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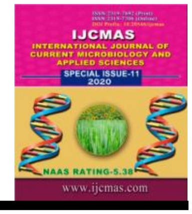

Original Research Article

Estimation of Heterosis and Combing Ability for Earliness and Yield Traits in Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl.]

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A B S T R A C T

Heterosis and combining ability studies carried out through diallel method using twelve parents with nine characters. The analysis revealed that P-1 was found good general combiner for all the characters consistently, however parent P-3, P-5, P-7, P-11 and P-12 were best general combiners for yield and flowering traits. The *gca* variances were higher than the *sca* variance for days to first male flowering, days to first female flowering, node at which first female flower appears, number of fruits per plant, fruit length fruit breadth and yield per plant. While average fruit weight had *gca* variances lower than the *sca* variances indicating the predominance of non-additive gene effects. The maximum heterosis for node at which first female flower appears was exhibited by P-3xP-7. The selection should be made for improvement of traits like days to first male female flowering, days to first male female flowering, fruit width. While node at which first female flower appears, number of fruits per plant, average fruit weight, fruit lengthand yield per plant may be improved through hybridization.

Introduction

India is blessed with a rich diversity of cucurbitaceous vegetables and is believed to be the primary and secondary centers of origin of many of them (Choudhari 1996). Among the cucurbits, bottle gourd belongs to the genus Lagenaria that is derived from "lagena", meaning bottle. The word *siceraria* means drinking vassals. In the old literature it is often referred as *Lagenaria* vulgaris (common) or *Lagenaria leucantha* (white flowered) but it is now generally agreed that the correct name of bottle gourd is [*Lagenaria siceraria* (Mol.) Standl.] with 2n=2x=22 chromosome number. The centre of origin has been located as the coastal areas of Malabar (North Kerala) and the humid forests of Dehradun (North India). It has spread to western countries from India and Africa. The tender fruits of bottle gourd can be used as a vegetable and sweets (eg. halva, kheer, petha and burfi) and pickles. A decoction made from the leaf is a very good medicine for jaundice. The fruit has cooling effect; it is a cardio tonic and diuretic. The pulp is good for overcoming constipation, cough, night blindness and as an antidote against of certain poisons. The tender fruit of bottle gourd is good for people suffering from biliousness, indigestion and convalescence. The plant extract is used as a cathartic and seeds are used in dropsy. The fruit is also known to have a good source of essential amino acids i.e. leucine, phenyl alanine, threonine, cystine, valine, aspartic acid and proline, along with a good source of vitamin B complex, especially thiamine, riboflavin and niacin. The mineral matter reported to be present in fair amount of calcium, phosphorus, iron, potassium, sodium and iodine.

The fruit is rich in pectin which showed good prospects for jelly preparation. The benefit of hybrid breeding for quality traits has not been exploited in bottle gourd. A knowledge of general combining ability (gca) and specific combining ability (sca) helps to make choice of the parents of hybrid and to know the nature of gene action as a basis of choosing an effective breeding methodology. The present investigation therefore was undertaken to identify potential parental combinations in order to have superior hybrids. Therefore, bottle gourd as vegetable is becoming important ingredient in daily diet, but relatively little attention has been paid towards development of hybrids/varieties rich in carotenoids with high yielding capacity. Although there are reports of high heterosis to the extent of 181.5 % and 97.52 % for yield and 70% for more number of female flowers, 68.7% for fruit weight and 150% for number of fruits (Mohanty and Mishra; 1999). The benefit of hybrid breeding for flowering behaviors and yield has not been exploited in bottle gourd. A knowledge of general combining ability (gca) and specific combining ability (sca) helps to make choice of the parents of hybrid and to know the nature of gene action as a basis of choosing an effective breeding methodology. The present investigation therefore was undertaken to identify potential parental combinations in order to have superior hybrids.

Materials and Methods

Twelve divers bottle gourd inbred viz, ABG-1 (P-1), Rajendra Chamatakar (P-2), VRBG-7 (P-3), VRBG-136 (P-4), Narendra Rashmi (P-5), NDBG-619 (P-6), Narendra Dharidar (P-7), Kalyanpur Long Green (P8), Kashi Ganga (P-9), NDBG-132 (P-10), Pant Lauki1 (P-11) and VRBG-6 (P-12) were selected and crossed with all possible combinations (66 F1) excluding reciprocals. The $F1^s$ and parents evaluated under complete randomized block design, which was replicated three times at research form of ICAR-Indian Institute of Vegetable Research, Varanasi during 2013 and 2014.

In each row seeds were sown keeping row to row and plant to plant spacing 4m x 70cm, respectively and managed as reported previously (De *et al.,* 2004). Observation were recorded on seven competitive plant in each parent and F1's from each replication selected at randomly for days to first male flowering, days to first female flowering, node at which first female flower appears, number of fruits per plant, average fruit weight (kg), fruit length (cm), fruit width (cm) and yield per plant (kg). The combining ability variances and their effects were worked out according to Griffing (1956, b) and heterosis was worked out over better parent.

