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COMBINING ABILITY STUDIES IN BHENDI (*ABELMOSCHUS ESCULENTUS* (L.) MOENCH) THROUGH DIALLEL ANALYSIS FOR YIELD AND YIELD ATTRIBUTING CHARACTERS

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Abstract

The present investigation was undertaken to evaluate six parents and thirty hybrids through diallel mating system to study general and specific combining ability effects and genetic analysis for various yield and yield attributing characters. In diallel analysis, the variance of the genotype for all the characters were highly significant indicating high genetic variability among the parents studied. Based on *gca* effects, the parent Hissar Unnat was adjudged as superior parent. Arka Anamika, MDU 1 and Pusa Savani were identified as next better parents. Among the hybrids, Hissar Unnat × Pusa Savani, Arka Anamika × Arka Abhay, Kamini × MDU 1 and Hissar Unnat × MDU 1 were rated as best hybrids for exploitation of heterosis based on mean performance. The hybrids Hissar Unnat × Pusa Savani, Arka Anamika × Arka Abhay and Hissar Unnat × MDU 1 had high positive significant sca for the characters, days to 50 per cent flowering, plant height at maturity, number of branches per plant, number of fruits per plant, fruit length, fruit weight and fruit yield per plant. Inclusion of these hybrids into multiple crosses, could be a worthwhile approach for tangible improvement of these traits. Hence the hybrids were suitable for heterosis breeding to improve fruit yield per plant and other yield components characters.

***Keywords*:** Bhendi, diallel analysis, combining ability, gca, sca

Introduction

Bhendi (*Abelmoschus esculentus* (L.) Moench) 2n=130 is a common vegetable cultivated in India. Being native of Tropical Africa, it is a prized vegetable of India. Bhendi is especially valued for its tender delicious fruit and is a rich source of iodine. The fruit has an average nutritive value of 3.21, which is higher than tomato, egg plant and cucurbits. The dehydrated bhendi is a processed product for preservation and export. Bhendi seeds forms a nutrition ingredient of cattle feed and is a source of vegetable oil. It is a potential export vegetable accounting for 60 percent of fresh vegetable. Its quick growth, short duration and photo insensitivity in nature enable the genetists and breeders to raise two or three crops a year and thus reduce the period for achieving the genetic results.

India ranks first in the production of bhendi in the world sharing 73 per cent production. In India, bhendi is cultivated in an area 532 lakh ha with a production of 58 lakh tones per year and productivity is 11.60 mt/ha (FAO, 2015). The production of green tender fruit was 35.24 lakh tonnes from major producing states in India namely Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pradesh, Karnataka and Assam. For improving the yield and quality in bhendi, breeders have suggested different methods of breeding. Among them, the diallel analysis was found to be the appropriate and effective method to assess the combining ability and gene action of the parents and their hybrids. The combining ability is the important genetic tool for the assessment of relative breeding potential of the parents and identifying the best combiners which may be hybridized to exploit heterosis. Additive and non-additive gene actions in the parents estimated through combining ability analysis may be useful in determining the possibility for commercial exploitation of heterosis and isolation of purelines among the progenies of the heterotic F_1. The present study was carried out to assess the breeding values of the chosen parents, to understand their genetic potential on yield and its component traits and to estimate the combining ability effects.

Materials and Methods

The present investigation was carried out at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, during January-March, 2016 and F_1 evaluation was carried out during June-August 2017. The experimental material consisted of six genotypes collected from various sources representing wide genetic diversity. The selected six genotypes namely Arka Anamika, Arka Abhay, Hissar Unnat, Kamini, MDU 1 and Pusa Savani were crossed in all possible combination and produced 30 hybrids (including reciprocal crosses). During January 2016, the seeds of the six varieties were sown in ridges and thirty crosses were effected as per the formula diallel (Hayman, 1960). During June 2017, F_1 hybrid seeds of 30 crosses obtained through diallel mating design was sown in the field along with their parents. Thirty hybrids along with their selfed parents were sown in randomized block design, replicated thrice. Each combination was sown in a row of 3.0 m length. A row spacing of 45 cm and plant to plant spacing of 30 cm were maintained. Recommended agronomic practices and need based plant protection measures were judiciously followed. The observations were recorded on five randomly selected competitive plants in each entry per replication. Observations were recorded on the following characters like days to 50 percent flowering, plant height at maturity (cm), number of branches per plant, number of fruits per plant, fruit length (cm), fruit girth (cm), fruit weight (g) and fruit yield per plant (g). the data was analysed following method I and model I of Griffing (1956)

