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Genetic variability studies for yield and yield attributing traits in F_2 generation of bottle gourd (*Lagenaria siceraria* (Mol.) Standl.)

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Abstract

The present investigation was carried out to estimate phenotypic and genotypic coefficients of variation, heritability (broad sense) and genetic advance as percent of mean in F_2 generation for twelve characters in four promising crosses of bottle gourd. Among the crosses studied, cross 3 (Pusa Sandesh x Arka Bahar), cross 2 (Pusa Naveen x Pusa Santhusti) and cross 1 (Pusa Naveen x Local Round) exhibited superior per se performance for almost all the yield contributing characters. The estimates of PCV was significantly higher than GCV for all the traits in all the cross combinations. The difference between the phenotypic coefficient of variation and genotypic coefficient of variation was found to be more for vine length, number of nodes per vine, number of branches per vine, number of fruits per vine, average fruit weight and fruit yield thus indicating that the variation was not only due to genotypes but also due to environmental influence. Moderate to high heritability coupled with high genetic advance observed in all the crosses for fruit yield per vine indicating preponderance of additive gene action governing the inheritance of this character and offers the best possibility of improvement through simple selection procedure. Moderate to high heritability coupled with moderate to high genetic advance as percentage of mean indicates the action of both additive and non-additive genes as in case of number of nodes per vine, number of branches per plant, internodal length, node at which first male flower appeared, node at which first female flower appeared, number of fruits per vine, average fruit weight and TSS content. Hence, direct selection has limited scope for further improvement of these traits.

Keywords: Variability, GCV, PCV, genetic advance as percentage of mean, heritability and bottle gourd

Introduction

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is an important cucurbitaceous vegetable having wide range of uses and is largely cultivated in the tropics and subtropics for its edible fruits. It is also known as calabash gourd, trumpet gourd, white flowered gourd and zucca melon. Bottle gourd is one of the largest produced cucurbit vegetables in the world having chromosome number of 2n = 22. It is a monoecious and cross pollinated crop in which large amount of variation has been observed for many economically important traits. Genetic variability present in the population is inevitable for the selection process. The heritable variations could be divided into additive and non-additive components. The heritable variations are also divided into dominant and inter-allelic interaction (Falconer, 1981) [9]. The broad sense heritability is the ratio of genotypic variance to the total variance in the non-segregating population. The genotypic variance includes non-additive components which are not transmitted to the next generation. Hence high heritability coupled with high genetic advance was reported to be more useful in practicing selection in a population (Johnson *et al*., 1955) [13].

Material and Methods

The study was carried out at College of Horticulture, Dr. Y. S. R. Horticultural University, Venkataramannagudem, West Godavari district, India during Summer, 2020 and Kharif, 2020. The experiment material consisted of four crosses (cross 1 - Pusa Naveen x Local Round, cross 2 - Pusa Naveen x Santhusti, cross 3 - Pusa Sandesh x Punjab Bahar and cross 4 - Pusa Sandesh x Arka Bahar) involving six diverse parents which were grown in completely randomized block design. Seeds were sown at a spacing of 3m between rows and 0.9 m between the plants.

The observations were recorded for vine length, internodal length, number of nodes per vine, number of branches per plant, node at which first male flower appeared, node at which first female flower appeared, days to first fruit harvest, days to last fruit harvest, number of fruits per vine, average fruit weight, fruit yield per vine and total soluble solids (TSS). The data recorded were statistically analyzed for genotypic coefficient of variation and phenotypic coefficient of variation according to Burton and Devane (1953) [5]. Heritability in broad sense was estimated as per the formulae suggested by Allard (1960) [3] and Genetic advance was estimated as per the formula proposed by Lush (1940) [19] and Johnson *et al*. (1955) [13].

Results and Discussion

The extent of variability present in the four crosses of bottle gourd in F2 generation were measured in terms of phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability and genetic advance as percentage over mean are given in Table 1. Considerable amount of variability was observed for all the characters under study and this proves that there is ample scope for selection in the subsequent generations. Segregation and recombination are found maximum in the F2 generation; therefore, it is the ideal generation for imposing selection.

In the case of vine length, the cross 2 i.e., Pusa Naveen x Pusa santhusti (11.60 and 10.88) exhibited moderate PCV and GCV which indicates improvement of this trait is possible up to certain extent in this cross and for other crosses *viz*., cross 1 (10.34 and 8.50), cross 3 (10.88 and 8.90) and cross 4 (10.77 and 7.74) this trait exhibited moderate PCV and low GCV. High heritability coupled with moderate genetic advance as percent of mean in majority of the crosses for this trait revealed that direct selection has scope but to a limited extent for improving this trait. These results are in agreement with the findings of Ahmad *et al*. (2019) [1] in bottle gourd; Ramesh *et al*. (2018) [22] and Harshitha *et al*. (2019) [11] in ridge gourd; Krishnamurthy and Avinashgupta (2019) [16] in pumpkin; Kumar *et al*. (2019) [1] in sponge gourd; Anburani *et al*. (2019) [4] in water melon.

