HortFlora Research Spectrum www.hortflorajournal.com
Vol. 5, Issue 3; 213-217 (September 2016) **ISSN: 2250-2823**

GENETICS OF YIELD AND ITS COMPONENT IN ASH GOURD {*Benincasa hispida (Thunb.) Cogn.*}

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ABSTRACT : An experiment was conducted to study the pattern of inheritance of vine length, fruits per plant, fruit weight and yield per plant from six generations (P_1, P_2, F_1, F_2, B_1 and B_2) means of ten crosses obtained by crossing nine inbred in ash gourd. Majority of the crosses indicated the contribution of dominance gene effects and duplicate epistasis. Among epistasis interactions, addictive x additive (i) played a significant role for vine length, fruits per plant and fruit weight, while additive × additive (i) and dominance × dominance (1) contributed towards fruit yield. These results suggest that heterosis breeding might be more effective for speedy improvement of this crop.

Keywords : *Ash gourd, Benincasa hispida, gene effect, dominance, epistasis.*

Ash gourd or wax gourd {*Benincasa hispida* (Thunb.) Cogn.} is a monotypic genus under the family cucurbitaceae. It is an important vegetable in China, India, the Philippines and other parts in Asia. The immature fruit is used as vegetable and made into curries, while the ripe fruit is cut into pieces and candied with sugar in the preparation of petha by confectioners. Besides its nutritional value, good storability and better transport qualities, the crop is also prized for its high medicinal value. In India, wide range of variability exists in ash gourd. However, little attention has been given towards its genetic improvement. A speedy improvement in this crop is possible by assessing the genetic wealth coupled with studying the pattern of inheritance of important genes responsible for yield and other useful traits. The study of gene effects has direct appropriate utility in formulating the appropriate breeding procedure based on the pattern of inheritance involved in the material for optimum utilization of available genetic variability. Unfortunately very little work has been conducted in ash gourd so far. Keeping in view the meagre information on genetic architecture, the present research programme was formulated to study the pattern of inheritance of vine length, fruits per plant, fruit weight and yield per plant in ash gourd.

Article's History:
Received : 03-08-2016 ***Accepted : 06-09-2016***

MATERIALS AND METHODS

Ten F_1 hybrids along with their 9 respective parents were chosen for this study during 1999 to 2001. The 9 inbred lines were, P_1 (S.12), P_2 (S.16), P_3 (S.8), P_4 (S.9-1), P_5 (S.6-1), P_6 (S.6), P_7 (S.0-1), P_8 (S.A-4) and P_9 (S.1). These lines were crossed to get their desired 10 F_1 hybrids namely, $P_1 \times P_3$, $P_1 \times P_5$, P_1 x P_9, P_2 x P_8, P_3 x P_7, P_3 x P_8, P_4 x P_6, P_4 x P_7, P_5 x P_6 and P_5 x P_9. These F_1's were selfed and backcrossed to their respective parents to obtain F_2 and back cross generations. Thus the final experimental material consisted of 9 parental lines, and 10 each of their F_1's, F_2's, B_1's and B_2's. The final field assessment was carried out in a randomized block design with 3 replications during summer 2001 to judge the performance of different generations of experimental materials. The crop was raised in rows of 4.5 m apart (*i.e.* between channel) with a spacing of 1.0 m between the plants. In each replication, 15 plants from each parental line and their F_1 hybrids, 60 plants from F_2 generations, and 30 plants from each B_1 and B_2 were taken for study. The observations were recorded for vine length, fruits per plant, fruit weight and yield per plant on single plant basis in each genotype. The means of six generations (P_1, P_2, F_1, F_2, B_1 and B_2) of all crosses for different characters were taken to estimate the gene effects for six parameters (m, d, h, i, j and l) for the interacting crosses, and for three parameters (m, d and h) for the non-interacting crosses, as suggested by Hayman (2). The significance of these parameters was ascertained by 't' test. The chi-square test Hayman (2) was carried out to detect the presence of non-allelic interactions.

