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Research Article

GENETIC ANALYSIS OF YIELD AND ITS COMPONENTS IN EGG PLANT IN SUMMER SEASON (*Solanum melongena* L.)

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Abstract- A field experiment was carried out comprised of 11 parents, 30 hybrids and commercial hybrid ABH-1 (check) during summer season 2015, at Collage farm, NAU, Navsari. The analysis of variance for all the traits revealed that parents were found to be significant for all the traits studied, indicating presence of the considerable amount of genetic variability in the parental material tested. IIHR-587 x NSRP-1, IIHR-534 x NSRP-1 and IIHR-587 x NSR-1 significant and desirable heterobeltiosis and standard heterosis for fruit yields. Combining ability studies revealed non-additive type of gene action for fruit yield involved in the expression of traits. IC-0742241, IIHR-534 NSR-1 and NSRP-1 were good general combiners for fruit yield per plant. Top three yielded cross IIHR-587 x NSRP-1 (0.3) and IIHR-534 x NSRP-1 (0.28) good desired sca effect. The overall analysis based on *gca* effect*, sca* effect*,* heterobeltiosis and standard heterosis revealed that cross IIHR-534 x NSRP-1 and IIHR-587 x NSRP-1 may be use for commercial exploitation.

Keywords- Heterosis, Combining ability, Egg plant, Specific combining ability, Fruit yield

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Introduction

Seasonal changes in day length or photoperiod act as an external temporal clue to Vegetables occupy an important place in diversification of agriculture and playing a vital role in food and nutritional security of ever-growing population of large vegetarian society. Among the vegetables, brinjal a native of India is an important solanaceous vegetable crop in countries, like India, Japan, Indonesia, China, Bulgaria, Italy, France, USA and several African countries. Confirmation of this fact was based on isozyme and morphological variation noticed in large germplasm collections from India [10]. It shows the secondary diversity in China and South East Asia [26]. However, it is widely cultivated in both temperate and tropical regions of the globe, mainly for their immature fruits as vegetable [18]. It is the third most important vegetable crop in India and contributing about 17.8 per cent of the total production of vegetables in the country [1]. It is named as “Poor man’s vegetable” because of its low cost of production, ease of culture and availability throughout the year. Fruits are widely used in various culinary preparations *viz.*, sliced bhaji, stuffed curry, bertha, chutney, vangi bath, pickles etc. Contrary to the common belief, it is quite high in nutritive value being rich in vitamins, minerals (calcium, magnesium, phosphorus) and fatty acids [25]. Exploiting hybrid vigour in a single cross hybrid depends on the two parents complementing each other with special reference to desirable traits. However, it is often noticed that all the desirable traits need not to be distributed between only these two parents. Therefore, it might be necessary to involve multiple cross combinations of parents to have wider genetic content as well as broaden the genetic base. This also improves the chances of accumulating a maximum number of desirable genes distributed between the parents so that heterosis is envisaged [22, 21]. Therefore, the exploitation of hybrid vigour in brinjal has been recognized as a practical tool in providing the breeder a means of increasing yield and improves economic traits.

The development of an effective heterosis-breeding programme in brinjal needs to elucidate the genetic nature and magnitude of quantitatively inherited traits and judge the potentiality of parents in hybrid combinations. Combining ability studies, like L x T Analysis provides information in this direction, particularly when large numbers of parents are to be screened for combining ability. Study of *gca* of genotypes helps in the selection of superior parents while *sca* of genotypes helps in deciding superior hybrid. The information generated in the process is used to understand the magnitude of heterosis of F1 hybrids. The low fruit yield levels in India are due to insufficient crop genetic improvement and development of high yielding hybrids. Thus, under such circumstances, it is necessary to develop hybrids superior to these types for qualitative and quantitative traits. With keeping this in view the paper deals with the genetic architecture of yield and its components in brinjal (*solanum melongena* L.)