For internodal length low estimates of PCV and GCV were recorded in three crosses *viz*., cross 1 (9.10 and 7.76), cross 2 (5.23 and 4.77) and cross 3 (5.23 and 4.84) indicating the presence of less genetic variability among the crosses and less scope for selection based on this trait. High heritability coupled with moderate to low range of GAM in all the crosses this trait. These results are in accordance with the findings of Deepthi *et al*. (2016) and Deepa *et al*. (2018) [8, 7] in bottle gourd; Pradhan *et al*. (2018) [21] in cucumber; Harshitha *et al*. (2019) [11] in ridge gourd and Sultana *et al*. (2015) [28] in pumpkin.

The moderate estimates of PCV and GCV for number of nodes per vine and number of branches per plant observed in majority of the crosses. High to moderate heritability coupled with moderate GAM in all the crosses for number of nodes per vine while for number of branches per plant high to moderate heritability coupled with high to moderate range of GAM recorded in all the crosses, indicates the action of both additive and non-additive genes in inheritance of both the traits. These outcomes are in accordance with the findings of Harshitha *et al*. (2019) [11] in ridge gourd and in contrast to the findings of Rana and Pandit (2011) [23] in snake gourd.

In respect to node which at first male flower appeared, three crosses showed moderate PCV and low GCV estimates i.e., cross 2 (10.95 and 9.23), cross 3 (10.44 and 9.98) and cross 4 (10.55 and 9.55), while cross 1 (13.11 and 12.12) showed moderate PCV and GCV. High heritability coupled with high to moderate range of genetic advance as percent of mean was observed in all the crosses indicating the predominance of additive gene action in the inheritance of this trait. Similar results are reported by Kandasamy *et al*. (2019) [14] and Rashid *et al*. (2020) [25] in bottle gourd; Gautham Suresh and Balamohan (2018) [10] and Ramesh *et al*. (2018) [22] in ridge gourd.

For the trait, node at which first female flower appeared moderate range of PCV and GCV were observed in all the crosses *viz*., cross 1 (12.54 and 11.69), cross 2 (11.14 and 10.76), cross 3 (12.54 and 11.21) and cross 4 (12.86 and 12.05). The difference between PCV and GCV value was less which indicated that there was limited role of environmental component. The high heritability estimates coupled with high genetic advance recorded in most of the crosses indicating the predominance of additive gene action in the inheritance of this trait. Similar results were reported by Rani *et al*. (2017) [24], Deepa *et al*. (2018) [7], Ahmad *et al*. (2019) [1], Kandasamy *et al*. (2019) [14] and Rashid *et al*. (2020) [25] in bottle gourd; Gautham Suresh and Balamohan (2018) [10] and Ramesh *et al*. (2018) [22] in ridge gourd; Janghel *et al*. (2018) [12] in musk melon.

Low estimates of PCV and GCV recorded for days to first fruit harvest and days to last fruit harvest indicates presence of less genetic variability among the crosses and thus less scope for selection of these traits. Moderate heritability coupled with low genetic advance for days to first fruit harvest while high heritability along with low genetic advance observed in majority of the crosses for days to last fruit harvest indicating high environmental influence on this trait. The results are in accordance with Rashid *et al*. (2020) [25] in bottle gourd; Koppad *et al*. (2015) [15], Harshitha *et al*. (2019) [11] and Ramesh *et al*. (2018) [22] in ridge gourd and Reshmi and Sreelathakumary (2017) [26] and Alekar *et al*. (2019) [2] in bitter gourd.

Moderate PCV and low GCV were found in all crosses for average fruit weight except cross 1 (14.80 and 12.00) and cross 2 (12.93 and 10.08) showed moderate PCV and GCV estimates. High heritability coupled with moderate genetic advance as percentage of mean was recorded by all crosses except cross 2, which exhibited moderate heritability and genetic advance as percentage of mean indicating the role of both additive and non-additive genes in governing these traits. These results were supported by Rani *et al*. (2017) [24] and Ahmad *et al*. (2019) [1] in bottle gourd; Koppad *et al*. (2015) [15] and Harshitha *et al*. (2019) [11] in ridge gourd; Kumar *et al*. (2013) [17] in sponge gourd; Rana and Pandit (2011) [23] in snake gourd.

