottle gourd, the varieties which have attractive green colour, have the problem of crook neck. Hence forth there need for detailed study of genetic variation in cultivated bottle gourd genotypes. This data will be essential to validate suggested comparative advantages and provide new options for crop improvement. So, the present study was undertaken to characterize genotypes of bottle gourd and analysis the variability present among the variety and its impact on yield.

2. Materials and methods

A study on morphological characterization and assessment of variability of 37 genotypes of bottle gourd as carried out at at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during summer. A NBPGR descriptor list with 5 important morphological characters affecting yield were used for characterization. Each qualitative descriptor was scored by observing five tagged plants per genotypes taking one plant from every block. On the basis of qualitative analysis best genotypes were found out. The genotypes have good marketable attributes were studied for different variability parameters affecting yield (quantitative character). Statistical analysis was carried out on 16 quantitative characters by using ANOVA as per the standard procedure suggested by Panse and Sukhatme [16]. Least significance difference (5%) was used to separate the different means. The genotypic and phenotypic variances and coefficients of variation were worked out as per method of Burton [1] and heritability and genetic advance by following the method as suggested by Lush [11], Robinson *et al.* [17], Burton and De Vane [2] and the correlations among various variables and the path coefficient were estimated as per the procedure of Dewey and Lu [3].

Germplasm lines and standard released varieties included under study

The seeds of bottle gourd genotypes GH-39, GH-40, GH-41, GH-42, GH-43, GH-44, GH-45, GH-46, GH-47, GH-48, GH-49, GH-50, GH-51, GH-52, GH-53, GH-54, GH-55, GH-56, GH-57, GH-58, GH-59, GH-60, Hisar Seletion were procured from vegetable science department, Hisar, Punjab Komal, Punjab Long, Punjab Normal from PAU, Punjab, Pusa Samridhi, Pusa Santhusti, Pusa Sandesh, P.S.P.L. from IARI, New Delhi, NDBG-15, NDBG-104, NDBG-10 from NDUAT, Faizabad, Arka Bahar from IIHR, Banglore, Rajendra Chamtkar from RAU, Bihar, Pant Lauki 3 from GBPUT, Uttarakhand and other local varities such as Dudhi Long, KBG-16,RS-1,were taken for Observation. As per the guide lines of NBPGR different descrptiors were used for evaluating the best genotypes of bottle gourd. The lists of descriptors are given below.

1. Fruit skin colour - light green, dark green, green, patchy green and others
2. Fruit shape - elliptical, elongate, pyriform, oblong, club shaped, top shaped, globular
3. Fruit pubescence - present, absent
4. Flesh texture - smooth, spongy, fibrous
5. Fruit neck - straight, crooked

3. Results and Discussion

Assessment of genotypes with qualitative characters

A total of 37 public sector genotypes under study showed a wide range of diversity in qualitative characters including, fruit skin colour, fruit shape, fruit pubescence, texture of fruit flesh and fruit neck.

1. Categorization of genotypes based on fruit skin colour

Based on fruit skin colour, out of thirty seven genotypes, sixteen genotypes had light green colour, fourteen green, five dark green and two mottle green (Table 1). The results were confirmed by the findings of Mladenovic *et al*. [14] and Gurucan *et al*. [5] who characterized the morphology of bottle gourd leaf.

Table 1: Categorization based on fruit skin colour

Fruit skin colour	Genotypes	Total	Score
Light green	Punjab long, Punjab komal, Punjab Normal, Pusa Sandesh, Dudhi Long, RS1, GH39, GH40, GH45, GH46, GH48, GH49, GH53, GH55 and GH56	16	1
Green	P.S.P.L, Arka Bahar, NDBG15, NDBG10, NDBG104, Hisar Selection, Rajendra Chamtkar, GH41, GH42, GH43, GH47, GH50, GH51 and GH58	14	2
Dark green	Pusa Santhusti, Pusa Samrudhi, KBG16, GH57 and GH59	5	3
Mottle green	GH52 and GH54	2	4
Striped green	----------	0	5

2. Categorization of genotypes based on fruit shape in longitudinal section

The genotypes revealed significant variation for the character fruit shape in longitudinal section. Out of thirty seven genotypes, nine genotypes showed elongate - straight, eighteen elongate -curved, one cylindrical, two oval, three club, one pyriform and three round (Table 2). Morimoto *et al*. [15] described the bottle gourd fruits at edible stages oblate, spherical, ovoid and pyriform shaped and at non edible stage dipper, club or elongated cylindrical shaped. Leo *et al*. [10] reported that three out of five land races cylindrical fruited and two bottle shaped.