Materials and Methods

The experimental material was developed at Regional Horticultural Research Station (R.H.R.S.), Navsari Agricultural University, Navsari during *Summer* 2015, by crossing five females (Line) with six males (Testers) in a Line x Tester mating system. Thus, the experimental material consisted of 42 entries comprising 30 hybrids, 5 lines (female parents) and 6 testers (male parents) along with two checks NSR-1 and ABH-1 among this two check one check included is inbreed was raised in a randomized block design with three replications in the early summer season. Each entry was accommodated in a single row of 6 m. length spaced at 90 cm apart with plant-to-plant spacing of 60 cm. Recommended practices and plant protection measures were adopted timely to raise the healthy crop. Five competitive plants from each entry in each replication were randomly selected before flowering and tagged for the purpose of recording observations on different traits (except days to flowering and days to 1st picking and number of picking) and their average values were used in the statistical analysis.

In the present, the averaged mean values were subjected to statistical analysis to test the significance of variation for the experiment design with the model of Panse and Sukhatme [16]. The superiority of hybrids for various traits was calculated over better parent and standard variety according to the method of Fonseca and Patterson [9]. Studies of heterosis (better-parent and standard check) and combining ability were estimated for yield and its component traits in the F1 generation of brinjal genotypes using Line X tester analysis was carried out by the method suggested by Kempthorne [12].

Result and Discussion

The analysis of variance indicated highly significant difference for both parents and hybrids for all the traits indicating the existence of the enormous amount of genetic variability in the genotype. The interaction effect of parent *vs.* hybrids was significant for all traits except (number of fruit per plant and average fruit weight) indicating the presence of heterosis for these traits *i.e.* performance of the group of parents differed with group of hybrids evaluated. For days to 50 per cent flowering and for days to first picking the cross IIHR-587 x GJB-3 IC-11066 x NSRP-1, IIHR-587 x NSRP-1 showed significant desired heterobeltiosis and standard heterosis [Table-1] so it clearly indicated the relation between days to 50 per cent flowering and days to first picking to the fruit yield. The result is similar with the earlier findings of Reddy and Patel [20] and Deshmukh *et al* [8].

Table-1 *Analysis of variance for parents and hybrids in respect of yield contributing traits*

SR. No	D.F	1	2	3	4	5	6	7	8	9	10	11
Replication	**2**	1.58	0.86	0.34	1.34	0.05	0.17	2.26	6.42	0.01	0	0
Treatments	**41**	20.76***	20.34***	11.99***	346.69***	2.74***	1.56***	34.04***	262.82*	0.34***	0.3***	0.02***
Parents	**10**	14.84***	13.16***	18.43***	409.14***	3.6***	2.34***	23.84***	219.12	0.3***	0.38***	0.03***
Crosses	**29**	23.51***	22.05***	0.8***	312.38***	1.36***	1.31***	39.05***	285.35*	0.33***	0.26***	0.01***
P vs. Hy	**1**	20.83***	62.96***	283.98***	1063.86***	36.75***	2.68***	24.77	309.4	1.2***	0.95***	0.04***
Female	**4**	5.43***	6.27***	3.58***	476.52***	3.72***	2.17***	27.14**	388.37*	0.29***	0.62***	0NS
Male	**5**	9.92***	1.99*	0.75*	195.16***	2.19***	0.78***	25.23**	65.85	0.33***	0.02***	0.04***
F vs. M	**1**	77.08***	96.63***	166.26***	1209.52***	10.19***	10.78***	3.7	308.46	0.16	1.2***	0.06***

