Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 2401-2404

SR Jogi
Department of Agricultural Botany, College of Agriculture, Latur, VNMKV, Parbhani (M.S.), India

VN Toprope
Department of Agricultural Botany, College of Agriculture, Latur, VNMKV, Parbhani (M.S.), India

AS Jondhale
Department of Agricultural Botany, College of Agriculture, Latur, VNMKV, Parbhani (M.S.), India

Correspondence
SR Jogi
Department of Agricultural Botany, College of Agriculture, Latur, VNMKV, Parbhani (M.S.), India

‘‘Generation mean analysis in okra (*Abelmoschus esculentus* (L.) Moench)”

SR Jogi, VN Toprope and AS Jondhale

Abstract
The present investigation, entitled “Generation mean analysis in Okra (*Abelmoschusesculentus* (L.) Moench)” was undertaken using six generations *viz.*, P_1, P_2, F_1, F_2, BC_1 and BC_2 derived from two crosses namely Pusa A4 x Phule Utkarsha and Arka Bahar x IC 31032A. The material was evaluated in a Randomized Block Design with two replicates during *kharif*, 2016. The characters studied were days to 50 % flowering, plant height (cm), number of branches per plant, inter-nodal length (cm), number of nodes per plant, number of fruits per plant, fruit length (cm), fruit diameter (mm), fruit weight (g), powdery mildew severity (%), fruit borer infestation (%) and fruit yield per plant (g). None the F_1’s in both the crosses exhibited significant better parent heterosis except plant height in Pusa A4 x Phule Utkarsha and inter-nodal length in both crosses. Whereas both crosses exhibited high standard heterosis and inbreeding depression for fruit yield and its component characters under study.

Keywords: Heterobeltiosis, Inbreeding depression and Standard heterosis.

Introduction
Okra (*Abelmoschusesculentus* (L) Monech) is an important vegetable crop grown in the tropical and subtropical parts of the world. Okra belongs to family Malvaceae with 2n =130 chromosomes and amphidiploid nature. Okra originated in Ethiopia (Sathish and Eswar, 2013) and was then propagated in North Africa, in the Mediterranean, in Arabia and India by the 12th century BC (Nzikou *et al*., 2006). It is an oligo purpose crop, but it is usually consumed for its green tender fruits as a vegetable in a variety of ways. Its average nutritive value is higher than tomato, egg-plant and most of the cucurbits.Nutritionally, okra green fruits are rich in vitamins (A, B and C) and minerals (Ca, P, Mg and Fe) and an excellent source of iodine.Okra seed oil is rich in unsaturated fatty acids such as linoleic acid, which is essential for human nutrition. Its mature fruit and stems contain crude fiber, which is used in the paper industry. The roots and stem of okra are used as clarifier for cane juice from brown sugar or gur is prepared (Chuhan, 1972).
It is commercially grown in India states of Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. India is leader in the world in area and production of okra with 5849 metric tons of production obtained from an area of 511lakh hectare under the crop (Anonymous, 2016). The area under the crop in Maharashtra during year 2015-16 was 12.19 lakh hectares. The state ranks seventh in the country with production of 119.09 metric tons. However, Maharashtra’s productivity is much lower than that of the country (Anonymous, 2016).

Materials and Methods:
Two crosses involving four genetically diverse parents *viz.*,Pusa A4, phuleUtkarsha, ArkaBahar and IC 31023A were effected in *kharif*, 2016 by hand emasculation and pollination. The F_1’s and parents were grown in *summer*, 2016 to advance the F_2’s and to prepare BC_1 and BC_2 crosses. Thus seed of six generation, P_1, P_2, F_1, F_2, BC_1 and BC_2 of two crosses were produced and were sown during*kharif*, 2017 in Randomized Block Design replicated twice. Each plot consisted one row of P_1, P_2, F_1, BC_1 and BC_2 and three rows of F_2. The row to row and plant to plant distance was kept as 45 cm and 30 cm, respectively.

