Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; SP2: 598-601

S Suganthi
Department of Genetics and Plant Breeding Faculty of Agriculture Annamalai University, Annamalainagar, Chidambaram, Tamil Nadu, India

P Sathiskumar
Department of Genetics and Plant Breeding Faculty of Agriculture Annamalai University, Annamalainagar, Chidambaram, Tamil Nadu, India

A Kamaraj
Department of Genetics and Plant Breeding Faculty of Agriculture Annamalai University, Annamalainagar, Chidambaram, Tamil Nadu, India

R Shanmugapriya
Department of Genetics and Plant Breeding Faculty of Agriculture Annamalai University, Annamalainagar, Chidambaram, Tamil Nadu, India

Correspondence
S Suganthi
Department of Genetics and Plant Breeding Faculty of Agriculture Annamalai University, Annamalainagar, Chidambaram, Tamil Nadu, India

Exploitation of heterosis through diallel analysis in bhendi (*Abelmoschus esculentus* (L.) Moench)

S Suganthi, P Sathiskumar, A Kamaraj and R Shanmugapriya

Abstract
A study was undertaken to identify the potential parents and superior hybrids for yield improvement in Bhendi at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University during the year 2015. 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 (diallel fashion) and produced 30 hybrids (including reciprocal crosses). The characters observed were days to 50 per cent flowering, plant height at maturity, number of branches per plant,fruit length, fruit girth, fruit weight and fruit yield per plant. Standard heterosis was computed for commercial exploitation of hybrid vigour. One of the parents Hissar Unnat, a national check variety was considered as standard variety to work standard heterosis. The hybrids selected based on the magnitude of heterosis, the hybrid Hissar Unnat × Pusa Savani possessed significant positive value for number of branches per plant, number of fruits per plant, fruit length, fruit weight and fruit yield per plant. Hissar Unnat × Pusa Savani recorded maximum negative and significant heterosis for days to 50 per cent flowering, Arka Abhay x Hissar Unnat negative and significant heterosis for plant height and Arka Anamika × MDU 1 recorded maximum negative and significant heterosis for fruit girth. These hybrids have been identified as best hybrids from the productivity point of view, further these high yielding hybrids may be tried under different environments to test their stability over locations and to confirm their superiority.

Keywords: heterosis, potential parents, genetic diversity

Introduction
Bhendi (*Abelmoschus esculentus* (L.) Moench) 2n=8x=72 or 144 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, eggplant and cucurbits. The plant is used for clarification of sugarcane juice before it is converted into jaggery. Seeds are used after roasting as substitute for coffee (Arya and Fagaria, 1991) [2]. The medicinal value of bhendi is associated with genitourinary disorders, spermatorhoea and chronic dysentery. 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. Seeds of Pusa makhmali had the highest oil content (173 per cent). Bhendi seeds contain 18 to 20 per cent oil and 10 to 13 percent of crude protein. It is an important member of the family Malvaceae. It has been reported by Willis (1966) [21] that there are 30 species under the genus in the old world and four in new world. Out of them *A. esculentus* is the only species known to be cultivated. However,

A. manihot spp. Manihot is also cultivated in a limited scale in Africa. 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) [5]. 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. To exploit the heterosis of potential yield components, knowledge of genetic architecture of fruit yield and its attributes is important in crop improvement. The magnitude of heterosis provides a basis for genetic diversity and a guide to the choice of desirable parents for developing superior hybrids. Therefore the present investigation was carried out to estimate the magnitude

of heterosis for fruit yield and contributing charcters in Bhendi.

Materials and Methods

The present investigation on the was carried out at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, during January-March, 2015 and F_1 evaluation was carried out during June-August 2015. 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 2015, the seeds of the six varieties were sown in ridges and thirty crosses were effected as per the formula diallel (Hayman, 1960). One of the parent Hissar Unnat, a national check variety was considered as standard variety to work standard heterosis. Thirty hybrids along with their selfed parents were sown in Randomized Block design, replicated thrice. Each combination was sown in a row of 3.0m length. A row spacing of 45cm 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. Data were recorded on the quantitative characters viz., Days to 50 per cent 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).