In the present study, many hybrids showed the existence of considerable heterosis for fruit yield as well as component traits over better parent and standard checks, NSR 1 and ABH-1. The degree of heterosis varied from cross to cross for all the eleven traits. Considerable heterosis in certain crosses and low in other crosses revealed that nature of gene action varied with the genetic architecture of parents. Negative heterosis is considered as desirable for days to 50 per cent flowering, days to 1st picking and total phenol, while for other traits significant positive heterosis was considered as desirable. The results in this pursuit are discussed in following ways. A vary wide range of heterosis was found for all traits under study [Table-3] Heterosis for yield range was found for heterobeltiosis was -30.53 per cent to 22.37 per cent and for standard heterosis 25.13 per cent to 31.58 per cent and 27.33 to 27.71 over both check. This result was harmony with Ramni *et al*, [19] and Deshmukh *et al* [8]. IIHR-587 x NSRP-1, IIHR-534 x NSRP-1 and IIHR-587 x NSR-1 were found superior heterobeltiosis as well as standard heterosis with higher mean [Table-2]. These hybrids also found better heterosis per cent for earliness as well as yield attribute traits like plant height, number of branches per plant, fruit girth, the number of fruit per plant and fruit weight. Likewise, cross IIHR-587 x NSRP-1, showed significant desired direction heterosis for earliness, plant height, fruit girth and average fruit weight, while IIHR-534 x NSRP-1 and IIHR-587 x NSR-1 for plant height, number of branches, fruit length, number of fruit per plant and average fruit weight, so it clearly indicated that this trait are related to fruit yield per plant so selection for such trait from transgressive segregants should be effective in future breeding programs. This result was supported by Makani *et al* [13], Chowdhury *et al.*[7], Ramani *et al.*[19], Shingh *et al*. [23]and Deshmukh *et al.*[8].

Table-2 *Analysis of variance (mean squares) and variance estimates for combining ability*

SR. No	D.F	1	2	3	4	5	6	7	8	9	10	11
R * E	**4**	0.88	0.8	0.49	8.72	0.04	0.2	1.4	225	0.01	0	0
Treatment	**29**	23.51**	22.05**	0.8**	312.38**	1.36**	1.31**	39.05**	285.35*	0.33**	0.26**	0.01**
Male	**4**	28.91**	24.87**	1.17**	158.54**	0.91*	0.18	26.42**	206.02	0.6**	0.02**	0.01**
Female	**5**	54.97**	50.65**	1.22**	1405.45**	1.06*	7.84**	161.16**	1506.38**	0.46**	1.58**	0
F x M	**20**	15.87**	15.62**	0.63**	132.22**	1.54**	0.29**	17.79**	60.97	0.24**	0.06**	0.01**
σ^2 Females		2.17*	1.95*	0.03	70.73**	-0.03	0.42**	7.96**	80.30***	0.01	0.08***	0.00
σ^2 Males		0.87	0.62	0.04	1.75	-0.04	-0.01	0.58	9.67**	0.02	0.00	0.00
σ^2 Environment		0.16	0.28	0.09	11.76	0.10	0.03	1.78	55.19	0.02	0.00	0.00
σ^2 gca		1.58**	1.34**	0.03**	39.38**	-0.03	0.23**	4.61**	48.20***	0.02**	0.04***	0.00
σ^2 sca		5.13***	4.93***	0.12**	32.31**	0.42**	0.07**	4.15**	-34.86	0.06***	0.02***	0.00***
σ^2 gca/σ^2sca		**0.31**	**0.27**	**0.29**	**1.22**	**-0.08**	**3.26**	**1.11**	**-1.38**	**0.28**	**2.31**	**0.01**

*, ** Significant at 5 and 1 per cent probability levels, respectively 1- 50 per cenr flowering, 2- Days to first picking, 3- Number of branches, 4- plant height, 5- fruit length, 6- fruit girth, 7- number of fruit per plant, 8- Average fruit weight, 9- Fruit yield, 10- Total phenol and 11- Total soluble sugar

In combining ability analysis the mean squares due to females and males were significant for all the traits and signifying that both females and males had considerable general combining ability (gca) and contributed towards additive genetic variance. [Table-2] Highly significant mean squares due to females x males were manifested by all the traits (except fruit per plant) suggesting its significant contribution in favour of specific combining ability (sca) variances. However, perusal of σ^2gca/σ^2sca ratio revealed greater than one additive gene action for plant height, fruit girth, the number of fruit per plant and total phenol and precise selection should be effective for such type of trait and similar result found by Bisht et al. [3], Kamalakkannan *et al.*[11], Suneetha *et al.* [24], Rai and Asati [18],Ansari and Singh [2], Chaudhari and Didel [6], Reddy and Patel [20], Naresh *et al.*[15] whereas, less than one ratio non-additive gene action was observed for days to 50 per cent flowering, days to first picking, number of primary branches, fruit length, average fruit weight, fruit yield and total soluble sugar, so it indicates non additive gene action and recombination breeding and bi-parental matting need to improve such trait and result supported by Muniappan *et al.* [14], Chattopadhyay *et al.*[5], Pachiyappan [27], Bhushan *et al.* [4], Dubey *et al*. [28], Reddy and Patel [20], Naresh *et al.*,[15].