Table 2: Categorization based on fruit shape in longitudinal section

Fruit shape in longitudinal Section	Genotypes	Total	Score
Elongate- straight	NDBG15, NDBG104, NDBG10, GH39, GH40, GH46, GH48, GH49 and GH51	9	1
Elongate- curved	P.S.P.L, KBG16, Hisar Selection, GH41, GH42, GH43, GH45, GH47, GH50, GH51, GH52, GH53, GH54, GH55, GH56, GH57, GH58 and Pusa Naveen	18	2
Cylindrical	Punjab Long	1	3
Oval	Punjab Normal and GH59	2	4
Club	Pusa Samridhi, Arka Bahar and GH44	3	5
Pyriform	Pusa Santhusti	1	6
Round	Punjab Komal, Pusa Sandesh and RS1	3	7

3. Categorization of genotypes based on fruit pubescence

According to nature of fruit pubescence, thirty genotypes have pubescence on fruit, where as the remaining seven genotypes were free from pubescence (Table 3). Yetisir *et al*. [20] reported that the same finding while categorizing the land races of Sub African region.

Table 3: Categorization based on fruit pubescence

Fruit Pubescence	Genotypes	Total	Score
Present	GH39, GH40, GH41, GH42,GH43, GH44, GH45, GH46, GH47, GH48,GH 49, GH50, GH51, GH52, GH53, GH54, GH55, GH56, GH57, GH58, GH59, Arka Bahar, Rajendra Chamatkar, Pusa Sandesh, Pusa Santhusti, Pusa Samridhi, RS1, Dudhi Long, KBG16 and Hisar Selection	30	1
Absent	PSPL, Punjab Komal, Pusa Naveen, NDBG10, NDBG15, NDBG104 and Punjab Long	7	2

4. Categorization of genotypes based on flesh texture

Out of thirty seven genotype, twenty eight genotypes showed smooth, nine genotypes spongy and no genotypes showed fibrous flesh texture (Tale 4). Mahato *et al*. [12] found the bottle gourd genotypes varying in flesh texture (Smooth to Fibrous).

Table 4: Categorization based on flesh texture

Flesh Texture	Genotypes	Total	Score
Smooth	KBG16, Hisar Selection, Punjab Long, Pusa Sandesh, Arka Bahar, Pusa Samridhi, Pusa Naveen, Dudhi Long, Pusa Santhusti, NDBG10, NDBG15, NDBG104, Rajendra Chamatkar, PSPL, RS1, GH39, GH40,GH41, GH42, GH43, GH44, GH45, GH46, GH50, GH51, GH52, GH53 and GH56	28	1
Spongy	Punjab Komal, GH47, GH48, GH49, GH54, GH55, GH57, GH58 and GH59	9	2
Fibrous	----------	0	3

5. Categorization of genotypes based on fruit neck

Based on observation for shape of fruit neck, ninteen genotypes were recorded straight and eleven crook neck (Table 5). Mashilo *et al.* [13] in South Africa found majority of the land races (33) with crooked neck and only 3 land races without neck.

Table 5: Categorization based on fruit neck

Fruit neck	Genotypes	Total	Score
Straight	NDBG10, NDBG15, NDBG104, GH39, GH40, GH44, GH46, GH48, GH49, GH51, Dudhi Long, Punjab long, Pusa Naveen, Pusa Samridhi, Arka Bahar, Pusa Santhusti, Punjab Komal, Pusa Sandesh and RS 1	19	1
Crook	PSPL, KBG16, Hisar Selection, GH41, GH42, GH43, GH45, GH47, GH50, GH51, GH52, GH53, GH54, GH55, GH56, GH57, GH58 and GH59	18	2

Assessment of Variability

Different traits affecting yield were analyzed and variability of different characters affecting yield were estimated. It was find that higher values for phenotypic coefficient of variability were obtained than that of genotypic coefficients of variability values, in all the characters which indicates that influence of environment on expression of these characters. Length of fruit followed by days to first female flower opening, days to first fruit harvest, days to first male flower opening, weight of 100 seeds, diameter of fruit and leaf length had larger differences between PCV and GCV values, as these were most influenced by the environment. The remaining characters recorded have smaller difference between PCV and GCV values, as they were less influenced by the environment, which indicates that selection of these characters is important in breeding point of view. The genotypic and phenotypic variances in terms of unit of their expression were observed high for length of fruit (55.55 and 61.57) followed by days to first female flower opening (29.80 and 33.38). The genotypic and phenotypic variances were observed low in case of vine length at final fruit harvest (0.28 and 0.44), days to 50% germination (0.45 and 1.50) and fruit yield per vine (0.46 and 0.61).The moderate genotypic and phenotypic variance was observed in days to first male flower opening (24.43 and 26.00), weight of 100 seeds (8.44 and 9.24) and diameter of fruit (5.08 and 5.57). In above all the cases, magnitude of phenotypic variance and coefficients of variation was higher than their respective genotypic estimates, indicating that influence of environment on the expression of these characters. High estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were recorded for diameter of fruit (20.76 and 21.73%), length of fruit (20.71 and 21.81%), weight of 100 seed (18.43 and 19.28%) and number of fruits per vine (16.73 and 17.94), indicating that a greater amount of genetic variability was present for these characters. Moderate value for PCV and GCV was estimated for number of primary branches per vine (15.29 and 16.81%), nodes to first male flower (10.82 and 11.16%), yield per hectare (8.04 and 10.67%), vine length at the time of final harvest (10.77 and 13.57%) and leaf length (12.45 and 13.43%), indicating that a moderate amount of genetic variability was present in these characters, which provided average scope for selection. The lowest estimates of PCV and GCV were observed for traits like days to 50% germination (6.33 and 11.55%), days to 44 first fruit harvest (7.89 and 8.35%) and leaf width (8.05 and 9.53%), indicating limited scope for improvement among these trait. So these type traits cannot be taken in improvement programme. In present study, the phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters (Table 6), indicates that the effect of environment in the expression of all phenotypic character which are taken understudied. These results are similar with the findings of Kumar *et al*. [9]. Kumar *et al*. [8]. Yadav and Kumar [19]. The values which were described in the text mentioned in (Table 6).

