Trait association and selection strategies in segregating generations of bottle gourd {*Lagenaria siceraria* (Mol) Standl} in southwestern Haryana

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ABSTRACT

The present investigations were carried out to evaluate the trait association and selection strategies of F_3 and F_4 segregating generations on growth, flowering and yield-related traits in bottle gourd {*Lagenaria siceraria* (Mol) Standl} under the agro-climatic conditions of southwestern Haryana. The study was conducted during the rainy season of 2022-23 at CCS Haryana Agricultural University, Hisar, Haryana using progenies derived from the F_2 population of hybrid 19BOGHYB-2. Five progenies were advanced and evaluated in both F_3 and F_4 generations in a randomized block design with three replications. Analysis of variance revealed highly significant differences among progenies for all sixteen traits studied, indicating the presence of substantial genetic variability. In both generations, progeny 1 consistently exhibited superior performance for important traits such as number of primary branches per plant (11.73 and 11.47), average fruit weight (793.33 and 813.33 g), number of fruits per vine (8.13 and 8.40) and fruit yield per plot (64.57 and 68.30 kg). Early flowering and earliness in fruit harvest were also observed in this progeny, making it desirable for selection. The results indicated that selection in early segregating generations is effective for improving yield and its contributing traits. Progenies 1 and 2 emerged as promising lines and may be further utilized in breeding programmes aimed at developing high-yielding and early-maturing varieties of bottle gourd.

Keywords: Bottle gourd; F_3 generation; F_4 generation; Genetic variability; Yield traits; Selection; Earliness

INTRODUCTION

Bottle gourd {*Lagenaria siceraria* (Mol) *Standl*} is an annual, monoecious cucurbit crop commonly known as calabash or white-flowered gourd, with a chromosome number of 2n = 22. In India, the crop recorded an annual production of 3,363,656 tonnes during 2022-2023 from an area of 200,795 hectares, with an average productivity of 16,752 kg per hectare. In the same period, Haryana produced 283,970 tonnes from 21,585 hectares, with a comparatively lower yield of 13,156 kg per hectare (Anon 2023). Despite its importance, the supply of cucurbit vegetables remains insufficient to meet the demands of the country's growing population. Haryana, in particular, has significant potential for expanding bottle gourd cultivation due to its consistent demand for both culinary and medicinal purposes.

The crop is highly versatile, its fruits are used as a vegetable as well as for making decorative items, containers, bowls and even musical instruments. Additionally, different plant parts such as tendrils, leaves, seeds and immature fruits of bottle gourd are utilized for various purposes, including traditional medicinal applications.

Bottle gourd is known for its health benefits, including its ability to reduce triglycerides, low-density lipoproteins (LDL), cholesterol levels, pain and inflammation. The mature seeds are a valuable source of amino acids and essential oils (Ogunbusola et al 2010). Economically, it is a highly remunerative crop, providing quick returns to farmers within two to three months.

However, the productivity of bottle gourd in Haryana remains relatively low compared to other leading cucurbit producing states, mainly due to the limited adoption of improved varieties.

Considerably more research has been undertaken to evaluate the performance of different bottle gourd genotypes in order to identify promising and stable varieties for higher production. Quantitative characterization of germplasm not only helps in identifying lines with desirable traits, but also supports the design of inheritance studies (Sidhu and Pathak 2016). At present, there is a growing demand among farmers for early-maturing and high-yielding varieties or hybrids. Preliminary identification of early-maturing genotypes can be carried out using traits such as node number to first female flowering, days to opening of female flowers and days to first fruit harvest. The collection and evaluation of germplasm is a prerequisite for its effective utilization. Rigorous evaluation helps in determining the potential of different accessions for use in specific crop improvement programmes.

MATERIAL and METHODS

The present experiment was conducted at the Vegetable Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, Haryana, during the rainy season of 2022-23. The study was based on an F_2 segregating population derived from the hybrid 19BOGHYB-2 under the All India Coordinated Research Project (AICRP) on bottle gourd.

Hisar experiences a hot semi-arid climate, characterized by extremely hot summers, with temperatures rising up to 44-47°C and cold winters, where temperatures may fall to 3-5°C. The region receives low annual rainfall (generally less than 400 mm), most of which occurs during the southwest monsoon period from July to September. The experimental site was located at an altitude of 215.2 meters amsl on the southwestern border of Haryana.

The F_2 segregating population of the bottle gourd hybrid 19BOGHYB-2 was used to select five F_3 progenies based on their performance for key traits, including disease resistance/tolerance, number of fruits per plant, fruit size (medium-long), shape (cylindrical), colour (green) and earliness. From these, the best five plants in each of the F_3 and F_4 progenies were identified based on the above criteria and advanced in both the years of study.