In respect of number of fruits per vine, all the crosses exhibited moderate PCV and GCV, except cross 1 (32.66, 24.32) which showed high PCV and GCV values. So, this character is amenable for selection. High to low range of heritability coupled with high to moderate range of genetic advance as percentage of mean was recorded. This was in line with the earlier findings of Deepa *et al*. (2018) [7] and Ahmad *et al*. (2019) [1] in bottle gourd; Gautham Suresh and Balamohan (2018) [10] and Ramesh *et al*. (2018) [22] in ridge gourd; Kandasamy *et al*. (2019) [14] in bitter gourd; Kumar *et al*. (2013) [17] in sponge gourd; Janghel *et al*. (2018) [12] in musk melon; Pradhan *et al*. (2018) [21] in cucumber; Sultana *et al*. (2015) [28] and Krishnamurthy and Avinashgupta (2019) [16] in pumpkin.

Fruit yield per vine manifested high estimates of PCV and

GCV (> 20%) in all the crosses except cross 4 (18.81 and 15.57) which showed moderate PCV and GCV indicating the existence of wide range of genetic variability among the crosses for this trait. There is a good scope for the further improvement of these characters through selection. High to moderate range of heritability in conjunction with high GAM was observed for this trait which indicates the preponderance of additive gene action governing the inheritance of this character and offers the best possibility of improvement through simple selection procedure. These results are in accordance with the conclusions of Deepthi *et al*. (2016), Rani *et al*. (2017) [8, 24], Deepa *et al*. (2018) [7] and Kandasamy *et al*. (2019) [14] in bottle gourd; Gautham Suresh and Balamohan (2018) [10] and Ramesh *et al*. (2018) [22] in ridge gourd; Alekar *et al*. (2019) [2] in bitter gourd; Kumar *et al*. (2013) [17] in sponge gourd and Pradhan *et al*. (2018) [21] in cucumber.

For TSS content all the crosses i.e., cross 1 (12.36 and 11.07), cross 2 (12.50 and 10.73), cross 3 (16.60 and 15.65) and cross 4 (11.67 and 11.23) exhibited moderate PCV and GCV estimates. High heritability accompanied with high genetic advance as percent of mean observed in majority of the crosses indicates high degree of additive gene effect implies less control by environment on the trait. Similar results were reported by Damor *et al*. (2016) [6] and Deepa *et al*. (2018) [7] in bottle gourd; Rasmi and Sreelathakumary (2017) [26] in bitter gourd; Kumar *et al*. (2013) [17] in sponge gourd; Rukam *et al*. (2008) [27] and Mehta *et al*. (2009) [20] in musk melon.

Table 1: Estimates of genetic parameters of different characters in f2 populations of bottle gourd

S. No.	Cross/Character	Mean	Range		Coefficient		Heritability (%)	Genetic advance	GA as % of mean
			Minimum	Maximum	PCV (%)	GCV (%)			
1	Vine length (m)								
	Cross 1	8.99	5.90	13.80	10.34	8.50	67.61	0.90	14.40
	Cross 2	7.29	5.76	10.28	11.60	10.88	26.93	1.60	21.01
	Cross 3	6.99	4.14	9.93	10.88	8.90	72.21	1.10	16.19
	Cross 4	7.26	6.51	12.59	10.77	7.74	80.00	1.20	16.11
2	Inter-nodal length (cm)								
	Cross 1	12.90	9.68	14.80	9.10	7.76	72.82	1.80	13.65
	Cross 2	11.97	10.35	12.01	5.23	4.77	83.16	1.10	8.96
	Cross 3	12.77	11.04	13.73	5.23	4.84	85.34	1.20	9.20
	Cross 4	12.62	9.00	14.31	10.42	9.37	80.91	2.20	17.36
3	Number of nodes per vine								
	Cross 1	66.72	44.20	84.11	14.03	10.69	58.01	11.20	16.77
	Cross 2	60.00	48.69	80.34	11.20	9.28	68.60	9.50	15.83
	Cross 3	54.48	32.66	69.67	14.69	9.95	45.90	7.60	13.89
	Cross 4	57.10	38.73	73.11	11.27	10.50	71.14	9.30	16.51
4	Number of branches per plant								
	Cross 1	29.83	22.81	42.40	19.28	15.32	57.08	7.10	23.84
	Cross 2	27.07	17.36	37.00	17.21	13.48	61.33	5.90	21.74
	Cross 3	23.95	15.00	31.00	17.85	12.20	46.71	4.10	17.18
	Cross 4	28.93	20.67	39.76	11.78	10.49	79.31	5.50	20.24

Table 1. Cont...