Results and Discussion

The ANOVA for the yield and yield attributing characters of bhendi were furnished in the Table 1. The 'f' values were highly significant for all the eight characters studied. The parents and hybrids exhibited highly significant variation for all the characters studied.

The mean sum of squares due to GCA, SCA and RCA were found to be highly significant for days to 50 percent flowering, plant height at maturity, number of branches per plant, number of fruits per plant, fruit length and fruit yield per plant. The ratio of GCA/SCA was found to be greater than one for the characters like days to 50 percent flowering, plant height at maturity, number of branches per plant, number of fruits per plant, fruit girth and fruit yield per plant indicating the role of additive gene action for these traits (Shwetha *et al.,* 2018). The GCA variance was higher than the SCA variance for all the characters except fruit girth indicated the additive gene action in expression of these traits (Table 2)

The estimates of gca effects indicated that the parent, Hissar Unnat had maximum negative and significant *gca* effect (–0.67) for days to 50 percent flowering, for plant height at maturity, the parent Arka Abhay had maximum negative and significant *gca* effect (-4.35) followed by Hissar unnat (-1.75), Hissar Unnat (0.27) for number of branches per plant, Pusa savani (0.89) and Hissar Unnat (0.70) for number of fruits per plant, Pusa savani (0.34) and Hissar Unnat (0.32) for fruit length, Pusa Savani (0.24) and Hissar Unnat (0.20) for fruit girth, the parents, Hissar Unnat recorded the highest positive and significant *gca* effect (0.22) followed by Pusa Savani (0.21) for fruit weight and for fruit yield per plant the parents Hissar Unnat (23.20) followed by Pusa Savani (18.11) recorded the highest positive and significant gca effect. The parent Hissar Unnat showed higher combining ability for three characters like days to 50 percent flowering, number of branches per plant, fruit weight and fruit yield per plant followed by Pusa Savani. (Table 3).

In the present investigation among the parents, the *gca* effect of Hissar Unnat was of high order for the characters such as days to 50 per cent flowering, number of branches per plant, number of fruits per plant, fruit length, fruit weight and fruit yield per plant. A perusal of *gca* effects for yield characters like days to 50 per cent flowering, number of fruits per plant, fruit length, fruit weight and fruit yield per plant indicated that the parent Hissar Unnat was a good general combiner. Earlier reports of significant *gca* effects for days to 50 per cent flowering, number of branches per plant, number fruits per plant, fruit length, fruit weight and fruit yield per plant were made by Dabandata *et al.* (2010), Wammanda *et al.* (2010), Thirupathi Reddy *et al.* (2012); Prashant Kumar *et al.* (2012), Kumar *et al.* (2014) and Pachiyappan and Saravanan (2018). Thus, Hissar Unnat was appeared to be of worthy for exploitation in breeding programmes aimed at yield improvement through component characters.

The specific combining ability is considered to be the best criterion for the selection of superior hybrids. Specific combining ability refers to the performance of a combination of specific inbred in particular cross. Specific combining ability may result from several cases, such as Mendalian segregation and recombination, incorrect genotypic classification and various types of factor interactions (Sprague and Tatum, 1942). The specific combining ability is the deviation from the performance predicted on the basis of general combining ability (Allard, 1960).

