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Inheritance patterns of bottle gourd (*lagenaria Siceraria* (Molina) Standl.) in f_4 progenies

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Abstract
This study investigated GCV, PCV, ECV, Heritability, GA, and correlation analysis for 13 characters in calabash derived of the cross Pusa Samrudhi × DHARWAD BOTTLE GOURD - 5 in the F4 generation. The traits including number of primary branches per vine, number of fruits per vine, yield per vine, and average fruit weight demonstrated considerable variability at both genotypic and phenotypic levels, accompanied by high heritability and notable genetic advance as a percentage of the mean. This indicates a predominant role of additive gene action, making these traits amenable to improvement through straightforward selection strategies. Yield per vine showed a strong and statistically significant positive correlation with several other characters—such as sex ratio, node at which the first female flower emerged, average fruit length, and fruit diameters at the pedicel, central, and stylar regions—at both genotypic and phenotypic levels. These associations highlight the importance of selecting for traits like node position of the first female flower, fruit length, diameters at various fruit positions, and fruit count per vine when aiming to enhance overall yield performance.

Keywords: Genetic variability, Correlation, bottle gourd, F_4 generation

Introduction
Calabash [*Lagenaria siceraria* (Molina) Standl.] is a widely cultivated vegetable belonging to the family Cucurbitaceae, characterized by a chromosome number of 2n=22. Due to its monoecious and andromonoecious floral nature, it predominantly undergoes cross-pollination (Swiander and Maccollum, 1994) [24]. Originally domesticated in Africa (Singh, 1990) [20], bottle gourd spread by floating seeds across seas to India, where it diversified into numerous indigenous varieties. From India, it further dispersed to regions including China, Indonesia, and as far as New Zealand.
Although the cultivation area and production of bottle gourd have been rapidly increasing, breeding efforts aimed at crop improvement remain limited. There is a growing demand for varieties exhibiting traits such as early fruiting, higher yields, an elevated female-to-male flower ratio, medium-length cylindrical green fruits, presence of pubescence, and resistance to pests and diseases like fruit fly, downy mildew, powdery mildew, gummosis, and fusarium wilt. To facilitate the incorporation of these desirable horticultural traits, F4 progenies were evaluated for genetic variability, heritability, genetic advance, and trait correlations to support breeding and crop enhancement programs.

Materials and Methods
The present investigation was conducted at the All India Coordinated Research Project on Vegetable Crops, AICRP-VC, MPKV, Rahuri, located in Ahilyanagar district of Maharashtra. The experimental layout followed a Randomized Block Design (RBD) with three replications. The study material comprised five F_4 progenies developed from the cross *Pusa Samrudhi* × *DHARWAD BOTTLE GOURD - 5*, each consisting of 20 plants along with their respective parental lines. The crop was planted using a spacing of 3 × 1 meters. Observations were recorded on randomly selected plants from the F_4 generation for key growth and yield-related traits, including vine length (m), number of primary branches per vine, days to appearance of the first female flower, sex ratio, node at which the first female flower appeared, days to first fruit harvest, number of fruits per vine, yield per vine (kg), average fruit weight (g), average fruit length (cm), and fruit diameters measured at the pedicel, center, and stylar end.

The estimation of GCV, PCV, as well as GA, was carried out using the method proposed by Johnson *et al*. (1955) [7]. The coefficients of variation were computed following the approach of Burton and De Vane (1953) [4], and heritability (broad sense) was estimated as per the formula by Lush (1949) [9]. Correlation coefficients among the traits were calculated using the procedure outlined by Snedecor and Cochran (1967) [23].

Table 1: Mean, range, GCV, PCV, ECV, heritability, genetic advance and percent mean of genetic advance of two parents and F_4 population of cross Pusa Samrudhi x DHARWAD BOTTLE GOURD - 5.

Sr. No.	Character	Mean	Range	GCV (%)	PCV (%)	ECV (%)	h^2 bs (%)	GA	GAM (%)
1.	Length of vine (m)	8.85	7.45-10.48	10.87	14.42	9.47	57	1.93	21.80
2.	Number of primary branches per vine	8.01	7.33-9.00	7.80	11.20	8.04	49	1.14	14.23
3.	Days required for appearance of first female flower	54.81	52.33-57.33	3.78	4.24	1.92	79	4.79	8.74
4.	Sex ratio (M: F)	15.04	14.23-15.46	11.00	11.79	4.26	87	1.52	10.10
5.	Node at which first female flower appeared	9.23	8.66-10.33	5.68	9.01	7.00	40	0.89	9.64
6.	Days required for first harvest of fruit	66.15	60.69-71.33	3.12	4.02	2.54	60	4.33	6.46
7.	Average weight of fruit (g)	721.91	634.66-809.66	11.20	12.31	5.11	83	200.56	27.78
8.	Average length of fruit (cm)	28.53	26.03-31.50	15.58	16.67	5.94	87	11.55	40.48
9.	Fruit diameter at pedicel (cm)	5.08	4.70-5.63	13.26	17.34	11.17	59	1.43	28.14
10.	Fruit diameter at center (cm)	5.55	4.73-6.21	14.95	17.58	9.24	72	1.89	34.05
11.	Fruit diameter at stylar end (cm)	5.77	4.83-6.58	12.44	15.97	10.02	61	1.48	25.64
12.	Number of fruits per vine	18.85	16.00-25.00	23.25	26.95	13.63	74	9.40	49.86
13.	Yield per vine (kg)	14.34	12.38-18.12	16.81	20.92	12.45	65	4.93	34.37

Table 2: Genotypic and Phenotypic Correlation co-efficient for yield and yield contributing characters in F_4 generation of cross Pusa Samrudhi x DHARWAD BOTTLE GOURD - 5.