RESULTS AND DISCUSSION

Chi-square test revealed that one cross each for vine length and fruit weight and two crosses for fruits per plant were non-interacting crosses (Table 1). The dominance components of genetic variation were mainly pronounced and degree of dominance showed over-dominance in all non-interacting crosses. These results indicate that the heterosis breeding may be useful in such crosses for improvement.

In vine length the estimates of mean effects (m) were positive and highly significant in all 9 interacting crosses (Table 2). Five out of 9 interacting crosses were significant for additive (d) gene effects and out of these P_1 x P_5 was positive. However, dominance (h) effects were found positive and significant for 8 crosses. The data revealed that the dominance (h) effects were more pronounced than additive (d) effects. The estimates of gene effects for three types of epistasis, i, j and l, were significant in 8, 2 and 3 crosses, respectively. Out of these the role of additive x additive (i) effect was more prevalent in determining longer vine length, except in the crosses P_3 x P_7 and P_5 x P_6, whereas dominance x dominance (l) effects was the major determining factor for this character. The complementary epistasis was observed in 3 crosses, (P_1 x P_7, P_5 x P_6 and P_5 x P_9) while rest of the 6 crosses showed duplicate type of epistasis. Thus, in vine length, duplicate epistasis was observed in majority of the crosses, and dominance (h) as well as additive x additive (i) components was the main contributing factors for this character. These results indicated that heterosis breeding and selection in later generations might be useful for getting longer vines. Sirohi and Choudhury (7) reported that the duplicate epistasis and dominance components were mainly contributed to vine length in bitter gourd. In pumpkin, Doijode and Sulladmath (1) noticed dominance (h) effects for vine length, while Mahajan (4) observed additive (d) and

Table 1. Estimates of non-interacting gene effects for different characters

Crosses	Gene effects			χ^2	Components of variation		Degree of dominance
	m	d	h		D	H	
Vine length							
$P_1 \times P_3$	6.647**	0.114	0.378	3.910	-0.366	0.912	1.578
Number of fruits per plant							
$P_1 \times P_9$	2.259**	-0.109	0.017	3.078	-1.859	3.014	1.273
$P_4 \times P_7$	2.136**	0.158	0.276	7.670	-1.228	2.504	1.427
Fruit weight							
$P_5 \times P_6$	4.485**	-0.843*	0.248	1.434	-0.586	1.667	1.687

*Significant at 5% level ** Significant at 1% level

Table 2 : Estimates of gene effects based on generation means for vine length.

Cross	m	d	h	i	j	l	χ^2	Epistasis
P_1xP_5	5.38**	0.58**	2.45**	1.44*	0.24	-0.62	116.97**	D
P_1xP_9	5.60**	-0.31	2.36**	2.30**	0.24	-1.59	14.95**	D
P_2xP_8	5.92**	-0.19	3.16**	2.56**	0.04	-1.01	14.19**	D
P_3xP_7	5.81**	0.11	3.15**	1.38*	0.66**	3.81**	42.87**	C
P_3xP_8	5.40**	-0.48	4.79**	3.88**	-0.14	-2.11	16.91**	D
P_4xP_6	5.12**	-0.96**	6.31**	5.04**	-0.41	-3.27**	16.56**	D
P_4xP_7	5.64**	-1.21**	4.41**	2.98**	-0.46*	-0.17	14.15**	D
P_5xP_6	5.37**	-0.41*	0.64	0.02	0.41	3.4**	11.18**	C
P_5xP_9	5.14**	-0.54**	2.95**	1.96**	0.35	1.43	11.57**	C

*Significant at 5% level, **Significant at 1% level, C=Complementary, D=Duplicate additive × additive (i) components of genetic variance for this trait.

As chi-suqare test indicated, 8 crosses in number of fruits per plant were classified as interactors, and $P_1 \times P_9$ and P_5 x P_6 as non-interactor (Table 1 and 3). The for getting higher number of fruits, and careful selection in later generations may be useful for fixing this character. Sharma *et al.* (6) reported the importance of dominance effect for number of fruits per plant in bottle gourd. However, in bitter gourd Suribabu *et al.* (10) indicated the role of both additive and non-additive gene effects for this character.