Heritability (h^2) and genetic advance

High heritability estimates were found for days to first male flower opening (93%), diameter of fruit (91%), length of fruit (90%), days to first female flower opening (89%) and number of fruits per vine (86%). However, moderate heritability estimates were observed for leaf length (85%), number of primary branches (82%), nodes to first male flower (79%) and fruit yield per vine (76%). However, characters under study reported for low heritability estimates are days to first fruit harvest (8%), days to 50% germination (30%) and yield per hectare (56%). Those traits showing high and moderate estimates of heritability selection based on phenotypic performance of these characters would be more effective. High genetic advance as per cent of mean was observed for diameter of fruit (40.85%), length of fruit (40.53%), weight of

100 seeds (36.31%) and number of fruits per vine (32.12%), moderate for number of primary branches (28.65%), nodes to first male flower (24.98%), leaf length (23.79%), days to first male flower opening (21.62%) and low for days to 50% germination (7.14%), yield per hectare (12.46%), leaf width (14.01%), days to first fruit harvest (15.36%) and vine length at final fruit harvest (17.63%).The results of the present experiment are in consonance with previous studies carried out on bottle gourd by several workers like Kumar *et al*. [8] and Yadav *et al.* [18] The values which were described in the text mentioned in (Table 6).

Table 6: Variability parameters of Bottle gourd

Characters	General mean	Range of mean		Component of variance		Coefficient of variation		h^2 (%)	GA	GAPM
		Max.	Min.	Genotypic	phenotypic	Genotypic	Phenotypic			
Days to 50%germination	10.60	8.33	12.33	0.45	1.50	6.33	11.54	0.30	0.75	7.14
Number of primary branches	6.85	5.16	9.33	1.10	1.33	15.29	16.81	0.82	1.96	28.65
Days to first male flower opening	45.65	37.93	55.26	24.43	26.00	10.82	11.16	0.93	9.8	21.62
Days to first female flower opening	56.40	44.36	66.86	29.80	33.38	9.67	10.24	0.89	10.6	18.83
Nodes to first male flower	10.07	13.83	7.60	2.12	2.68	13.64	15.35	0.79	2.66	24.98
Nodes to first female flower	13.29	10.70	16.40	2.41	3.28	11.68	13.62	0.73	2.74	20.64
Leaf length (cm)	15.34	10.86	18.73	3.65	4.24	12.45	13.43	0.85	3.65	23.79
Leaf width (cm)	12.99	10.20	15.20	1.09	1.53	8.05	9.53	0.71	1.82	14.01
Days to first fruit harvest	68.68	55.16	79.60	29.39	32.91	7.89	8.35	0.08	10.5	15.36
Length of fruit (cm)	35.97	16.90	47.26	55.55	61.57	20.71	21.81	0.90	14.5	40.53
Diameter of fruit (cm)	10.86	8.20	17.16	5.08	5.57	20.76	21.73	0.91	4.43	40.85
Vine length at final fruit harvest (m)	4.93	3.60	5.83	0.28	0.44	10.77	13.57	0.63	0.86	17.63
Weight of 100 seeds (g)	15.76	11.34	23.60	8.44	9.24	18.43	19.28	0.91	5.72	36.31
Number of fruits per vine	6.86	5.16	9.33	1.34	1.54	16.73	17.94	0.86	2.22	32.12
Fruit yield per vine (kg)	5.30	3.50	7.26	0.46	0.61	12.91	14.77	0.76	1.23	23.25
Yield per hectare (t)	26.56	22.21	31.90	4.55	8.03	8.04	10.67	0.56	3.31	12.46

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