General combining ability effects were estimated for parents while specific combining ability effects were estimated for hybrids. Average performance of genotype in a series of cross is known as general combining ability. Specific combining ability is a performance of a parent under consideration, in a specific cross. The traits wise categorization of general combining ability is given in [Table-4] Nature and magnitude of combining ability provides a guideline in identifying good parents and way of their utilization in a breeding programme. Female IC-0742241 and IIHR-534 was found good general combiner for fruit yield among them IC-0742241 also found good general combiner for a number of branches, plant height, fruit girth and average fruit weight and IIHR-534 good general combiner for plant height, fruit girth and number of fruit per plant. IIHR-587 and IC-111066-2 found good general combiner for earliness as well as for fruit weight and quality trait. Among male parent, NSR-1 found good general combiner for most of the traits except days to first picking, fruit length, fruit girth and average fruit weight and NSRP-1 was found for earliness, number of fruit per plant and for fruit yield.

Table-3 *Heterosis ranged and Most heterotic hybrids for yield per plant for heterobeltiosis and standard heterosis over checks (NSR-1) and (ABH-1).*

Sr. No	Range of heterosis			IIHR-587 x NSRP-1			IIHR-534 x NSRP-1			IIHR-587 x NSR-1		
	BP	SC1	SC2	BP	SC1	SC2	BP	SC1	SC2	BP	SC1	SC2
9	-30.53 to 22.37	25.13 to 31.58	27.33 to 27.71	22.37**	22.37**	18.77*	13.38*	31.58**	27.71**	13.38*	31.58**	27.71**
1	-7.82 to 7.82	-8.33 to 12.04	-7.30 to 13.30	-6.7**	-7.22**	-6.18**	-5.32**	-1.11	0	-3.89**	-3.89**	-2.81**
2	-6.80 to 7.36	-4.09 to 14.25	-6.35 to 11.56	-4.42**	-2.59**	-4.88**	-3.74**	2.91**	0.49	-0.49	1.41	-0.98
3	-8.68 to 35.67	57.92 to 96.98	47.87 to 84.87	18.62**	85.8**	73.98**	5.76	81.9**	70.33**	25.76**	96.98**	84.45**
4	-16.97 to 23.99	4.55 to 72.43	-4.47 to 57.57	-0.71	17.3*	7.19	-5.7	37.24**	25.41**	9.96	29.9**	18.7**
5	-18.17 to 38.38	-3.25 to 25.22	-9.83 to 16.70	10.17*	15.4**	7.55	13.55**	18.94**	10.85*	7.19	7.19	-0.1
6	-40.16 to 13.92	-30.59 to13.92	-33.35 to 9.38	-14.04**	7.69	3.4	-13.65**	8.18	3.87	3.05	3.05	-1.06
7	-39.72 to 17.44	-33.25 to33.53	-41.40 to17.40	-1.4	12.16	-1.39	-15.96*	-0.1	-12.17	1.62	1.62	-10.65
8	-18.72 to 8.10	-13.41 to20.21	-17.41 to14.66	8.05	20.21**	14.66*	3.01	7.58	2.62	3.72	15.39*	10.07
10	-47.28 to 39.08	-13.89 to93.06	12.68 to 95.77	3.45	4.17	5.63*	25.77**	84.72**	87.32**	6.94*	6.94*	8.45**
11	16.35 to 9.65	-10.31 to 6.30	4.08 to 13.67	1.97	-1.15	5.71*	4.05	3.05	10.2**	0.38	0.38	7.35**