Table 1: Details of experimental material.

Generation	Cross I	Cross II
P_1	Pusa A4	ArkaBahar
P_2	PhuleUtkarsha	IC 31032A
F_1	Pusa A4 x PhuleUtkarsha	PhuleUtkarsha x IC 31032A
F_2	Selfing of F_1	Selfing of F_1
BC_1	(Pusa A4 x PhuleUtkarsha) x Pusa A4	(PhuleUtkarsha x IC 31032A) x ArkaBahar
BC_2	(Pusa A4 x PhuleUtkarsha) x PhuleUtkarsha	(PhuleUtkarsha x IC 31032A) x IC 31032A

Estimation of heterosis

Heterobeltiosis was measured as the proportion of the deviation of the mean value from the better parent value and standard heterosis from the value of standard check. Following formulae were used to calculate different heterosis.

1. Better parent (heterobeltiosis) = $(\overline{F_1} - \overline{BP} / \overline{BP}) \times 100$

2. Standard check = $(\overline{F_1} - \overline{\text{Std. Check}} / \overline{\text{Std. Check}}) \times 100$

(Standard heterosis)

Where,

$\overline{F_1}$: Average performance of F_1 hybrid.

$\overline{BP}$: Mean values of Better parent.

$\overline{\text{Std. check}}$: Mean values of standard check.

Estimation of inbreeding depression

Inbreeding depression was computed by the following formula,

Inbreeding depression = $[(\overline{F_1} - \overline{F_2}) / \overline{F_1}] \times 100$

Where,

$\overline{F1}$ = mean of F_1

$\overline{F2}$ = mean of F_2

The significance of heterosis and inbreeding depression was tested with the help of critical difference (C.D) for heterosis (Mp or Bp) is taken into account cross wise. For inbreeding depression mean value of F_1 and F_2 are compared. When, difference is greater than C.D. It is considered significant and vice versa.

Results:

Estimation of heterosis and inbreeding depression.

Heterosis is the superiority or inferiority of F_1's over the parents whereas inbreeding depression is called as a loss in fitness or vigour due to inbreeding. The results pertaining to heterobeltiosis, standard heterosis and inbreeding depression of the present investigation are presented in (Table 1).

Pusa A4 × PhuleUtkarsha

Among the characters studied the cross, Pusa A4 × PhuleUtkarsha had exhibited highest and significant heterobeltiosis for powdery mildew severity (6.94) followed fruit borer (5.12), intermodal length (4.65), fruit length (2.94) and plant height (1.76).

The standard heterosis over PrabhabniKranti was ranged from -6.67 % (days to 50% flowering) to 54.40% (fruit yield per plant). The highest positive and significant standard heterosis over ParbhaniKranti was recorded by fruit yield per plant (54.40 %) followed by number of fruits per plant (50.33 %), number of nodes per plant (18.18 %), plant height (17.43 %), fruit length (17.33 %), fruit weight (13.65 %), fruit diameter (5.73 %) and intermodal length (4.03 %). Whereas, it was ranged from -8.70% (days to 50 % flowering) to 92.86 % (fruit yield per plant) over Private hybrid. The highest positive and significant standard heterosis over Private hybrid was recorded for fruit yield per plant (92.86 %) followed by number of fruits per plant (52.32 %), number of branches per plant (48.18 %), fruit weight (37.32 %) and fruit length (26.10 %) in desirable direction.

The negative heterosis is desirable for days to 50 % flowering. In the present investigation the cross Pusa A4 × PhuleUtkarsha, expressed significant negative standard heterosis over PrabhabniKranti (-6.67%) and Private hybrid (-8.70 %).