Table 3 : Estimates of gene effects based on generation means for fruits per plant.

Cross	m	d	h	i	j	l	χ^2	Epistasis
P_1xP_3	2.08**	-0.05	1.23*	0.89*	-0.80*	-0.74*	7.87*	D
P_1xP_5	2.03**	0.26*	0.82*	0.64*	0.16	-0.60	18.13**	D
P_2xP_8	1.98**	0.17*	1.72**	1.18**	-0.11	-0.69*	12.15**	D
P_3xP_7	2.30**	0.12	0.84*	0.76*	0.08	-1.05*	9.12*	D
P_3xP_8	1.91**	0.49**	1.42**	0.94*	0.34*	-0.56	8.23*	D
P_4xP_6	2.03**	0.19	0.16	-0.30	-0.09	1.64**	12.64**	D
P_5xP_6	2.00**	-0.50**	0.70	0.52	-0.44*	-0.41	10.79*	D
P_5xP_9	2.30**	-0.15	0.72	0.54	0.07	-0.97*	11.29*	D

*Significant at 5% level, **Significant at 1% level, C=Complementary, D=Duplicate

Table 4 : Estimates of gene effects based on generation means for fruit weight.

Cross	m	d	h	i	j	l	χ^2	Epistasis
P_1xP_3	5.47**	0.33	0.76	-0.18	-0.18	1.21*	15.83**	C
P_1xP_5	4.53**	0.91**	2.78*	2.30**	-0.27	-3.56*	10.67*	D
P_1xP_9	4.28**	0.99*	1.39*	1.62*	0.13	-1.31*	11.25*	D
P_2xP_8	4.91**	2.22*	0.14	1.56*	1.19**	3.63**	12.41**	C
P_3xP_7	4.84**	-1.37**	2.59*	1.42*	-1.01**	0.41	15.16**	C
P_3xP_8	4.04**	0.77	3.26*	1.74*	-0.05	-0.89	16.10**	D
P_4xP_6	4.92**	1.18**	1.24*	1.20*	0.97*	-0.87	9.93*	D
P_4xP_7	3.86**	-0.39	8.51**	8.06**	-0.42	-8.82**	122.40**	D

*Significant at 5% level, **Significant at 1% level, C=Complementary, D=Duplicate

additive (d) gene effects were found significant in 4 crosses, of which 3 were positive. While 5 out of 8 crosses were significant with all positive values for dominance (h) gene effects. The relative magnitude of none of the additive and dominance effects exceeded the mean effects (m). The results indicated that the dominance effects played greater role for more fruits per plant. The interaction of i and j effects were significant and positive in 5 and 1 crosses, respectively. Five out of 8 crosses showed significant dominance × dominance (l) effects, though all were negative. The magnitude of additive × additive (i) effects were fairly larger and in favourable direction than the other interactions. It indicated the major role of additive × additive (i) gene effects for more number of fruits per plant. Duplicate epistasis was observed for all the interacting crosses. All these results strongly advocated that the heterosis breeding is advantageous

Among the 10 crosses, 9 were classified as interactor (Table 4) and the cross $P_5 \times P_6$ as non-interactor (Table 1) for fruit weight. Four out of 6 crosses had significant additive (d) gene effects in positive direction. However, 7 crosses showed significant dominance (h) effect in positive direction for this trait. In terms of absolute magnitude, the dominance effects were higher than the additive effects for all the crosses, except in $P_2 \times P_8$ cross. The three types of epistasis (i, j and l) were significant in 8, 3 and 6 crosses, respectively. All the crosses had significant additive x additive (i) gene effects, except P_1 x P_3 and 2 crosses each had additive × dominance (j) and dominance x dominance (l) effects in positive side. The absolute magnitude of the total epistasis gene effects

Table 5 : Estimates of gene effects based on generation means for total yield per plant.