Results and Discussion

Highly significant variances were observed for both general and specific combining ability for all the characters under study. Findings indicated that parents and crosses differed significantly with regard to their general and specific combining ability, respectively. The *gca* variances were higher than the *sca* variance for days to first male flowering, days to first female flowering, node at which first female flower appears, number of fruits per plant, fruit length fruit breadth and yield per plant. This indicated the limited scope of heterosis breeding for these characters and population improvement through recurrent selection should be adopted for exploiting the genetic variations (Kushwaha and Ram, 1996; Jha *et al.,* 2009, Singh *et al.,* (2012a). While, the gca variances was lower than the sca variance for average fruit weight may be improved through hybridization (heterosis) as indicating the predominance of non-additive gene effects (Table-1).

The information regarding gca effect of the parent is of prime importance as it is difficult to pickup good general combiner for all the characters. Finding revealed that P-3, P-5, P-7, P11 and P-12 were best general combiners for yield and flowering traits on the basis of per se performance and significant gca effects (Table 2). On the basis of per se performance and significant gca effects, P-11 was good general combiner for days to first male flowering and yield per plant.P-7 was found good general combiner for days to first female flowering. Based on *per se* performance and gca effects P-1 was the good general combiner for node at which first female flower appears and average fruit weight. Whereas, P-8 and P-2 were found good general combiner for fruit length and fruit width, respectively (Table 3). Similar findings were reported by Kumar *et al.,* (2014; Jha *et al.,* 2016).

Among 66 crosses, the P-2 x P-7 was best specific combiner for node at which first female flower appears, number of fruits per plant and yield per plant. P-1 x P-12 for days to first male flowering, P-4 x P-5 for days to first female flowering, P-8 x P-9 for average fruit weight, P-8 x P-10 for fruit length and P-1 x P-10 was found good specific combiner for fruit width when considered on the basis of per se performance and sca effects (Table 4). Similar findings were reported by Jankiram and Sirohi, (1991), Vegad *et al.,* (2011) and Jha *et al.,* (2016).

Significant heterosis over better parent was revealed in order to magnitude by node at which first female flower appears (-46.15%)followed by yield per plant (23.25%),number of fruits per plant (19.90%), days to first female flowering (-17.93%), fruit length (17.06%), days to first male flowering (-16.15%), average fruit weight (15.40%) and fruit width (6.38%). The results also conformity with those obtained by Pal *et al.,* (2005), Singh *et al.,* (2012b) and Jha *et al.,* (2009 & 2016). The high heterosis response observed in most of the hybrid further supported the predominant role of non-additive component in the inheritance of the character studied.

The top three crosses selected separately on the basis of high sca effects and heterosis over better parents are presented in table 4. Some of the cross combination were observed superior with respect to sca effects and heterosis. The parent viz., P-1, P-2, P-3, P-7 and P-11 may be used for hybridization for exploitation of heterosis over better parent.

The cross combinations P-1 x P-12, P-3 xP-7, P-4 x P-7 and P-11 x P-12 would be tested further for yield and yield contributing traits along with flowering traits which may be utilized under different agro-climatic conditions for commercial exploitations of hybrid vigour. On the basis of above findings it can be concluded that improvement in bottle gourd for yield contributing traits and flowering behaviours would be brought out through recurrent selection and hybridization.

Table.1 Analysis of variance for combining ability for nine characters

Source of Variance	df	Days to first male flowering	Days to first female flowering	Node at which first female flower appears	Number of fruits per plant	Average fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Yield per plant (kg)
gca	11	15.07 **	17.33 **	7.26 **	0.66 **	3781.87 **	19.01 **	0.17 **	0.51 **
sca	66	4.43 **	6.69 **	7.03 **	0.26 **	5164.72 **	5.74 **	0.07 **	0.417 **
Error	154	0.56	0.67	1.05	0.02	1217.73	0.85	0.03	0.09

*,**, Significant at 5 and 1 percent level of probability, respectively.

