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Gene action for growth, yield and quality traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl]

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Introduction

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) is cucurbitaceous vegetable crop having chromosome number 2n=22. It is one of the important cucurbits in India, both as rainy and summer season vegetable. The fresh fruit has light green smooth skin and white flesh. The genus Lagenaria included six species that are distributed in Africa, Madagascar, Indo- Malaysia and the neotropics. There is only one cultivated species, *Lagenaria siceraria*, which is an annual and monoecious. The five other species are wild, perennial and dioecious, occurring in east Africa and Madagascar. Five wild species of Lagenaria exist in Africa: *L. breviflora* (Benth.), *L. abyssinica*, *L. rufa*, *L. sphaerica* and *L. guineensis*. It was also observed that *L. siceraria* germplasm is more diverse than its wild relatives viz. *L. sphaerica*, *L. abyssinica* and *L. breviflora* for qualitative and quantitative traits. The variability for various characters was found wide in Europe, India and Japan (Badade *et al.*, 2001; Saito *et al.*, 2008; Kumar *et al.*, 2011; Schlumbaum and Vandorpe, 2012). Wild species produce small round fruits with strong bitter taste (Morimoto *et al.* 2005).

Lagenaria siceraria (Mol.) Standl. commonly known as white-flowered gourd, Doodhi, Lauki (Hindi), Kadoo (Marathi) which is official in Ayurvedic Pharmacopoeia. It is one of the excellent fruit crops for human being gifted by the nature that have all of the essential constituents that are required for normal and good health (Habibur, 2003).

In India, the total area covered under bottle gourd is 0.223 million ha with production of 3.72 million tonnes and its productivity is 16.68 tonnes per ha. (Anonymous, 2023-24).

The tender fruits of bottle gourd can be used as a vegetable or for making sweets (e.g. Halva, kheer, petha and burfi), kofta and pickles. The fruit is rich in pectin also, which showed good prospects for jelly preparation, and the dried shells of mature fruits are hard and are used as containers, utensils, musical instruments or ornamental items.

The edible portion of fruit contains 96.3 per cent moisture, 2.9 per cent carbohydrates, 0.2 per cent protein, 0.1 per cent fat, 0.5 per cent mineral matter and 11 mg of vitamin C per 100 g fresh weight (Thamburaj and Singh, 2018).

The bottle gourd has lot of variation for different morphological characters like fruit bearing capacity, fruit girth, fruit length, length of main shoot, number of branchesper plant, number of seeds per fruit, seed weight, seed length, seed breadth, seed shape and seed colour (Decker-Walters *et al.*, 2004; Morimoto *et al.*, 2005; Clarke *et al.*, 2006, Achigan- Dako *et al*., 2008 and Yetisir *et al.*, 2008).

Material Method

The present research work entitled **"Heterosis, combining ability and gene action for fruit yield and quality traits in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.)"** was conducted during *Zaid* seasons of 2022-23 (Y_1) and 2023-24 (Y_2) to study the heterosis, combining ability, nature and magnitude of gene action, heritability in narrow sense and genetic advance in per cent of mean using line × tester mating design at the Main Experiment Station (MES) of the Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) India. The observations were recorded on twenty-two characters including two qualitative traits. The treatments were sown in rows spaced 3.0 meters apart with a plant to plant spacing of 0.5 meter.

The selected parental lines *i.e.*; HAU-22, Pant Lauki-3, Solan Selection-2, NDBG-63-1-1, NDBG-65-2-1, NDBG-83-1, NDBG-0-1-1, Kashi Ganga, Narendra Pooja, Narendra Rashmi, and testers NDBG-18, Narendra Kamna, Narendra Prabha were crossed in the all possible combination to get 30 F_1 seed for the study of gene action among F_1's and parents for fruit yield and quality attributing traits. Distinguishing features of the parental lines are given in (Table-1).