*, ** Significant at 5 and 1 per cent probability levels, respectively 1- 50 per cenr flowering, 2- Days to first picking, 3- Number of branches, 4- plant height, 5- fruit length, 6- fruit girth, 7- number of fruit per plant, 8- Average fruit weight, 9- Fruit yield, 10- Total phenol and 11- Total soluble sugar

Table-4 *Summary of general combining ability effects of the parents for different traits*

	1	2	3	4	5	6	7	8	9	10	11
Females											
IIHR-587	G	G	A	P	A	A	P	G	A	G	A
IC-0742241	P	A	G	G	G	P	G	P	G	P	A
IIHR-534	P	P	A	G	A	G	G	A	G	P	A
IIHR-596	P	P	P	G	A	G	A	P	P	G	A
IC-111066-2	G	G	A	P	A	G	P	G	P	G	A
Male											
NSR-1	G	A	G	G	P	A	G	A	G	G	A
GAOB-2	P	P	A	G	A	A	P	A	A	A	A
GJB-2	A	A	P	A	A	A	A	A	P	A	G
GJB-3	A	G	A	A	P	A	A	A	A	P	P
JBGR-1	P	P	A	A	A	A	A	A	P	P	A
NSRP-1	G	G	A	A	A	A	G	A	G	A	A

G = Good parent having significant gca effect in desired direction, A = Average parent having either positive or negative but non-significant gca effects and P = Poor parent having significant gca effects in undesired direction

1- 50 per cent flowering, 2- Days to first picking, 3- Number of branches, 4- plant height, 5- fruit length, 6- fruit girth, 7- number of fruit per plant, 8- Average fruit weight, 9- Fruit yield, 10- Total phenol and 11- Total soluble sugar

In the present investigation, positive specific combining ability is favourable for all the traits under study except for days to first flowering, days to 50 per cent flowering, days to first picking and none of the cross showed a desired significant effect for all traits. On the basis of per se performance best top hybrids for fruit yield IIHR-587 x NSRP-1, IIHR-534 x NSRP-1 and IIHR-587 x NSR-1 among them first two had a positive significant sca effect [Table-5]. IIHR-587 x GJB-3, IIHR-587 x NSRP-1 and IC-11066 x NSRP-1 had desired significant effect for earliness. IIHR-596 x JBGR-1 had desired mean value and sca effect for plant height, fruit girth and total phenol. The high positive or negative specific combining ability effect recorded by the crosses involved either good x good, good x average, good x poor, average x average, average x poor or poor x poor combining parents. Therefore, information of general combining ability effect alone may not be sufficient to predict the magnitude of heterosis. Hence, information of general combining ability effects of the parents needs be supplemented by that of specific combining ability effects and of hybrid performance as well. The crosses involving one good general combining parent could produce desirable transgressive segregants in the subsequent generation revealed that there was some degree of correspondence between *per se* performance and *sca* effects of hybrids as well as *gca* effects of parents and estimates of heterosis for most of traits. Hence, *gca* and *sca* effects and *per se* performance all play important roles in the manifestation of heterosis for various traits. Bi-parental mating with the reciprocal recurrent selection would be appropriate to maintain the required genetic variability in the breeding population and at the same raise the frequency of desirable genes. Top ranking hybrids may be further tested for area locations, identifying for high yielding hybrids.

Table-5 *Top three parents and hybrids for per se performance and combining ability effect*