Seeds from the selected F_3 and F_4 plant progenies were sown in a randomized block design with three replications. Each plot measured 5 m × 3 m and accommodated ten plants per replication. Observations were recorded on 16 quantitative traits from five randomly selected plants in each generation. The mean values across replications were used for statistical analysis.

Data on 16 quantitative traits were recorded across two generations and pooled analysis was performed. Analysis of variance (ANOVA) was carried out to assess the significance of differences among progenies, following the method suggested by Panse and Sukhatme (1985). Parameters such as ANOVA, critical difference (CD) and coefficient of variation (CV) were computed using the online statistical software developed by Sheoran et al (1998).

RESULTS and DISCUSSION

Table 1 presents the ANOVA results for cross 19BOGHYB-2 in F_3 and F_4 generations. The treatment mean sum of squares was recorded highly significant across all sixteen traits studied, indicating the presence of ample genetic variability within both progenies. This variability is crucial, as it provides a strong foundation for effective selection in early generations.

In a diverse collection of genotypes, when certain bottle gourd lines consistently outperform others for key traits such as yield, earliness and fruit quality, it is advantageous to prioritize these superior genotypes for further breeding programmes. The identification of such promising progenies ensures that breeding efforts are directed toward lines with the greatest potential for improvement.

Comparable variability in bottle gourd has also been reported by Das (2017) and Vaidya (2018), reinforcing the reliability of these findings and highlighting the broad genetic base available for selection in bottle gourd crop.

Trait association and selection strategies for segregation generations on flowering traits

Mean performance of various characters of F_3 and F_4 generations are presented in Tables 2 and 3 respectively. Wide range of variability was observed for each trait studied among the progenies and these values were comparable in both generations.

Table 1. Analysis of variance (ANOVA) of F_3 and F_4 generations for bottle gourd cross 19BOGHYB-2

Character	Mean sum of squares					
	F_3 generation			F_4 generation		
	Replications	Genotypes	Error	Replications	Genotypes	Error
Days to 50% germination	1.94	28.77**	3.18	2.50	23.96**	3.53
Number of primary branches/plant	0.09	21.64**	6.08	0.02	18.52**	7.29
Days to first female flower opening	2.96	95.81**	44.08	1.07	136.90**	41.68
Days to first male flower opening	30.66	100.94**	33.58	1.78	125.02**	60.72
Node to first male flower	3.05	3.77**	0.90	3.18	3.55**	0.71
Node to first female flower	4.44	3.64**	1.64	2.95	1.69**	0.84
Days to first fruit harvest	31.99	77.16**	33.40	42.58	89.19**	20.43
Average fruit weight (g)	640.00	68,160.00**	10,560.00	1,440.00	82,973.33**	7,026.67
Number of fruits/vine	0.28	5.56**	2.23	0.21	7.42**	1.79
Fruit yield/plot (kg)	32.99	1,261.33**	208.01	20.33	1,618.65**	154.27
Leaf length (cm)	4.71	19.27**	5.85	2.28	17.13**	7.67
Leaf width (cm)	1.77	44.63**	7.35	9.13	9.48**	1.45
Fruit length (cm)	2.95	194.47**	25.69	25.65	250.22**	26.11
Fruit diameter (cm)	2.35	10.05**	1.84	3.40	14.76**	2.55
Vine length (m)	2.06	4.67**	0.73	0.73	9.71**	1.88
100-seed weight (g)	1.01	17.00**	2.46	2.37	18.12**	1.42

*Significant at 5% LoS, **Significant at 1% LoS

In F_3 generation, progenies 1 and 2 took a minimum number of days (7.73 and 8.60 respectively) for 50 per cent germination, which were at par. Progeny 4 took a maximum number of days (11.87) for 50 per cent germination. Same was the trend in the F_4 generation. In F_4 generation, progenies 1 and 2 recorded minimum number of days (7.87 and 8.33 respectively) for 50 per cent germination, while progeny 4 took maximum number of days (11.53).

In F_3 generation, the maximum number of branches (11.73 and 10.07) was noted in progenies 1 and 2 respectively, which were at par and minimum was noted in progenies 4 (8.47), 3 (8.60) and 5 (9.20), all being at par and also at par with progeny 2 (10.07). In F_4 generation also, progenies 1 and 2 recorded the maximum number of branches (11.47 and 9.87 respectively), which were at par. Here the minimum number of primary branches per plant was observed in progenies 4 (8.33), 5 (8.80) and 3 (8.93), all being at par and also at par with progeny 2 (9.87).