The specific combining ability estimates demonstrated that the cross combination Hissar Unnat × Pusa Savani (-0.45) depicted highest negative significant *sca* effect for days to 50 per cent flowering and was good combiner for earliness. The hybrid MDU 1 × Pusa Savani recorded maximum positive and significant *sca* effect for plant height at maturity while for the characters number of branches per plant, number of fruits per plant, fruit length and fruit yield per plant while, the hybrid Hissar Unnat × Pusa Savani recorded maximum positive significant *sca* effect. The hybrid Hissar Unnat × MDU 1 for fruit weight (Table 4). So, from the above discussion it may be considered that, the hybrids Hissar Unnat × Pusa Savani, Arka Anamika x Arka Abhay and Hissar Unnat × MDU 1 could be used as the best hybrid for exploitation of heterosis. The hybrids Hissar Unnat × Pusa Savani, Hissar Unnat × Arka Anamika and Hissar Unnat × MDU 1 were the better hybrids for exploitation of heterosis.

In the present study, the hybrid Hissar Unnat × Pusa Savani showed high *sca* effect with the combination of superior *gca* parent for plant height at maturity, number of branches per plant, number of fruits per plant, fruit weight and fruit length. Similarly, the cross Hissar Unnat × Pusa Savani recorded high *sca* effect for fruit yield per plant with combination of superior *gca* parents. So, it is worth of mentioning that parents with consistently good general combining ability produces hybrids with significant *sca* effects. Similar results were obtained by Mehta *et al.* (2007), Mukesh Kumar *et al.* (2013) and More *et al.* (2015)

From the perusal of *sca* effects of the hybrids, it was evident that all types (significantly positive or negative or non-significant) of *sca* effects could be obtained in hybrids with different types (high × high, high × low, low × high and low × low) of parental *gca* combinations (Table 5)

Therefore, it may not be always necessary to attempt crosses between high × high *per se* or *gca* or low × low *per se* or *gca.* However combinations in which atleast one parent had high *gca* or high *per se* may be rewarding. So it can be observed that a good performing parent may not be a good general combiner, a good general combiner need not always produce a good specific combination. However, it can be noticed that atleast one general combining parent was involved in desirable specific combination and the best performing crosses involved atleast one parent with high mean and crosses with significant *sca* effects can be utilized for transgressive segregants. The interaction between recessive alleles from poor combiner and dominant alleles from good combiner could have resulted in such potential crosses from good × poor parental combiners (Dubey, 1975). There were instances in which involvement of both poor combiners produced superior specific combining hybrids as evidenced from the combinations of Arka Anamika × MDU 1 for days to 50 per cent flowering and number of branches per plant, Kamini × MDU 1 for number of fruits per plant, Arka Anamika × Arka Abhay for fruit length. These findings were in concordance with Amarantha Reddy *et al.* (2013) and Raju and Selvam (2017).

Conclusion

Based on *sca* effects of hybrid Hissar Unnat × Pusa Savani days to 50 per cent flowering, number of branches per plant, number of fruits per plant, fruit length, fruit weight and fruit yield per plant, Arka Abhay x Hissar Unnat for plant height at maturity and Kamini × Pusa Savani for fruit girth were adjudged as the best hybrid and suitable for exploitation of heterosis.

Table 1 : Analysis of variance for fruit yield and its attributing characters in bhendi

Source	df	MSS							
		Days to 50 per cent flowering (days)	Plant height at maturity (cm)	Number of branches per plant	Number of fruits per plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (g)	Fruit yield per plant (g)
Replication	2	0.19	2.16	0.14	0.01	0.01	0.02	0.01	2.32
Genotype	35	1.53**	106.69**	0.49**	8.67**	3.20**	0.59**	3.61**	7524.68**
Error	70	0.07	0.79	0.07	0.12	0.03	0.02	0.01	2.02

** Significant at 1 per cent level

Table 2 : Analysis of variance for combining ability effects for fruit yield and yield attributing characters in bhendi

Sources	Mean sum of squares							
	Days to 50 per cent flowering	Plant height at maturity	No. of branches per plant	No. of fruits per plant	Fruit length	Fruit girth	Fruit weight	Fruit yield per plant
GCA	1.63**	90.18**	0.35**	4.77**	1.02**	0.36**	0.41**	5419.40**
SCA	0.47**	23.15**	0.20**	4.58**	1.80**	0.14**	2.32**	1525.73**
RCA	0.17**	29.77**	0.07*	0.57**	0.35**	0.20**	0.35**	2520.32**
GCA/SCA	3.47	3.40	1.75	1.04	0.57	2.57	0.18	3.55