Trait	Best performing parents		Best general combiner		Best performing hybrids	SCA effect	Standard heterosis-1	Standard heterosis - 2
	Female	Male	Female	Male				
Days to 50 per cent flowering	IIHR-587	JBGR-1	IIHR-587	NSR-1	IIHR-587 x GJB-3	-2.55*	-8.33**	-7.3**
	IC-11066	GJB-3	IC-11066	NSRP-1	IC-11066 x NSRP-1	-2.76*	-8.33**	-7.3**
	IC-0742241	NSRP-1	-	_	IIHR-587 x NSRP-1	-0.48	-7.22**	-6.18**
Days to first picking	IIHR-587	JBGR-1	IIHR-587	NSRP-1	IC-11066 x NSRP-1	-2.85*	-4.09**	-6.35**
	IC-11066	NSRP-1	IC-11066	GJB-3	IIHR-587 x GJB-3	-2.37*	-3.59**	-5.86**
	IC-0742241	GJB-3		_	IIHR-587 x NSRP-1	-0.57	-2.59**	-4.88**
Number of primary branches per plant	IC-0742241	NSR-1	IC-0742241_	NSR-1	IIHR-587 x NSR-1	0.42	96.98**	84.45**
	IIHR-534	JBGR-1	_	_	IIHR-596 x JBGR-1	0.96*	94.87**	82.47**
	IIHR-596	NSRP-1	_	_	IC-0742241 x NSR-1	0.21	94.35**	81.99**
Plant height	IIHR-534	JBGR-1	IIHR-534	GAOB-2	IC-0742241 x GAOB-2	18.34*	72.43**	57.57**
	IC-0742241	GJB-3	IC-0742241	NSR-1	IC-0742241 x NSR-1	0.53	47.1**	34.42**

	IIHR-596	GJB-2	IIHR-596	_	IIHR-534 x GJB-2	9.17*	45.5**	32.96**
Fruit length (cm)	IIHR-534	IC-0742241	IC-0742241	_	IIHR-596 x JBGR-1	1.2*	25.22**	16.7**
	IC-11066	JBGR-1			IC-0742241 x NSRP-1	0.82*	23.87**	15.44**
	IIHR-596	GAOB-2	_	_	IC-11066 x GJB-2	0.97*	22.15**	13.84**
Fruit girth (cm)	IIHR-596	NSRP-1	IIHR-596		IC-11066 x NSR-1	0.52*	13.92**	9.38*
	IC-11066	GAOB-2	IC-11066		IIHR-534 x JBGR-1	0.19	8.55*	4.22
	IIHR-534	JBGR-1	IIHR-534	_	IIHR-534 x NSRP-1	0.2	8.18	3.87
Number of fruit per plant	IC-0742241	GJB-2	IC-0742241	NSRP-1	IC-0742241 x NSRP-1	0.34	33.53**	17.4*
	IIHR-534	NSRP-1	IIHR-534	NSR-1	IC-0742241 x NSR-1	-0.6	31.09**	15.26*
	IIHR-596	JBGR-1		-	IIHR-534 x GJB-2	3.96*	29.89**	14.2*
Average fruit weight (gm)	IIHR-587	GJB-3	IIHR-587		IIHR-587 x NSRP-1	0.61	20.21**	14.66*
	IC-111066-2	NSRP-1	IC-11066		IC-11066 x GJB-3	5.02	17.99*	12.55
	IC-0742241	GJB-2			IIHR-587 x GJB-2	5.75	17.01*	11.62
Fruit yield (kg/plant)	IIHR-534	NSRP-1	IC-0742241	NSR-1	IIHR-587 x NSRP-1	0.3*	31.58**	27.71**
	IIHR-596	GAOB-2	IIHR-534	NSRP-1	IIHR-534 x NSRP-1	0.28*	31.58**	27.71**
	IC-0742241	NSR-1		-	IIHR-587 x NSR-1	0.24	22.37**	18.77*
Total phenol (mg g^{-1})	IIHR-596	GAOB-2	IIHR-596	NSR-1	IIHR-596 x GJB-3	-0.13*	-13.89**	-12.68**
	IIHR-587	GJB-2	IIHR-587	-	IIHR-596 x JBGR-1	-0.09*	-7.64**	-6.34*
	IC-0742241	NSR-1	IC-11066	-	IIHR-596 x GJB-2	0.03	-1.74	-0.35
Total soluble sugar (per cent)	IC-0742241	GJB-3	GJB-2		IIHR-587 x JBGR-1	0.15*	6.3*	9.75**
	IIHR-587	GAOB-2		-	IIHR-596 x GAOB-2	0.09*	5.34*	13.49**
	IIHR-534	GJB-2		-	IIHR-534 x GJB-2	0.05	4.58	12.03**

Conflict of Interest: None declared

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