Estimate of inbreeding depression presented in Table No.1 revealed that among the characters studied, it was ranged from -11.04 % (number of branches per plant) to 39.05 % (fruit borer infestation). The maximum positive significant inbreeding depression exhibited by fruit borer infestation (39.05 %) followed by fruit yield per plant (24.74 %), number fruits per plant (16.23 %), fruit length (13.25 %) and fruit weight (11.15 %).Whereas, lowest inbreeding depression which is desirable in direction were recorded by number of branches per plant (-11.04 %), number of nodes per plant (0.52 %), inter-nodal length (1.40%) and plant height (3.56%).

ArkaBahar× IC 31032A

Among the characters studied the heterobeltiosis for this cross was ranged from -32.86 % (fruit diameter) to 20.97 % (inter-nodal length). The highest significant heterobeltiosis was recorded by inter-nodal length (20.97 %) and plant height (13.20 %). Negative heterobeltiosis was desirable for powdery mildew severity (-9.83 %).

The range of standard heterosis over ParbhaniKranti in this cross among character was from -36.81 % (fruit borer infestation) to 34.25 % (plant height). The highest significant positive standard heterosis recorded by plant height (34.25 %), number of nodes per plant (22.31 %), fruit diameter (13.21 %), inter-nodal length (10.29 %), number of fruits per plant (9.15 %) and fruit yield per plant (5.85 %).

Standard heterosis over Private hybrid was ranged from -11.59 % (fruit borer infestation) to 54.55 % (number of branches per plant). The highest positive significant standard heterosis over Private hybrid recorded by number of branches per plant (54.55 %), fruit yield per plant (32.22 %), fruit weight (28.38 %), fruit diameter (11.84 %) and number of fruits per plant (10.60 %). Negative standard heterosis recorded by fruit borer infestation (-11.59 %), powdery mildew severity (-3.95 %) and days to 50% flowering (-2.17 %).

The range of inbreeding depression among the characters was ranged from -66.46% (fruit borer infestation) to 20.93 % (plant height). The lowest inbreeding depression is desirable to yield and yield contributing traits like number of branches per plant (-12.35 %), fruit weight (2.95 %), fruit length (3.67 %) and inter-nodal length (5.75 %). Whereas, positive highest inbreeding depressions were recorded by plant height (20.93 %), fruit yield per plant (13.84 %), number of nodes per plant (13.24 %) and number of fruits per plant (10.89 %).

Table 1: Estimate of better parent heterosis and standard heterosis over Parbhani Kranti and Private hybrid in two crosses of okra

Crosses	Percent heterosis over			Inbreeding depression (%)	Components of heterosis			
	BP (%)	SH (%)			(-h)	(i)	(-d)	½ j
		C-I	C-II					
Days to 50% flowering								
Pusa A4 x PhuleUtkarsha	0.00	-6.67**	-8.70**	-2.38**	7.25**	8.00**	2.00**	0.62**
ArkaBahar x IC 31032A	4.65	0.00	-2.17	1.11**	-2.75**	-4.00**	0.001	-0.37
Plant height (cm)								
Pusa A4 x PhuleUtkarsha	1.76	17.43	-10.34	3.56**	-13.68	-20.68	-4.60	0.05
ArkaBahar x IC 31032A	13.20**	34.25**	2.50	20.93**	108.54**	89.64**	1.30	0.05
No. of branches per plant								
Pusa A4 x PhuleUtkarsha	-18.50	0.31	48.18	-11.04**	2.49**	2.76**	-0.80**	-0.45**
ArkaBahar x IC 31032A	-8.84	4.62	54.55*	-12.35**	-0.27**	-0.24**	-0.10**	-0.11**
Inter-nodal length (cm)								
Pusa A4 x PhuleUtkarsha	4.65**	4.03*	-1.54	1.40*	0.51**	0.57**	-0.71**	-0.19**
ArkaBahar x IC 31032A	20.97**	10.29**	4.38*	5.75**	1.42**	1.18**	-1.19**	-0.15**
No. of nodes per plant								
Pusa A4 x PhuleUtkarsha	-6.53	18.18*	-4.67	0.52*	1.50**	2.10**	1.50**	0.95**
ArkaBahar x IC 31032A	-9.75	22.31*	-1.33	13.24*	4.09**	2.84**	3.70**	0.42*
No. of fruits per plant								
Pusa A4 x PhuleUtkarsha	-1.28	50.33**	52.32**	16.23**	3.84**	2.34**	5.90**	3.85**
ArkaBahar x IC 31032A	-2.33	9.15**	10.60**	10.89**	8.43**	7.68**	2.80**	0.82**