In F_3 generation, progenies 1, 4, 5 and 2 took minimum number of days for first female flower opening (54.80, 55.53, 57.67 and 59.13 respectively), which were at par and progeny 3 recording maximum number of days (61.80), at par with progenies 2 (59.13 days) and 5 (57.67 days). In F_4 generation, progenies 1, 4 and 5 took minimum number of days for first female flower opening (54.27, 55.00 and 57.07 respectively), which were at par and progenies 3 and 2 recorded maximum number of days (62.73 and 58.67 respectively), which were also at par.

In F_3 generation, progenies 1, 4 and 5 took a minimum number of days for first male flower opening (46.33, 47.60 and 49.40 respectively), which were at par. In F_4 generation, progenies 4, 1, 5 and 2 recorded the minimum number of days for first male flower opening (46.33, 46.47, 48.87 and 50.13 respectively) which were at par.

In progeny 3, first male flower appeared on the lowest node in progenies 4 (7.47) and 3 (7.80). In F_4 generation, progeny 4 (7.33) recorded first male flower on the lowest node. In the F_3 generation, node to first female flower was recorded in progenies 3, 4 and 2 on the lowest node (10.40, 10.53 and 10.73

Table 2. Mean performance of cross (19BOGHYB-2) F_3 generation of bottle gourd for growth, flowering and fruit yield

Component	Progeny					$CD_{0.05}$	SE(m)	CV (%)
	1	2	3	4	5			
Days to 50% germination	7.73	8.60	9.73	11.87	9.40	1.21	0.36	6.66
Number of primary branches/plant	11.73	10.07	8.60	8.47	9.20	1.67	0.50	9.07
Days to first female flower opening	54.80	59.13	61.80	55.53	57.67	4.49	1.36	4.06
Days to first male flower opening	46.33	51.47	53.53	47.60	49.40	3.92	1.18	4.13
Node to first male flower	8.53	8.27	7.80	7.47	8.87	0.64	0.19	4.10
Node to first female flower	11.47	10.73	10.40	10.53	11.60	0.87	0.26	4.14
Days to first fruit harvest	67.93	72.27	74.40	69.27	70.53	3.91	1.18	2.88
Average fruit weight (g)	793.33	753.33	680.00	633.33	620.00	69.47	20.98	5.22
Number of fruits/vine	8.13	7.60	6.93	6.47	6.73	1.01	0.31	7.36
Fruit yield/plot (kg)	64.57	57.27	47.12	40.99	41.85	9.75	2.94	10.13
Leaf length (cm)	18.47	19.33	18.87	21.40	20.80	1.64	0.49	4.33
Leaf width (cm)	20.40	22.73	19.33	23.47	23.60	1.83	0.55	4.38
Fruit length (cm)	33.40	30.87	27.47	25.00	23.73	3.43	1.04	6.38
Fruit diameter (cm)	8.33	7.47	6.80	6.07	6.33	0.92	0.28	6.84
Vine length (m)	5.85	5.64	5.06	4.27	4.95	0.58	0.18	5.88
100-seed weight (g)	20.80	19.13	18.87	17.87	17.93	1.06	0.32	2.93

Table 3. Mean performance of cross (19BOGHYB-2) F_4 generation of bottle gourd for growth, flowering and fruit yield

Component	Progeny					$CD_{0.05}$	SE(m)	CV (%)
	1	2	3	4	5			
Days to 50% germination	7.87	8.33	9.40	11.53	9.27	1.27	0.38	7.16
Number of primary branches/plant	11.47	9.87	8.93	8.33	8.80	1.83	0.55	10.07
Days to first female flower opening	54.27	58.67	62.73	55.00	57.07	4.36	1.32	3.97
Days to first male flower opening	46.47	50.13	54.20	46.33	48.87	5.27	1.59	5.60
Node to first male flower	8.20	8.80	8.20	7.33	8.47	0.57	0.17	3.63
Node to first female flower	11.13	10.80	11.33	10.47	11.33	0.62	0.19	2.94
Days to first fruit harvest	68.80	71.60	75.33	68.73	70.20	3.06	0.92	2.25
Average fruit weight (g)	813.33	736.67	670.00	626.67	613.33	56.67	17.11	4.28
Number of fruits/vine	8.40	7.73	7.20	6.33	6.93	0.91	0.27	6.47
Fruit yield/plot (kg)	68.30	57.00	48.17	39.73	42.67	8.40	2.54	8.58
Leaf length (cm)	19.33	20.53	18.67	21.60	20.93	1.87	0.57	4.84
Leaf width (cm)	22.53	24.20	22.47	22.93	24.27	0.82	0.25	1.83
Fruit length (cm)	35.40	31.47	28.07	24.20	25.47	3.45	1.04	6.25
Fruit diameter (cm)	8.67	7.47	6.80	5.73	6.47	1.08	0.33	8.03
Vine length (m)	6.24	6.16	4.31	4.72	4.72	0.93	0.28	9.27
100-seed weight (g)	21.13	20.27	19.33	18.20	18.47	0.81	0.24	2.16

respectively). In F_4 generation, first female flower was recorded on the lowest node (10.47 and 10.80) in progenies 4 and 2 respectively, the two being at par.