Table.2 Estimate of general combining ability (GCA) effects of parents in diallel population for nine characters

Parents	Days to first male flowering	Days to first female flowering	Node at which first female flower appears	Days to 1st harvesting	Number of fruits per plant	Average fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Yield per plant (kg)
	1	2	3	4	5	6	7	8	9
P_{-1}	2.50 **	3.27 **	-0.88 **	3.10**	-0.36 **	23.92 **	-1.67**	0.25 **	0.79 **
P_{-2}	0.21	0.29	0.47	0.10	0.10 *	3.44	-0.87**	0.07	0.54 **
P_{-3}	-0.62 **	-0.33	0.28	-0.24	0.37 **	-5.87	1.13**	0.10 *	0.99 **
P_{-4}	0.21	-0.19	-1.72 **	-0.33	0.07	-26.80 **	-0.09	-0.06	-0.23 **
P_{-5}	0.43 *	-0.50 *	0.68 *	-0.86 **	0.24 **	18.22 *	0.02	0.06	-0.35 **
P_{-6}	-0.14	-0.45 *	-0.45	-0.24	0.22 **	-7.25	0.08	-0.04	-0.65 **
P_{-7}	-0.21	-0.54 *	0.17	-0.81 **	0.04	-17.97 *	2.08 **	-0.17 **	0.09 *
P_{-8}	0.41 *	0.17	0.02	0.17	-0.24 **	3.11	1.30 **	-0.05	-0.25 **
P_{-9}	-0.12	-0.12	-0.19	-0.43 *	0.00	-10.16	-0.35	-0.12 *	-0.74 **
P_{-10}	0.24	-0.21	0.40	0.10	-0.07	22.70 *	0.44	0.02	-1.24 **
P_{-11}	-1.00**	-0.02	0.55 *	0.48 *	-0.12 **	-13.78	-0.16	-0.02	0.67 **
P_{-12}	-1.91**	-1.38**	0.69 **	-1.02**	-0.25 **	10.45	-1.93 **	-0.03	0.37 **
SE(Gi)	0.192	0.210	0.26	0.212	0.039	8.929	0.235	0.045	0.077
SE(GIGJ)	0.700	0.309	0.397	0.313	0.057	13.189	0.348	0.066	0.114

*,**, Significant at 5 and 1 percent level of probability, respectively.

Table.3 Ranking of three desirable parents on the basis of per se performance and gca effects for nine characters

Characters	Desirable parents according to *per se* performance	Good general combiners	Best parents based on *per se* performance and *gca*effects
Days to first male flowering	P-7 P-11 P-10	P-12 P-11 P-3	P-11
Days to first female flowering	P-7 P-11 P-3	P-12 P-7 P-5	P-7
Node at which first female flower appears	P-1 P-7 P-5	P-4 P-1 P-9	P-1
Number of fruits per plant	P-5 P-6 P-9	P-3 P-5 P-6	P-5 P-6
Average fruit weight (g)	P-2 P-8 P-6	P-1 P-10 P-5	P-1 P-10
Fruit length (cm)	P-8 P-2 P-4	P-7 P-8 P-3	P-8
Fruit width (cm)	P-6 P-2 P-8	P-1 P-3 P-2	P-2
Yield per plant (kg)	P-6 P-8 P-9	P-3 P-9 P-11	P-11

Table.4 Top three hybrids selected separately on the basis of heterosis over better parent and SCA effects

Characters	Best three crosses based on heterosis	Heterosis %	Best three crosses based on SCA	SCA ettects
Days to first male flowering	P-2 x P-12 P-1 x P-7 P-5 x P-11	-16.15 ** -13.99** -12.12**	P-1 x P-12 P-4 x P-11 P-1 x P-5	-4.46** -3.25** -3.13**
Days to first female flowering	P-11 x P-12 P-7 x P-10 P-7 x P-12	-17.93** -12.95** -12.95**	P-4 x P-5 P-10 x P-12 P-6 x P-10	-4.70** -4.29** -4.27**
Node at which first female flower appears	P-3 x P-7 P-4 x P-7 P-1 x P-7	-46.15** -36.92** -35.38**	P-2 x P-7 P-7 x P-12 P-1 x P-3	-6.42** -5.02** -.355**
Number of fruits per plant	P-4 x P-7 P-1 x P-4 P-11 x P-12	19.90** 13.16** 11.79**	P-2 x P-7 P-5 x P-8 P-3 x P-7	0.97** 0.86** 0.80**
Average fruit weight (g)	P-3 x P-11 P-6 x P-11 P-3 x P-7	15.40** 10.14** 7.76	P-8 x P-9 P-11 x P-12 P-2 x P-10	115.56** 114.36** 89.26**
Fruit length (cm)	P-7 x P-8 P-1 x P-8 P-7 x P-11	17.06** 16.40** 13.24**	P-8 x P-10 P-6 x P-8 P-6 x P-11	4.50** 3.75** 3.64**
Fruit width (cm)	P-6 x P-7 P-2 x P-10 P-4 x P-5	6.38 6.05 5.60	P-1 x P-10 P-3 x P-5 P-3 x P-9	0.64** 0.43** 0.29**
Yield per plant (kg)	P-1 x P-6 P-3 x P-7 P-1 x P-4	23.25** 16.39* 14.69	P-2 x P-7 P-2 x P-11 P-11 x P-12	1.09** 0.94** 0.83**

*, **, Significant at 5 and 1 percent level of probability, respectively.

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