*,**significance at 5% and 1% respectively. C-I = ParbhaniKranti, C-II = Private hybrid

Continued…

Table 1: Estimate of better parent heterosis and standard heterosis over Parbhani Kranti and Private hybrid in two crosses of okra

Crosses	Percent Heterosis over			Inbreeding depression (%)	Component of heterosis			
	BP%	SH%			(-h)	(i)	(-d)	½ j
		C-I	C-II					
Fruit length (cm)								
Pusa A4 x PhuleUtkarsha	2.94	17.33	26.10*	13.25**	5.28**	4.68**	1.53**	0.85**
ArkaBahar x IC 31032A	-20.34**	-14.26	-7.86	3.67**	3.72**	3.79**	2.36**	-0.13
Fruit diameter (mm)								
Pusa A4 x PhuleUtkarsha	-4.11	5.73	4.45	7.28**	3.66**	3.75**	1.06**	0.85**
ArkaBahar x IC 31032A	-32.86**	13.21*	11.84	-1.35*	2.21*	5.13**	-5.62**	0.15
Fruit weight (g)								
Pusa A4 x PhuleUtkarsha	-12.44*	13.65	37.32*	11.15**	4.43**	5.20**	2.75**	2.18**
ArkaBahar x IC 31032A	-28.49**	6.25	28.38	2.95**	9.25**	11.79**	-5.58**	-0.93**
Powdery mildew severity (%)								
Pusa A4 x PhuleUtkarsha	6.94*	-2.48	8.48**	-0.43**	3.36**	3.26**	-0.44**	0.10*
ArkaBahar x IC 31032A	-9.83**	-13.66**	-3.95	-0.99**	0.05	1.26**	1.42**	0.76**
Fruit borer infestation (%)								
Pusa A4 x PhuleUtkarsha	5.12	3.90	45.35**	39.05**	19.09**	18.54**	7.65**	4.03**
ArkaBahar x IC 31032A	19.03	-36.81	-11.59	-66.46**	-41.35**	-42.02**	-5.86**	-3.56**
Fruit yield per plant (g)								
Pusa A4 x PhuleUtkarsha	-14.32	54.40**	92.86**	24.74**	155.28**	151.14**	151.30**	109.78**
ArkaBahar x IC 31032A	-19.05	5.85	32.22*	13.84**	282.52**	306.43**	-39.76**	-0.89

*,**significance at 5% and 1% respectively. C-I = ParbhaniKranti, C-II = Private hybrid

Discussion:

Heterosis and inbreeding depression

None of the cross combinations exhibited significant heterobeltiosis except ArkaBahar × IC 31032A for plant height, Pusa A4 × PhuleUtkarsha and ArkaBahar × IC 31032A for internodal length and ArkaBahar × IC 31032A for powdery mildew severity. The results are in the harmony of Aware *et al.* (2014) for intermodal length and plant height. Similar results earlier reported by Javia (2013) and Sabesan *et al.* (2016) reported similar findings for intermodal length.

The highest positive and significant standard heterosis over ParbhaniKranti exhibited for intermodal length, number nodes per plant, number of fruits per plant and fruit yield per plant in the cross Pusa A4 × PhuleUtkarsha. Whereas, for plant height, intermodal length, number of nodes per plant, number of fruits per plant, fruit diameter in the cross ArkaBahar × IC 31032A. However, the positive and significant standard heterosis over Private hybrid was exhibited for number of fruits per plant, fruit length, fruit weight and fruit yield per plant in the cross Pusa A4 × PhuleUtkarsha. Whereas, for number of branches per plant, number of fruits per plant and fruit yield per plant in the cross ArkaBahar × IC 31032A. Similar results were reported by Aware *et al.* (2014) for fruit yield per plant, diameter of fruit, plant height and number of fruits per plant; Verma *et al.* (2015) for number of fruits per plant, fruit yield per plant, for number of nodes per plant and plant height; Neetu *et al.* (2015) for plant height and number of fruits per plant; Sabesan *et al.* (2016) for plant height, intermodal length, number of nodes per plant and number of fruits per plant.