S. No.	Cross/Character	Mean	Range		Coefficient		Heritability (%)	Genetic advance	GA as % of mean
			Minimum	Maximum	PCV (%)	GCV (%)			
5	Node number at which first male flower appeared								
	Cross 1	16.50	12.00	22.00	13.11	12.12	85.42	3.90	23.07
	Cross 2	13.82	10.00	16.00	10.95	9.23	71.05	2.30	16.03
	Cross 3	13.72	11.00	15.68	10.44	9.98	91.46	2.70	19.66
	Cross 4	14.00	11.08	17.17	10.55	9.55	81.96	2.50	17.81
6	Node number at which first female flower appeared								
	Cross 1	19.75	14.80	25.55	12.54	11.69	86.92	4.40	22.46
	Cross 2	16.90	13.00	20.00	11.14	10.76	76.75	3.00	17.61
	Cross 3	15.15	13.88	18.00	12.54	11.21	80.03	3.10	20.67
	Cross 4	17.08	12.98	22.00	12.86	12.05	87.82	4.00	23.27
7	Days to first fruit harvest								
	Cross 1	64.78	57.88	70.00	4.81	3.45	51.47	3.30	5.10
	Cross 2	62.93	53.08	69.07	5.46	4.56	69.62	5.00	6.69
	Cross 3	62.66	48.06	71.85	5.50	3.99	52.80	3.70	5.98
	Cross 4	62.58	51.00	73.00	6.49	4.18	41.39	3.40	5.54
8	Days to last fruit harvest								
	Cross 1	118.50	105.00	130.00	4.07	3.63	79.55	7.90	6.67
	Cross 2	121.12	106.00	134.80	2.81	2.26	64.40	4.50	3.73
	Cross 3	117.52	111.87	123.89	2.51	2.15	73.58	4.87	3.80
	Cross 4	136.68	108.00	133.75	2.94	2.25	58.73	4.40	3.56

Table 1. Cont...

S. No.	Cross/Character	Mean	Range		Coefficient		Heritability (%)	Genetic advance	GA as % of mean
			Minimum	Maximum	PCV (%)	GCV (%)			
9	Average fruit weight (g)								
	Cross 1	1101.50	760.00	1500.00	14.80	12.00	65.72	284.40	19.04
	Cross 2	1297.00	980.00	1700.00	12.93	10.08	49.40	167.50	13.15
	Cross 3	1102.67	812.60	1452.00	10.62	8.67	66.65	160.00	14.58
	Cross 4	1308.50	1070.97	1802.13	10.00	8.94	79.87	215.30	16.45
10	Number of fruits per vine								
	Cross 1	8.85	4.00	13.00	32.66	24.32	55.49	3.30	37.33
	Cross 2	8.50	6.13	12.25	16.90	16.02	89.73	2.70	31.25
	Cross 3	8.43	4.00	11.00	19.90	11.81	29.51	1.00	12.10
	Cross 4	9.43	5.20	13.42	21.22	17.21	65.77	2.70	28.75
11	Fruit yield per vine								
	Cross 1	9.08	4.70	13.25	29.20	22.52	60.47	2.90	35.78
	Cross 2	10.00	4.00	14.70	27.39	24.35	79.00	4.40	44.58
	Cross 3	7.90	3.40	11.00	26.70	20.37	52.62	2.30	28.94
	Cross 4	11.21	4.90	13.70	18.81	15.57	68.47	3.10	26.53
12	Total soluble solids (ºBrix)								
	Cross 1	4.32	2.36	4.34	12.36	11.07	80.16	0.70	20.42
	Cross 2	3.20	2.51	4.20	12.50	10.73	73.76	0.60	18.99
	Cross 3	3.30	2.10	4.30	16.60	15.65	88.93	1.00	30.41
	Cross 4	2.92	2.00	3.80	11.67	11.23	92.54	0.60	22.25

Where, Cross 1 = Pusa Naveen x Local Round, Cross 2 = Pusa Naveen x Pusa Santhusti, Cross 3 = Pusa Sandesh x Punjab Bahar, Cross 4 = Pusa Sandesh x Arka Bahar.

Conclusion

In the present study, high PCV and GCV with moderate to high heritability and high genetic advance were observed in all the crosses for fruit yield per vine. The moderate estimates of PCV and GCV along with moderate to high heritability and moderate to high genetic advance were observed for vine length, number of nodes per vine, number of branches per plant, node at which first male flower appeared, node at which first female flower appeared, average fruit weight and TSS content. Characters with high PCV and GCV indicate maximum amount of variability in them and can be used in further crop improvement programme. Evaluation of promising crosses over generations and locations should be done, so that they can achieve homozygosity and can be recommended for commercial cultivation. The cross 2 (Pusa Naveen x Pusa Santhusti) and cross 4 (Pusa Sandesh x Arka Bahar) showed higher yield and high heritability for most characters under study and can be summated that these two crosses are promising in providing better source population for exercising selection.

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