All the recommended agronomic package of practices and protection measures were followed to raise a good crop. Fertilizers and manures were applied as per recommended dose. Observations were recorded on all the six plants maintained carefully in each plot for twenty quantitative characters viz., Days to first staminate flower anthesis, Days to first pistillate flower anthesis, Node number to first staminate flower appearance, Node number to first pistillate flower appearance, Days to first fruit harvest, Vine length (m), Node per vine, Internodal length (cm), Number of primary branches per plant, Fruit length, Fruit circumference (cm), Fruit weight (kg), Fruit per plant, Total soluble solids (%), Ascorbic acid, Reducing sugar, Non-Reducing sugar (%), Total sugar (%), Dry matter content (%), Fruit yield per plant (kg). genetic components of variation were calculated for the analysis of numerical approach followed the method given by Jinks and Hayman (1953), Hayman (1954a).

Table-1: Details of parental lines/genotypes

S. No.	Name of Parents	Symbol	Source
1.	HAU-22	L_1	CCSHAU, Hisar

2.	Pant Lauki-3	L_2	GBPUA&T, Pant Nagar
3.	Solan Selection-2	L_3	Dr. Y. S. Parmar University of Horticulture and Forestry, Solan
4.	NDBG-63-1-1	L_4	ANDUA&T, Ayodhya
5.	NDBG-65-2-1	L_5	ANDUA&T, Ayodhya
6.	NDBG-83-1	L_6	ANDUA&T, Ayodhya
7.	NDBG-0-1-1	L_7	ANDUA&T, Ayodhya
8.	Kashi Ganga	L_8	IIVR, Varanasi
9.	Narendra Pooja	L_9	ANDUA&T, Ayodhya
10.	Narendra Rashmi	L_{10}	ANDUA&T, Ayodhya
11.	NDBG-18	T_1	ANDUA&T, Ayodhya
12.	Narendra Kamna	T_2	ANDUA&T, Ayodhya
13.	Narendra Prabha	T_3	ANDUA&T, Ayodhya

Results and Discussion

Results and Discussion The estimates of components of variation provide detailed accounts of additive and dominant components and allied statistics. The genetic progress in a population largely depends upon the relative values of these components. The diallel cross analysis through analytical method is based on a number of assumptions regarding applicability of this method as advocated by Hayman (1954). The estimates of gca and sca variances, predictability ratio and average degree of dominance had been given in Table-2.

In the year Y_1, estimates of sca variance (σ2s) were higher than gca variances (σ2g) for the trait's node number to first staminate flower appearance, node number to first pistillate flower appearance, vine length, internodal length, number of primary branches per plant, fruit length, fruit circumference, average fruit weight, number of fruit per plant, total soluble solids, ascorbic acid, reducing sugars, non-reducing sugar, total sugars, dry matter content in fruit and fruit yield per plant while, gca variance (σ2g) were higher than sca variance (σ2s) for days to first staminate flower anthesis, days to first pistillate flower anthesis, days to first fruit harvest, Node per vine main vine.

The value of sca variances were found significant and positive for node number to first staminate flower appearance, node number to first pistillate flower appearance, vine length, internodal length, number of primary branches per plant, fruit length, fruit circumference, average fruit weight, number of fruit per plant, total soluble solids, ascorbic acid, reducing sugars, non-reducing sugar, total sugars, dry matter content in fruit and fruit yield per plant while, rest of the characters were non-significant with negative value. Like, positive and significant gca variances were also exhibited by all the traits except days to first staminate flower anthesis, days to first pistillate flower anthesis, number of primary branches per plant fruit circumference and total soluble solids.

The value of average degree of dominance were more than unity (1) for node number to first staminate flower appearance (1.17), vine length (1.31), Node per vine main vine (1.17), internodal length (1.33), number of primary branches per plant (2.06), fruit circumference (2.70), average fruit weight (1.44), number of fruits per plant (1.03), total soluble solids (2.42), reducing sugars (1.18), non-reducing sugar (1.33), total sugars (1.18), dry matter content (1.18) and fruit yield per plant (1.50) which revealed over dominance. Less than unity (1) was observed for days to first staminate flower anthesis (0.31), days to first pistillate flower anthesis (0.63), node number to first pistillate flower appearance (0.99), days to first fruit harvest (0.58), fruit length (0.75) and ascorbic acid (0.95) which showed incomplete dominance. The magnitude of over dominance was highest for fruit circumference (2.70), total soluble solids (2.42), number of primary branches per plant (2.06), fruit yield per plant (1.50), average fruit weight (1.44), internodal length (1.33), non-reducing sugar (1.33), vine length (1.31), reducing sugars (1.18), total sugars (1.18), dry matter content (1.18) node number to first staminate flower appearance (1.17), Node per vine main vine (1.17) and number of fruits per plant (1.03).