The negative heterosis is desirable for days to 50 % flowering, powdery mildew severity and fruit borer

infestation. In the present investigation negative significant standard heterosis was recorded in the cross Pusa A4 × PhuleUtkarsha for days to 50 % flowering where as in the cross ArkaBahar × IC 31032A for powdery mildew severity and fruit borer infestation. Similar results were reported by Medagam *et al.* (2013) for days to 50% flowering; Verma *et al.* (2015) for days to 50 % flowering and Kumar *et al.* (2013) for days to 50 % flowering. Therefore, these hybrids may be advanced and exploited in future breeding programmes for improving yield and its components in okra. These hybrids offer high scope for the exploitation of heterosis.

The maximum positive and significant inbreeding depression was exhibited for fruit yield per plant, number of fruit per plant, fruit length and fruit weight in the cross Pusa A4 × Phule Utkarsha, where as it was for plant height, fruit yield per plant, number of nodes per plant and number of fruits per plant in the cross ArkaBahar × IC 31032A. Similar results were reported by Aware *et al.* (2014) for plant height; Neetu *et al.* (2015) for fruit yield per plant, number of fruits per plant and fruit length and Sabesan *et al.* (2016) for number of nodes per plant, number of fruits per plant, fruit length, fruit weight and fruit yield per plant. However, the lowest inbreeding depressions recorded for number of branches per plant, number of nodes per plant, inter-nodal length and plant height in the cross Pusa A4 × PhuleUtkarsha and for number of branches per plant, fruit diameter and intermodal length in ArkaBahar × IC 31032A.

Thus the cross, Pusa A4 x PhuleUtkarsha showed high standard heterosis with inbreeding depression for fruit yield per plant, fruit weight, fruit diameter, fruit length, number of fruits per plant. Whereas the cross, ArkaBahar x IC 31032A for fruit yield per plant, number of fruits per plant, number of nodes per plant, plant height indicate that these traits were influenced by non-additive gene action. This could be exploited for heterosis breeding. Similar results were observed by Sabesan *et al.* (2016), Neetu *et al.* (2015) and Aware *et al.* (2014).

The F_1 of Pusa A4 x PhuleUtkarsha for plant height, number of nodes per plant and fruit length and F_1 of ArkaBahar x IC 31032A for fruit length, fruit diameter and fruit weight recorded significant standard heterosis and residual heterosis in F_2 generation had low inbreeding depression in both crosses indicating the predominance of additive and additive x additive gene actions for these traits is considered to be beneficial to get the better segregants through pedigree method. Aware *et al.* (2014) and Neetu *et al.* (2015) reported the role of additive and additive x additive gene actions in controlling these traits.

Low and negative significant heterosis and positive significant inbreeding depression was observed for inter-nodal length and fruit borer infestation in Pusa A4 x PhuleUtkarsha and days to 50 % flowering in ArkaBahar x IC 31032A indicated to obtain desirable segregants for these traits in subsequent segregating generation of these crosses.