Cross	m	d	h	i	j	l	χ^2	Epistasis
P_1xP_3	9.78**	-1.80*	8.59*	4.52*	-2.04**	3.59*	24.05**	C
P_1xP_5	9.59**	-0.28	7.15*	4.16*	-2.16**	-3.66*	51.61**	D
P_1xP_9	9.08**	0.69	9.73*	8.22**	-0.08	-8.25**	49.53**	D
P_2xP_8	9.65**	2.16*	7.96*	1.96	-0.05	2.75*	28.72**	C
P_3xP_7	10.20**	1.47*	5.65*	2.86	1.03	-0.05	59.38**	D
P_3xP_8	7.69**	1.46*	13.97**	9.62**	-0.79	-7.66**	112.87**	D
P_4xP_6	8.71**	0.58	6.10*	3.32	-0.18	4.32*	35.10**	C
P_4xP_7	8.56**	0.35	17.09**	12.94**	-0.17	-10.61**	43.65**	D
P_5xP_6	8.19**	-1.50*	11.93**	6.88**	-0.54	-3.09*	130.81**	D
P_5xP_9	10.63**	-1.03	10.97**	2.66	-1.50*	6.05*	11.14*	C

*Significant at 5% level, **Significant at 1% level, C=Complementary, D=Duplicate

exceeded the mean effects in 4 crosses ($P_1 \times P_5$, $P_2 \times P_8$, $P_4 \times P_7$ and $P_5 \times P_9$), and additive and dominance gene effects in all the crosses, except $P_3 \times P_8$. Here, additive x additive (i) component played greater role for higher fruit weight, followed by dominance × dominance (l) type. Three interacting crosses ($P_1 \times P_3$, $P_2 \times P_8$ and $P_3 \times P_8$) showed complementary gene action, while the rest had duplicate type of epistasis for the inheritance of this character. So, in majority of the crosses the mode of inheritance of fruit was controlled by dominance (h) gene effect and additive x additive (i) played greater role than other components of interaction. This result suggested heterosis breeding for the improvement of this character. Lawande and Patil (3) observed dominance gene effect for fruit weight in bitter gourd. Similarly, Mohanty (5) concluded that the average fruit weight was regulated by non-additive gene action in pumpkin.

All the 10 crosses had significant chi-square values for yield per plant (Table 5), and so they grouped as interactors. Additive (d) gene effects were significant in 5 crosses, among them 3 were positive. All the crosses had significant positive dominance (h) effects for this character. The dominance effects were larger than the mean (m) effects in 5 crosses. The relative magnitude of the dominance and additive effect to the mean effects suggested that the dominance effects made a major contribution to the inheritance of this character. The estimates of the epistasis (i, j and l) were significant in 6, 3 and 9 crosses, respectively. All additive × additive (i) gene action showed positive effect; while 4, out of 9 significant dominance × dominance (l) epistasis had positive values. The total epistasis effects exceeded the additive (d) and dominance (h) effects in all crosses, and mean (m) effects in 5 crosses. These results clearly suggested that the dominance (h) component made a greater contribution as main effect, and additive × additive (i) and dominance x dominance (l) components played role among epistasis effects. The majority of the crosses showed duplicate epistasis for this trait. Hence, a substantial gain through heterosis breeding can possibly be manipulated for higher yield in ash gourd. Similar results have been reported by several workers for yield per plant in different cucurbits. Sirohi and Choudhury (8) concluded that dominance (h) and dominance x dominance (l) genetic components were responsible for total yield per plant in bitter gourd. Sharma et al. (6) reported that dominance effects were predominant for total yield in bottle gourd. Sirohi and Ghorui (9) noticed the presence of duplicate epistasis and contribution of dominance and dominance × dominance components for higher yield in pumpkin.

The results of present investigation clearly indicated that the studied traits were mostly governed by dominance (h) gene effects and duplicate epistasis that suggested usefulness of developing F_1 hybrids in cultivation to get higher production and productivity in ash gourd.

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Citation : Mandal J. and Sirohi P.S. (2016). Genetics of yield and its components in ash gourd {*Benincasa hispida* (Thumb.) Cogn.} *HortFlora Res. Spectrum,* **5**(3) : 213-217.