The general predictability ratio was less than one for all the characters. σ2A were lower than σ2D for the characters node number to first staminate flower appearance, days to first fruit harvest, fruit length, fruit circumference and non-reducing sugar while, σ2A were higher than σ2D for the characters days to first staminate flower anthesis, node number to first pistillate flower appearance, vine length, Node per vine main vine, internodal length, number of primary branches per plant, average fruit weight, days to first, pistillate flower anthesis, number of fruits per plant, total soluble solids, ascorbic acid reducing sugars, total sugars, dry matter content in fruit and fruit yield per plant.

In the year Y_2, estimates of sca variance (σ2s) were higher than gca variances (σ2g) for the trait's days to first pistillate flower anthesis, node number to first staminate flower appearance, node number to first pistillate flower appearance, vine length, internodal length, number of primary branches per plant, fruit length, fruit circumference, average fruit weight, total soluble solids, ascorbic acid, reducing sugars, non-reducing sugar, total sugars, dry matter content in fruit and fruit yield per plant while, gca variance (σ2g) were higher than sca variance

($\sigma2s$) for days to first staminate flower anthesis, days to first fruit harvest, node per vine main vine and number of fruit per plant.

The value of sca variances were found significant and positive for node number to first staminate flower appearance, node number to first pistillate flower appearance, vine length, internodal length, number of primary branches per plant, fruit length, fruit circumference, average fruit weight, total soluble solids, ascorbic acid, reducing sugars, non-reducing sugar, total sugars, dry matter content in fruit and fruit yield per plant while, rest of the characters were non-significant with negative value. Likewise, positive and significant gca variances were also exhibited by all the traits except days to first pistillate flower anthesis, internodal length, number of primary branches per plant, fruit circumference, total soluble solids and total sugar.

The value of average degree of dominance were more than unity (1) for days to first pistillate flower anthesis (1.58), node number to first staminate flower appearance (1.19), node number to first pistillate flower appearance (1.15), vine length (1.52), Node per vine main vine (1.32), internodal length (1.86), number of primary branches per plant (2.74), fruit circumference (2.08), average fruit weight (1.37), total soluble solids (1.43), ascorbic acid (1.18), reducing sugars (1.14), total sugars (2.67), dry matter content (1.26) and fruit yield per plant (1.42) which, revealed over dominance. Less than unity (1) was observed for days to first staminate flower anthesis (0.35), days to first fruit harvest (0.65), fruit length (0.65), number of fruits per plant (0.61) and non-reducing sugar (0.61) which showed incomplete dominance.

The magnitude of over dominance was highest for number of primary branches per plant (2.74), total sugars (2.67), fruit circumference (2.08), internodal length (1.86), days to first pistillate flower anthesis (1.58), vine length (1.52), total soluble solids (1.43), fruit yield per plant (1.42), average fruit weight (1.37), Node per vine main vine (1.32), dry matter content (1.26), node number to first staminate flower appearance (1.19), ascorbic acid (1.18), node number to first pistillate flower appearance (1.15) and reducing sugars (1.14). The general predictability ratio was less than one for all the characters.

$\sigma2A$ were lower than $\sigma2D$ for the characters days to first pistillate flower anthesis, node number to first staminate flower appearance, node number to first pistillate flower appearance, vine length, internodal length, number of primary branches per plant, average fruit weight, fruit circumference, total soluble solids, ascorbic acid, reducing sugars, total sugars, dry matter content in fruit and fruit yield per plant. $\sigma2A$ were higher than $\sigma2D$ for the characters days to first staminate flower anthesis, node per vine main vine, days to first fruit harvest, number of fruits per plant, fruit length, and non-reducing sugar.