References

1. Akhtar M, Singh JN, Srivastav K, Shahi JP. Studies on generation mean analysis for yield and its associated traits in okra [*Abelmoschus esculentus* (L.) Moench]. *Internat.* J of Plant Sci. 2010; 5(1):323-326.
2. Alake CO, Ariyo OJ, Kehinde OB. A quantitative analysis of the genetics of yield and yield components in West African okra, *Abelmoschuscaillei (A. Chev) Stevels*. Int. J Plant Breed. Genet. 2012; 6(2):94-104.
3. Anonymous. National Horticulture Board (NHB), 2015-2016. *http://nhb.gov.in/area%20_production.html* 310.
4. Arora D, Jindal SK, Ghai TR. Generation mean analysis for earliness related traits in okra (*Abelmoschusesculentus* L. Moench). J Genet. and Breed. 2007; 61:1-7.
5. Aware SA, Deshmukh DT, Thakare SV, Zambre SM. Heterosis and inbreeding depression studies in okra (*Abelmoschusesculentus* (L.) *Moench*). Internat. J Curr. Microbial. App. Sci. 2014; 3(12):733-747.
6. Jagan K, Reddy KR, Sujatha M, Sravanthi V, Reddy SM. Heterosis for yield and yield components in okra (*AbelmoschusEsculentus* L.). IOSR J of Pharmacy and Bio. Sci. 2013a; 7(4):69-70.
7. Javia RM. Line x tester analysis for heterosis in okra [*Abelmoschusesculentus* (L.) *Moench*]. Asian J of Bio. Sci. 2013; 8(2):251-254.
8. Jindal SK, Arora D, Ghai TR. Heterosis and combining ability for yield traits in okra *(Abelmoschusesculentus* (L.) *Moench).* J Res. Punjab agric. Univ. 2010a; 47(1&2):42-45.
9. Kumar S, Kumar R, Singh BB, Kumar A, Kumar S, Kumar S. Study on the heterosis for yield and yield component in okra [*Abelmoschus esculentus* (L.) *Moench*]. *Internat.* J of Agric. Sci. 2014; 10(2):562-571.
10. Neetu Singh, Kumar AK R, Pal M. Heterosis and inbreeding depression in okra (*Abelmoschusesculentus* (L.) *Moench*). *Internat.* J of Scientific and Innovative Res. 2015; 3(2):15-24.
11. Obiadalla-Ali HA, Eldekashy MHZ, Helaly AA. Combining ability and heterosis studies for yield and its components in some cultivars of okra. (*Abelmoschusesculentus* (L.) *Moench*). American-Eurasian J Agric. & Environ. Sci. 2013; 13(2):162-167.
12. Patel KD, Barad AV, Savaliya JJ, Butani AM. A studieson hybrid vigour and inbreeding depression in okra (*Abelmoschusesculentus* (L.) *Moench.* The Asian J of Hort. 2010a; 5(2):277-280.
13. Patel KD, Barad AV, Savaliya JJ, Butani AM. Generation mean analysis for fruit yield and its attributing traits in okra [*Abelmoschus esculentus* (L.) Moench]. The Asian J of Hort. 2010b; 5(2):256-259.
14. Sabesan T, Saravanan K, Satheesh kumar P. Studies on heterosis, inbreeding depression and residual heterosis for fruit yield and its components in okra [*Abelmoschusesculentus* (L.) *Moench.*]. 2016; 16(2):669-674.
15. Senthil kumar P, Sreeparvathy S. Studies on heterosis in okra (*Abelmoschusesculentus* (L.) *Moench*). Electr. J of Plant Breed. 2010; 1(6):1431-1433.
16. Soher EA, El-Gendy, Abd El-Aziz MH. Generation mean analysis of some economic traits in okra (*Abelmoschusesculentus* L. *Moench*). J Applied Sci. 2013; 13(6):810-818.
17. Tiwari JN, Kumar S, Ahlawat TR, Kumar A, Patel N. Heterosis for yield and its components in okra [*Abelmoschusesculentus* (L.) *Moench]*. Asian J Hort. 2015; 10(2):201-206.
18. Verma A, Sood S. Genetic expression of heterosis for fruit yield and yield components in intraspecific hybrids of okra (*Abelmoschus esculentus* (L.) *Moench*). SABRAO J of Breed and Gen. 2015b; 47(3):221- 230.