*Significant at 5 per cent level ; **Significant at 1 per cent level

Table 3 : gca effects of parents for fruit yield and yield component characters in bhendi

Combining ability effects								
Parents	Days to 50 per cent flowering	Plant height at maturity	No. of branches per plant	No. of fruits per plant	Fruit length	Fruit girth	Fruit weight	Fruit yield per plant
Arka Anamika	0.44**	3.45**	0.01	-0.38**	0.07**	–0.10**	-0.06**	11.53**
Arka Abhay	0.05	-4.35**	0.03	-0.53**	-0.17**	-0.07**	0.02	-2.84**
Hissar Unnat	-0.67**	-1.75**	0.27**	0.70**	0.32**	0.20**	0.22**	23.20**
Kamini	0.14**	1.11**	-0.05	-0.49**	-0.37**	-0.10**	-0.18**	-24.49**
MDU 1	-0.07	1.56**	-0.26**	-0.19**	-0.20**	-0.17**	-0.20**	-25.52**
Pusa Savani	0.11**	-0.03	-0.01	0.89**	0.34**	0.24**	0.21**	18.11**

*Significant at 5 per cent level
**Significant at 1 per cent level

Table 4 : sca effects of hybrids for fruit yield and yield components characters in bhendi

S. No.	Hybrids	Days to 50 per cent flowering	Plant height at maturity	No. of branches per plant	No. of fruits per plant	Fruit length	Fruit girth	Fruit weight	Fruit yield per plant
1	Arka Anamika x Arka Abhay	-0.17	2.61**	-0.05	0.54**	0.79**	-0.14**	0.36**	12.78**
2	Arka Anamika x Hissar Unnat	-0.23*	-0.55	0.10	0.42**	0.26**	0.09	0.42**	18.65**
3	Arka Anamika x Kamini	-0.15	-2.40**	0.14	0.45**	0.32**	0.07	0.17**	4.37**
4	Arka Anamika x MDU 1	-0.38**	-4.26**	0.24**	0.64**	0.47**	-0.36**	0.26**	8.54**
5	Arka Anamika x Pusa Savani	-0.29**	-0.56	-0.02	-0.10	0.09	0.16**	0.45**	9.07**
6	Arka Abhay x Arka Anamika	0.22*	6.76**	0.06	0.01	-0.12	0.20	0.50**	13.99**
7	Arka Abhay x Hissar Unnat	-0.33**	-5.02**	0.18	-0.20	0.06	-0.26**	0.53**	17.04**
8	Arka Abhay x Kamini	-0.19*	-0.33	0.11	0.44**	0.43**	0.31**	0.61**	10.78**
9	Arka Abhay x MDU 1	-0.20*	0.02	0.05	0.63**	0.71**	-0.19**	0.12**	10.97**
10	Arka Abhay x Pusa Savani	-0.01	1.04**	0.18	0.22	0.08	0.06	0.46**	11.75**
11	Hissar Unnat x Arka Anamika	0.67**	3.99**	0.01	-0.89**	-0.42**	-0.03	-0.44**	-13.13**
12	Hissar Unnat x Arka Abhay	0.28*	-0.29	-0.34**	-0.67**	-0.17*	-0.35**	-0.48**	34.35**
13	Hissar Unnat x Kamini	-0.20*	-1.15**	0.04	0.21	0.57**	-0.33**	0.35**	9.99**
14	Hissar Unnat x MDU 1	0.12	-0.13	0.03	0.18	0.01	0.21**	0.63**	9.04**