In the F_3 generation, progenies 1, 4 and 5 of bottle gourd cross 19BOGHYB-2 took minimum number of days for first fruit harvest (67.93, 69.27 and 70.53 respectively), which were at par. In F_4 generation, progenies 4, 1, 5 and 2 took minimum number of days for first harvest (68.73, 68.80, 70.20 and 71.60 respectively). Hence, the genotypes which were earlier in flowering and node number for fruiting traits with maximum number of branches per plant may serve as ideal donors for the characters concerned. The results are also in agreement with that of Kandasamy et al (2019), who identified LS12 as the best genotype among 20 genotypes of bottle gourd as it recorded higher mean values for six out of twelve characters studied and Kumar et al (2023) who reported variability in growth and yield traits in segregating generation in bottle gourd.

Trait association and selection strategies for segregation generations on growth and fruit yield traits

In F_3 generation, the maximum leaf length was observed in progenies 4 and 5 (21.40 and 20.80 cm respectively), which were at par. In F_4 generation, maximum leaf length was observed in progenies 4, 5 and 2 (21.60, 20.93 and 20.53 cm respectively), which were at par. In F_3 generation, the maximum leaf width was observed in progenies 5, 4 and 2 (23.60, 23.47 and 22.73 cm respectively), all being at par. In F_4 generation, maximum leaf width was observed in progenies 5 and 2 (24.27 and 24.20 cm respectively), which were at par.

In F_3 generation, the maximum fruit length (33.40 and 30.87 cm), diameter (8.33 and 7.47 cm) and vine length (5.85 and 5.64 m) were observed in progenies 1 and 2 respectively, which were at par. Progeny 1 recorded maximum 100-seed weight (20.80 g). In F_4 generation, the maximum fruit length (35.40 cm), fruit diameter (8.67 cm) and 100-seed weight (21.13 g) were observed in progeny 1. In this generation, the maximum vine length was recorded in progenies 1 and 2 with 6.24 and 6.16 m respectively, which were at par. The results of the present study are in agreement with that of Alekar et al (2019), who reported that characters number of female flowers, fruits per vine, average length, weight and diameter of fruit should be given priority for selecting high yielding genotypes in F_4 population in bitter gourd.

The results are also in agreement with those of Vaidya (2018) who also observed a similar range of values for fruit length and fruit diameter in F_3 and F_4 generations of bottle gourd. Mali (2015) reported high estimates of heritability for number of branches and fruits per vine, average fruit weight and fruit yield per vine mainly in F_3 and F_4 progenies of muskmelon. Similar differential performance in growth, yield and yield attributes in ridge gourd was reported by Koppad et al (2016). Similar differential performance in bottle gourd was reported by Kandasamy et al (2019) and Kumar et al (2023).

In F_3 generation, maximum average fruit weight (793.33 and 753.33 g), number of fruits per vine (8.13 and 7.60) and fruit yield per plot (64.57 and 57.27 kg) were observed in progenies 1 and 2 respectively. In F_4 generation, the maximum average fruit weight (813.33 g) was observed in progeny 1 followed by 2 (736.67 g) and the maximum fruit yield per plot (68.30 kg) was also recorded in progeny 1 followed by 2 (57.00 kg). The maximum number of fruits per vine (8.40 and 7.73) was observed in progenies 1 and 2 respectively, the two being at par.

These results are comparable with the results of Chandramouli et al (2021) for the traits average fruit weight and number of fruits per vine in segregating generation in bottle gourd. Similar results regarding yield traits were also obtained by Kumar et al (2023) and Tiwari et al (2024) in bottle gourd.

CONCLUSION

The present study demonstrated significant genetic variability among F_3 and F_4 segregating generations of bottle gourd for growth, flowering and yield-related traits, indicating good scope for selection and genetic improvement. The consistent superior performance of progenies 1 and 2 across both generations for key traits such as fruit yield, number of fruits per vine, average fruit weight and earliness highlights their potential as promising breeding lines. Selection in early segregating generations proved to be effective in identifying desirable genotypes, suggesting that these progenies can be further advanced and utilized in varietal development programmes. Overall, the findings emphasize the importance of systematic evaluation and selection in segregating populations for enhancing productivity and developing improved cultivars suited to the agro-climatic conditions of southwestern Haryana.

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