In the year pooled, estimates of sca variance (σ2s) were higher than gca variances (σ2g) for the trait's days to first pistillate flower anthesis, node number to first staminate flower appearance, node number to first pistillate flower appearance, vine length, internodal length, number of primary branches per plant, fruit length, number of fruit per plant, days to first fruit harvest, fruit circumference, average fruit weight, total soluble solids, ascorbic acid, reducing sugars, non-reducing sugar, total sugars, dry matter content in fruit and fruit yield per plant while, gca variance (σ2g) were higher than sca variance (σ2s) for days to first staminate flower anthesis and Node per vine main vine.

The value of sca variances were found significant and positive for days to first pistillate flower anthesis, node number to first staminate flower appearance, node number to first pistillate flower appearance, vine length, internodal length, number of primary branches per plant, fruit length, number of fruit per plant, days to first fruit harvest, fruit circumference, average fruit weight, total soluble solids, ascorbic acid, reducing sugars, non-reducing sugar, total sugars, dry matter content in fruit and fruit yield per plant while, rest of the characters were node per vine main vine was non-significant with negative value. Likewise, positive and significant gca variances were also exhibited by all the traits except number of primary branches per plant, fruit circumference, total soluble solids and total sugar.

The value of average degree of dominance were more than unity (1) for days to first pistillate flower anthesis (1.29), node number to first staminate flower appearance (1.20), node number to first pistillate flower appearance (1.09), vine length (1.36), internodal length (1.57), number of primary branches per plant (2.57), fruit circumference (3.38), average fruit weight (1.40), total soluble solids (1.86), reducing sugars (1.16), total sugars (1.62), dry matter content (1.18) and fruit yield per plant (1.43) which, revealed over dominance. Less than unity (1) was observed for days to first staminate flower anthesis (0.65), Node per vine main vine (0.45), fruit length (0.74), ascorbic acid (0.95), days to first fruit harvest (0.94), number of fruits per plant (0.86) and non-reducing sugar (0.76) which showed incomplete dominance.

Table-2: Components of genetic variance, average degree of dominance, predictability ratio for twenty characters in bottle gourd over two years (Y1 = 2023, Y2 = 2024) and pooled