15	Hissar Unnat x Pusa Savani	-0.45**	-1.48**	0.38**	3.15**	1.00**	0.16**	1.02**	24.34**
16	Kamini x Arka Anamika	0.33**	-0.07	-0.06	0.28	0.22**	0.31**	-0.06	34.37**
17	Kamini x Arka Abhay	0.01	-6.41**	0.06	-0.22	0.26**	0.15*	0.30**	30.54**
18	Kamini x Hissar Unnat	-0.28*	-2.53**	0.11	0.78**	0.69**	0.59**	0.49**	59.76**
19	Kamini x MDU 1	-0.18*	-0.74*	0.24**	0.70**	0.23**	-0.11*	0.27**	-1.05*
20	Kamini x Pusa Savani	-0.09	-1.10*	0.21*	0.29*	0.10	-0.40**	0.34**	6.41**
21	MDU 1 x Arka Anamika	0.22**	-1.17**	0.17	-0.11	0.30**	-0.10	0.05	41.50**
22	MDU 1 x Arka Abhay	-0.22*	-6.61**	0.22*	-0.06	0.24**	-0.19	-0.10*	33.75**
23	MDU 1 x Hissar Unnat	-0.17	-5.16**	0.01	0.50**	0.26**	-0.08	0.69**	55.89**
24	MDU 1 x Kamini	0.11	-0.01	0.11	-0.17	-0.36**	-0.67**	0.04	0.06
25	MDU 1 x Pusa Savani	-0.05	-2.44**	-0.14	0.15	0.41**	-0.04	0.32**	6.00**
26	Pusa Savani x Arka Anamika	0.50**	5.55**	0.39**	-0.56**	-0.47**	0.01	0.25**	-12.26**
27	Pusa Savani x Arka Abhay	0.17	-0.51	0.17	-0.95**	-0.73**	-0.06	-0.74**	-21.94**
28	Pusa Savani x Hissar Unnat	-0.22*	-3.03**	0.28*	0.11	-0.12	-0.67**	-0.18**	13.65**
29	Pusa Savani x Kamini	0.17	1.39**	0.22*	-0.61**	-0.67**	-0.59**	-0.51**	-49.31**
30	Pusa Savani x Pusa Savani	-0.22*	0.62	0.01	-0.67**	-0.52**	-0.19**	-0.51**	-51.49**

*Significant at 5 per cent level
**Significant at 1 per cent level

Table 5 : Superior hybrids selected based on *gca* and *sca* effects

S. No.	Characters	*gca* effect	*sca* effect	Based on two criteria		
				High × High	High × Low (or) Low × High	Low × Low
1.	Days to 50 per cent flowering (days)	Hissar Unnat	Hissar Unnat × Pusa Savani, Arka Anamika × MDU 1	-	Hissar Unnat × Pusa Savani	Arka Anamika × MDU 1
2.	Plant height at maturity (cm)	Arka Abhay, Hissar Unnat	Arka Abhay × Hissar Unnat	Arka Abhay × Hissar Unnat	–	-
3.	Number of branches per plant	Hissar Unnat	Hissar Unnat × Pusa Savani, Arka Anamika × MDU 1	-	Hissar Unnat × Pusa Savani	Arka Anamika × MDU 1
4.	Number of fruits per plant	Pusa Savani, Hissar Unnat	Hissar Unnat × Pusa Savani, Kamini × MDU 1	Hissar Unnat × Pusa Savani	Hissar Unnat × Pusa Savani	Kamini × MDU 1
5.	Fruit length (cm)	Pusa Savani, Hissar Unnat	Hissar Unnat × Pusa Savani, Arka Anamika × Arka Abhay	Hissar Unnat × Pusa Savani	Hissar Unnat × Pusa Savani	Arka Anamika × Arka Abhay
6.	Fruit girth (cm)	MDU 1, Kamini	Kamini × MDU 1, Pusa Savani Kamini	MDU 1 Kamini	Pusa Savani Kamini	-
7.	Fruit weight (g)	Hissar Unnat, Pusa Savani	Hissar Unnat × Pusa Savani, Hissar Unnat × MDU 1	Hissar Unnat × Pusa Savani	Hissar Unnat × MDU 1	-
8.	Fruit yield per plant (g)	Hissar Unnat, Pusa Savani	Hissar Unnat × Pusa Savani, Hissar Kamini□Unnat	Hissar Unnat × Pusa Savani	Kamini Hissar Unnat	-

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