Sr. no.	Character		1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Length of vine (m)	G	1.000	0.683**	0.397	-0.499*	-0.378	0.651**	0.891**	0.858**	-0.472*	-0.655*	-0.878**	-0.374	-0.849**
		p	1.000	0.376	-0.328	-0.314	-0.104	0.155	0.625**	0.670**	-0.311	-0.31	-0.503*	-0.447*	-0.648**
2.	Number of primary branches per vine	G	-	1.000	-0.115	-0.512*	-0.3	0.671**	0.691**	0.805**	-0.152	-0.36	-0.580**	-0.138	-0.188
		P		1.000	0.246	-0.597**	-0.143	0.346	0.576**	0.467*	-0.285	-0.29	-0.484*	-0.487*	-0.36
3.	Days required for appearance of first female flower	G	-	-	1.000	0.141	0.211	0.545**	0.145	0.025	-0.086	-0.215	-0.224	-0.168	-0.558**
		P			1.000	0.03	0.293	0.495*	-0.291	-0.345	0.322	0.426*	0.27	0.266	0.498*
4.	Sex ratio (M: F)	G	-	-	-	1.000	0.878**	-0.553**	-0.817**	-0.706**	0.746**	0.886**	0.982**	0.935**	0.498*
		P				1.000	0.542**	-0.486*	-0.658**	-0.554**	0.693**	0.649**	0.769**	0.783**	0.527**
5.	Node at which first female flower appeared	G	-	-	-	-	1.000	-0.254	-0.47	-0.441	0.237	0.401*	0.670**	0.576**	0.154
		P					1.000	-0.194	-3080	-0.14	0.635**	0.602**	0.623**	0.579**	0.540**
6.	Days required for first harvest of fruit	G	-	-	-	-	-	1.000	0.453*	0.379	-0.309	-0.547**	-0.594**	-0.492*	-0.105
		P						1.000	0.32	0.197	-0.218	-0.075	-0.285	-0.217	-0.065
7.	Average weight of fruit (g)	G	-	-	-	-	-	-	1.000	0.964**	-0.630**	-0.865**	-0.910**	-0.935**	-0.854**
		P							1.000	0.907**	-0.673**	-0.584**	-0.808**	-0.738**	-0.751**
8.	Average length of fruit (cm)	G	-	-	-	-	-	-	-	1.000	0.416*	0.694**	0.910**	0.686**	0.734**
		P								1.000	0.399	0.335	0.586**	0.557**	0.567**
9.	Fruit diameter at pedicel (cm)	G	-	-	-	-	-	-	-	-	1.000	0.924**	0.790**	0.944**	0.678**
		P	-								1.000	0.940**	0.936**	0.854**	0.835**
10.	Fruit diameter at center (cm)	G	-	-	-	-	-	-	-	-	-	1.000	0.968**	0.933**	0.746**
		P	-									1.000	0.874**	0.828**	0.786**
11.	Fruit diameter at stylar end (cm)	G	-	-		-	-	-	-	-	-	-	1.000	0.905**	0.920**
		P	-										1.000	0.728**	0.901**
12.	Number of fruits per vine	G	-	-	-	-	-	-	-	-	-	-	-	1.000	1.110**
		P	-											1.000	0.820**
13.	Yield per vine (kg)	G	-	-	-	-	-	-	-	-	-	-	-	-	1.000
		P	-												1.000

S: Symbol, G: Genotypic, P: Phenotypic

*, **: Significance at 5% and 1%, respectively.

Results and Discussion

A substantial extent of variation was observed among the F_4 progenies for all recorded traits. Vine length ranged between 7.45 and 10.48 m, with considerable diversity also seen in traits such as primary branches per vine (7.33-9.00), days to first female flower (52.33-57.33), and sex ratio (14.23-15.46). The first female flower emerged between the 8.66th and 10.33rd node, while the time to first fruit harvest spanned from 60.69 to 71.33 days. Traits linked to productivity, including number of fruits per vine (16-25), fruit weight (634.66-809.66 g), and yield per vine (12.38-18.12 kg), also showed marked variability. Fruit-related dimensions like length and diameter at various positions (pedicel, center, stylar end) were also notably diverse.

Genotypic (GCV), phenotypic (PCV), and environmental (ECV) coefficients of variation demonstrated wide ranges across most parameters, with traits such as number of fruits per vine, yield per vine, and fruit length exhibiting the highest variability. In general, PCV values slightly exceeded GCVs, indicating minimal environmental interference. These patterns align with earlier findings in bottle gourd and muskmelon by researchers like Reddy (1989) [18], Pandit *et al*. (2009) [13], and Mali (2015) [10].

Heritability in the broad sense ranged from moderate to high (40-87%), suggesting that genetic improvement via selection is feasible. Traits like fruit length and fruit number per vine showed high heritability coupled with high genetic advance as a percentage of the mean, indicating that additive gene action is predominant. On the other hand, yield per vine, fruit weight, and fruit diameters exhibited moderate genetic advance with high heritability, suggesting a mix of additive and non-additive genetic effects.

Correlation analysis revealed that genotypic associations were generally stronger than phenotypic ones. Yield per vine displayed significant positive correlations with fruit length, number of fruits per vine, sex ratio, and fruit diameters, while vine length and average fruit weight had a negative influence on yield. These interrelationships offer valuable insights for selecting yield-contributing traits in breeding programs. Similar correlation trends have been reported by Kumar *et al*. (2007) [8], Gupta *et al*. (2015) [5], and others in bottle gourd and related cucurbits.

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