Result and Discussion

Heterosis works as a basic tool for improved production of crops in the form of F_1 hybrids. The heterotic studies can provide the basis for the exploitation of valuable hybrid combinations in the future breeding programmes and their commercial utilization. The hybrids with high amount of heterosis can be exploited. The hybrids are normally assessed in terms of per cent increase over mid parent, better parent and standard parent. Swaminathan *et al.* (1972) [18] and Bobby and Nadarajan (1994) [3] stressed the need for computing standard heterosis for commercial exploitation of hybrid vigour. Hence, for the evaluation of hybrids, standard heterosis is to be given more importance rather than the other two.

Earliness is an important trait in vegetables like bhendi. Earliness is required in such crops for realisisng the potential economic yield in a less time as possible, which is an important consideration for a vegetable grower. In the present investigation, for days to 50 per cent flowering Standard heterosis was maximum negative and significant in Hissar Unnat × Arka Abhay and Hissar Unnat x Pusa Savani (-2.85 per cent) followed by Hissar Unnat × Pusa Savani (-2.85 per cent) and Pusa Savani × Hissar Unnat (-1.59 per cent). Six hybrids recorded negative and significant standard heterosis. Similar results have been observed by Solankey and Singh (2010) [17], Thirupathi Reddy *et al*. (2012) [19], Patel *et al*. (2015) [12] and kumar *et al*. (2015) [9]. Plant height at maturity is one of the important ideotype in bhendi for higher yield. The results for plant height showed that Standard heterosis was maximum negative and significant Arka Abhay x Hissar Unnat (-15.14 per cent), Hissar Unnat x Arka Abhay (-14.61 per cent) and Arka Abhay x Kamini (-13.81 per cent). Twenty six hybrids recorded negative and significant values for this character. The present findings are in close association with results reported by Solankey and Singh (2011) and Lyngdoh *et al*. (2013). Number of fruits per plant, fruit length, fruit weight and fruit girth are all very closely related productivity parameters. The trait number of fruits per plant exhibited maximum positive and significant standard heterosis by the hybrid Hissar Unnat × Pusa Savani (42.78 per cent) followed by Pusa Savani × Hissar Unnat (41.46 per cent). Thirty hybrids recorded positive significant values. Recording fruit length, Thirty hybrids exhibited positive and significant standard heterosis and it was maximum in Pusa Savani × Hissar Unnat (17.14 per cent) followed by Hissar Unnat × Pusa Savani (15.76 per cent). In case of fruit girth twenty six hybrids exhibited negative and significant standard heterosis and it was maximum in Kamini × MDU 1 (-25.07 per cent) followed by Kamini × Pusa Savani (-21.86) and Kamini × Hissar Unnat (-21.60 per cent). With regard to fruit weight, Thirty hybrids recorded positive significant standard heterosis and it was maximum in Pusa Savani × Hissar Unnat (24.96 per cent) followed by Pusa Savani × Arka Abhay (23.76 per cent) and Hissar Unnat × MDU 1 (23.19 per cent). These results are in harmony with the earlier findings of Jethava (2014) [7], Nagesh *et al.* (2014) [11] and Kumar *et al*. (2015) [9]. Fruit yield per plant is the ultimate and the most important trait. In the present study, standard heterosis was maximum positive and significant in Hissar Unnat × Pusa Savani (35.16) followed by Hissar Unnat × Arka Anamika (32.09 per cent) and Hissar Unnat × Arka Abhay (31.30 per cent). Twenty hybrids recorded positive and significant values for the fruit yield per plant (Table 1.)

The hybrids selected based on the magnitude of heterosis, the hybrid Hissar Unnat × Pusa Savani possessed significant positive value for number of branches per plant, number of fruits per plant, fruit length, fruit weight and fruit yield per plant. Hissar Unnat × Pusa Savani recorded maximum negative and significant heterosis for days to 50 per cent flowering, Arka Abhay x Hissar Unnat negative and significant heterosis for plant height and Arka Anamika × MDU 1 recorded maximum negative and significant heterosis for fruit girth. Similar results for earliness were reported by Jindal *et al.* (2009) [8]. These hybrids have been identified as best hybrids from the productivity point of view, further these high yielding hybrids may be tried under different environments to test their stability over locations and to confirm their superiority. These findings are in consonance with Mehta *et al.* (2007) [10], Wammanda *et al.* (2010) [20] and Lyngdoh *et al.* (2013). Maximum standard heterosis for yield parameters were reported by Dabandata *et al.* (2010) [4], Senthil Kumar and Sreeparvathy (2010) [14], Wammanda *et al.* (2010) [20], Lyngdoh *et al.* (2013), Solankey *et al.* (2013) [16], Arti Verma and Sonia Sood (2015) [1] and Shashikumar and Thirupathi Reddy (2015) [15].