	Parameters / Characters	gca variance ($\sigma^2 g$)			sca variance ($\sigma^2 s$)			Average degree of dominance $\sqrt{\sigma 2s/2\sigma 2g}$			Predictability ratio 2σ2g/2σ2g + σ2s			$\sigma^2 A$			$\sigma^2 D$		
S.No.		Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled	Y1	Y2	Pooled
1.	Days to first staminate flower anthesis	0.49	0.388**	0.492**	0.09	0.098	0.419 *	0.31	0.35	0.65	0.91	0.88	0.7	0.99	0.77	0.98	0.09	0.09	0.41
2.	Days to first pistillate flower anthesis	0.31	0.079	0.272*	0.24	0.3998	0.919**	0.63	1.58	1.29	0.71	0.28	0.37	0.61	0.15	0.54	0.24	0.39	0.91
3.	Node number to first staminate flower appearance	0.36 **	0.368**	0.374**	1.00 **	1.053**	1.081**	1.17	1.19	1.2	0.4s2	0.41	0.4	0.73	0.73	0.74	1.00	1.05	1.08
4.	Node number to first pistillate flower appearance	0.732**	0.648**	0.713**	1.439 **	1.741**	1.723**	0.99	1.15	1.09	0.5	0.42	0.45	1.46	1.29	1.42	1.43	1.74	1.72
5.	Days to first fruit harvest	0.399**	0.968*	0.775**	0.2768	0.8335	1.397*	0.58	0.65	0.94	0.74	0.69	0.52	0.79	1.93	1.55	0.27	0.83	1.39
6.	Vine length (m)	0.015*	0.015*	0.018*	0.052**	0.068**	0.065**	1.31	1.52	1.36	0.36	0.3	0.34	0.02	0.02	0.03	0.05	0.06	0.06
7.	Node per vine	0.57**	0.632**	0.946**	-3.04	-2.202	-0.391	1.17	1.32	0.45	-0.6	-1.34	1.26	1.15	1.26	1.89	-3.04	-2.20	-0.39
8.	Internodal length (cm)	0.058*	0.039	0.055*	0.207**	0.275**	0.272**	1.33	1.86	1.57	0.35	0.22	0.28	0.11	0.07	0.11	0.20	0.27	0.27
9.	Number of primary branches per plant	0.226	0.065	0.094	1.925**	0.978**	1.251**	2.06	2.74	2.57	0.19	0.11	0.13	0.45	0.12	0.18	1.92	0.97	1.25
10.	Fruit length (cm)	5.541**	5.594**	5.651**	6.362**	4.769**	6.22**	0.75	0.65	0.74	0.63	0.7	0.64	11.08	11.18	11.3	6.36	4.76	6.22
11.	Fruit circumference (cm)	0.173	0.18	0.1971	2.5451 **	1.5801**	2.2556**	2.7	2.08	3.38	0.12	0.18	0.14	0.34	0.36	0.39	2.54	1.58	2.25
12.	Average fruit weight (kg)	0.003 *	0.003 *	0.003 *	0.014**	0.010**	0.012**	1.44	1.37	1.4	0.32	0.34	0.33	0	0	0	0.01	0.01	0.01
13.	Number of fruits per plant	0.058**	0.040**	0.049**	0.124**	0.0304	0.074**	1.03	0.61	0.86	0.48	0.72	0.57	0.11	0.08	0.09	0.12	0.03	0.07
14.	Total soluble solids (ºB)	0.009	0.023	0.014	0.102**	0.094**	0.094**	2.42	1.43	1.86	0.14	0.32	0.22	0.01	0.04	0.02	0.10	0.09	0.09
15.	Ascorbic acid (mg/100g)	0.075**	0.043*	0.058**	0.135**	0.119**	0.107**	0.95	1.18	0.95	0.52	0.41	0.52	0.14	0.08	0.11	0.13	0.11	0.10
16.	Reducing sugars (%)	0.021**	0.013*	0.017**	0.059**	0.035**	0.045**	1.18	1.14	1.16	0.41	0.43	0.42	0.04	0.02	0.03	0.05	0.03	0.04
17.	Non-reducing sugar (%)	0.002*	0.007**	0.004**	0.007**	0.005**	0.004**	1.33	0.61	0.76	0.36	0.72	0.63	0	0.01	0	0.00	0.00	0.00
18.	Total sugars (%)	0.021**	0.0035	0.01	0.059**	0.049**	0.053**	1.18	2.67	1.62	0.41	0.12	0.27	0.04	0	0.02	0.05	0.04	0.05
19.	Dry matter content in fruit (g/100g)	0.069**	0.062**	0.064**	0.192**	0.198**	0.179**	1.18	1.26	1.18	0.41	0.38	0.41	0.13	0.12	0.12	0.19	0.19	0.17
20	Fruit yield per plant (kg)	0.063*	0.095*	0.0783*	0.283**	0.382**	0.321**	1.5	1.42	1.43	0.3	0.33	0.32	0.063*	0.095*	0.12	0.18	0.15	0.28

The magnitude of over dominance was highest for fruit circumference (3.38), number of primary branches per plant (2.57), total soluble solids (1.86), total sugars (1.62), internodal length (1.57), fruit yield per plant (1.43) average fruit weight (1.40), vine length (1.36), days to first pistillate flower anthesis (1.29), node number to first staminate flower appearance (1.20), node dry matter content (1.18), reducing sugars (1.16) and node number to first pistillate flower appearance (1.09). The general predictability ratio was less than one for all the characters except node per vine main vine (1.26).

σ2A were lower than σ2D for the characters days to first pistillate flower anthesis, node number to first staminate flower appearance, node number to first pistillate flower appearance, vine length, internodal length, number of primary branches per plant, fruit circumference, average fruit weight, total soluble solids, reducing sugars, non-reducing sugar, total sugars, dry matter content in fruit and fruit yield per plant. σ2A were higher than σ2D for the characters days to first staminate flower anthesis, Node per vine main vine, days to first fruit harvest, ascorbic acid, number of fruits per plant and fruit length. The result of present study suggested preponderance of dominance genes in the expression of most of the component traits studied. Therefore, heterosis breeding approach might be advantageous rather than selection to develop superior hybrids for high fruit yield in bottle gourd.

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