Grafius (1959) [6] Suggested that there could not be any one gene system for yield *per se* and that the yield was an end product of multiplicative interaction between yield components. Hence, from the foregoing discussion, it may be concluded that Hissar Unnat × Pusa Savani, Arka Anamika × Arka Abhay and Arka Anamika × MDU 1 can be rated as best hybrids and the hybrids Arka Anamika × Hissar Unnat and Arka Abhay × Pusa Savani can be rated as better hybrids based on the magnitude of heterosis (Table 2).

It is clear from the above discussion that the above said

hybrid was found to be the most promising for fruit yield and other yield attributing characters. The conclusion drawn from the results manifested that both additive and non-additive component of genetic variances.

Were involved with predominance of dominance variances for most of the yield characters. As additive variance is predominant for the characters, days to 50 per cent flowering, plant height at maturity, number of branches per plant, fruit length, fruit girth. Pedigree selection is an appropriate method to improve these characters. As selection based on progeny performance exploits only additive component of genetic variances, bi-parental mating or diallel selective mating, which allows intermating among selected segregants in the different cycles, would be useful to recover superior homozygotes in later generations.

Table 1: Percentage of standard heterosis of diallel hybrids in sesame

S. No	Hybrids	Days to 50 per cent flowering (per cent)		Plant height at maturity (per cent)		Number of branches per plant (per cent)		Number of fruits per plant (per cent)	
		Direct	Reciprocal	Direct	Reciprocal	Direct	Reciprocal	Direct	Reciprocal
1	Arka Anamika × Arka Abhay	2.21*	0.95*	3.39**	-9.22**	6.61	3.30	11.85**	11.85**
2	Arka Anamika × Hissar Unnat	1.26	-2.54	0.28**	-7.15**	16.62*	16.62*	13.17**	23.69**
3	Arka Anamika × Kamini	2.85**	0.95**	-2.56**	-2.42**	6.61	9.91	13.17**	9.87**
4	Arka Anamika × MDU 1	1.26	0.00	-4.90**	-2.72**	9.91	0.00	13.82**	15.14**
5	Arka Anamika × Pusa Savani	2.85*	0.00	3.33**	-7.01**	16.62	-6.71	13.17**	19.74**
6	Arka Abhay × Hissar Unnat	-1.27**	-2.85**	-15.14**	-14.61**	9.91**	30.03**	9.87**	17.77**
7	Arka Abhay × Kamini	0.64	0.64	-13.81**	-1.86**	9.91	6.61	9.22**	11.85**
8	Arka Abhay × MDU 1	-0.64	0.64	-13.26**	-0.93**	6.61	-6.71	13.17**	13.82**
9	Arka Abhay × Pusa Savani	1.58	0.64	-8.10**	-7.15**	16.62	6.61	11.85**	23.04**
10	Hissar Unnat × Kamini	-2.21*	-0.64*	-8.53**	-3.82**	16.62*	9.91*	21.07**	11.85**
11	Hissar Unnat × MDU 1	-1.59	-0.64	-9.62**	0.01**	6.61	6.61	21.07**	15.14**
12	Hissar Unnat × Pusa Savani	-2.85**	-1.59**	-10.37**	-4.72**	33.33**	16.62**	42.78**	41.46**
13	Kamini × MDU 1	0.64	0.00	-2.72**	-2.70**	6.61	0.00	13.17**	15.14**
14	Kamini × Pusa Savani	1.58	0.64	-3.23**	-5.83**	16.62	3.30	14.49**	21.72**
15	MDU 1 × Pusa Savani	0.01	1.26	-4.78**	-5.94**	-6.71	-6.71	15.14**	23.04**

*Significant at 5 per cent level; **Significant at 1 per cent level
Standard variety-Hissar Unnat

Table 1: Contd…

S. No	Hybrids	Fruit length (per cent)		Fruit girth (per cent)		Fruit weight (per cent)		Fruit yield per plant (per cent)	
		Direct	Reciprocal	Direct	Reciprocal	Direct	Reciprocal	Direct	Reciprocal
1	Arka Anamika × Arka Abhay	10.28**	11.65**	-10.30**	-16.55**	20.14**	14.17**	21.39**	12.61**
2	Arka Anamika × Hissar Unnat	8.37**	13.07**	-5.94**	-5.10**	15.99**	21.29**	21.95**	32.09**
3	Arka Anamika × Kamini	8.45**	5.92**	-5.83**	-15.45**	14.33**	15.05**	18.35**	-3.23**
4	Arka Anamika × MDU 1	10.65**	7.32**	-20.13**	-16.92**	15.45**	14.85**	21.58**	-4.49**
5	Arka Anamika × Pusa Savani	7.24**	12.52**	-3.63	-3.89	20.30**	17.30**	18.56**	26.26**
6	Arka Abhay × Hissar Unnat	7.32**	9.18**	-16.08**	-5.15**	16.85**	22.57**	12.71**	31.30**
7	Arka Abhay × Kamini	7.92**	4.98**	-3.99**	-8.62**	19.58**	15.99**	14.65**	-4.53**
8	Arka Abhay × MDU 1	10.37**	7.65**	-16.71**	-14.03**	14.13**	15.35**	15.40**	-5.80**
9	Arka Abhay × Pusa Savani	4.36**	12.56**	-5.78*	-3.89*	14.81**	23.76**	11.85**	25.63**
10	Hissar Unnat × Kamini	13.90**	6.13**	-2.94**	-21.60**	20.37**	14.51**	31.75**	-5.78**
11	Hissar Unnat × MDU 1	9.24**	6.35**	-6.20*	-3.63*	23.19**	14.87**	29.92**	-5.19**
12	Hissar Unnat × Pusa Savani	15.76**	17.14**	0.68	1.05	22.75**	24.96**	35.16**	26.59**
13	Kamini × MDU 1	3.15**	7.22**	-25.07**	-4.10**	14.69**	14.17**	-5.76**	-5.80**
14	Kamini × Pusa Savani	3.71**	11.16**	-21.86**	-3.31**	14.31**	20.45**	-5.22**	25.75**
15	MDU 1 × Pusa Savani	7.22**	13.10**	-11.09**	-5.15**	14.11**	20.18**	-6.36**	25.98**

*Significant at 5 per cent level; **Significant at 1 per cent level
Standard variety-Hissar Unnat

Table 2: Superior hybrids selected based on standard heterosis

S. No	Characters	Standard heterosis (d_{iii})
1.	Days to 50 per cent flowering (days)	Hissar Unnat × Pusa Savani, Hissar Unnat × Arka Abhay, Pusa Savani × Hissar Unnat
2.	Plant height at maturity (cm)	Arka Abhay × Hissar Unnat, Hissar Unnat × Arka Abhay, Arka Abhay × Kamini
3.	Number of branches per plant	Hissar Unnat × Pusa Savani, Hissar Unnat × Arka Abhay
4.	Number of fruits per plant	Hissar Unnat × Pusa Savani, Pusa Savani × Hissar Unnat
5.	Fruit length (cm)	Hissar Unnat × Arka Anamika, Hissar Unnat × Pusa Savani, Pusa Savani × Hissar Unnat
6.	Fruit girth (cm)	Kamini × MDU 1, Kamini × Pusa Savani, Arka Anamika × MDU 1
7.	Fruit weight (g)	Pusa Savani × Hissar Unnat, Hissar Unnat × MDU 1, Arka Abhay × Pusa Savani
8.	Fruit yield per plant (g)	Hissar Unnat × Pusa Savani, Arka Anamika × Hissar Unnat, Hissar Unnat × Kamini

References

1. Arti Verma, Sonia Sood. Genetic expression of heterosis for fruit yield and yield components in interspecific hybrids of okra (*Abelmoschus esculentus* (L.) Moench). J Breed. Genet. 2015; 47(3):221-230.
2. Arya PS, Fagaria MS. Okra needs proper care. Indian Farm Digest. 1991; 24(4):17-18.
3. Bobby TPM, Nadarajan N. Heterosis and combining ability studies in rice hybrids involving CMS lines. Oryza. 1994; 31:5-8.
4. Dabandata C, Beli MJ, Amougou A, Ngalle BN. Heterosis and combining ability in a diallel cross of okra (*Abelmoschus esculentus* (L.) Moench). Agronomie Africaine, 2010, 22(1).
5. FAO, Stat, 2015. www.faostat.org.
6. Grafius JK. Heterosis in barley. Agronomy J. 1959; 51:551-554.
7. Jethava BA. Heterosis and combining ability in okra (*Abelmoschus esculentus* (L.). Moench). M.Sc., Thesis, Navsari Agricultural University, Navsari, 2014.
8. Jindal SK, Deepak Arora, Ghai TR. Heterobeltiosis and combining ability for earliness in okra (*Abelmoschus esculentus* (L.) Moench). Crop Improvement. 2009; 36(1):1-5.
9. Kumar N, Saravaiya SN, Patel AI, Nazaneen NS. Heterosis studies in okra (*Abelmoschus esculentus* (L.) Moench). Trends Biosci. 2015; 8(1):236-241.
10. Mehta N, Asati BS, Mamidwar SR. Heterosis and gene action in Okra. Bangladesh J Agril. Res. 2007; 32(3):421-432.
11. Nagesh GC, Mugle R, Rathod V, Basavaraj LB, Mahaveer SM. Heterosis and combining ability studies in okra (*Abelmoschus esculentus* (L.). Moench) for yield and quality parameters. Nig. J Genet. 2014; 9(4):1717-1723.
12. Patel HB, Bhanderi DR, Patel AI, Tank RV, Akilesh Kumar. Magnitude of heterosis for fruit yield and its contributing characters in okra (*Abelmoschus esculentus* L.) Moench. J Life Sci. 2015; 10(2):939-942.
13. Patel HB, Bhanderi DR, Patel AI, Tank RV, Akilesh Kumar. Magnitude of heterosis for fruit yield and its contributing characters in okra (*Abelmoschus esculentus* L.) Moench. J Life Sci. 2015; 10(2):939-942.
14. Senthil Kumar P, Sreeparvathi S. Studies on heterosis in okra (*Abelmoschus esculentus* (L.) Moench). Elect. J. Plant Breeding. 2010; 1(6):1431-1433.
15. Shashikumar M, Thirupathi Reddy. Heterotic potential of single cross hybrids in okra (*Abelmoschus esculentus* (L.) Moench). J Global agric. Ecol. 2015; 64(1):45-66.
16. Solankey SS, Singh AK, Singh RK. Genetic expression of heterosis for yield and quality traits during different growing seasons in okra *Abelmoschus esculentus* L. Indian J Agri. Sci. 2013; 83(8):815-819.
17. Solankey SS, Singh AK. Studies on combining ability in okra (*Abelmoschus esculentus* (L.) Moench). The Asian Journal of Horticulture. 2010; 5(1):49-53.
18. Swaminathan MS, Siddiq EA, Sharma SD. Outlook for hybrid rice in India. *In:* Rice Breeding, Int. Rice Res., Inst., Manila, Philippines, 1972, 609-613.
19. Thirupathi Reddy M, Hari Babu K, Ganesh M, Begum H. Combining ability and heterosis for yield and yield components in Okra (*Abelmoschus esculentus* (L.) Moench. Chilean J Agri. Res. 2012; 72(3):27-33.
20. Wammanda DT, Kadams AM, Jonah PM. Combining ability analysis and Heterosis in a diallel cross of okra (*Abelmoschus esculentus* (L.) Moench*).* African J Agrl. Res. 2010; 5(16):2108-2115.
21. Willis JC. Dictionary of the flowering plants 7th Revised Edition, Cambridge Univ., Press, London, 1966.