DIALLEL ANALYSIS IN OKRA [*Abelmoschus esculentus* (L.) Moench]

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DIALLEL ANALYSIS IN OKRA [*Abelmoschus esculentus* (L.) Moench]

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CERTIFICATE

This is to certify that the thesis entitled **"DIALLE ANALYSIS IN OKRA [*Abelmoschus esculentus* (L.) Moench]"** submitted by **SHWETHA A. (UHS15PGM580)** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **VEGETABLE SCIENCE** of the University of Horticultural Sciences, Bagalkot is a record of research work done by him during the period of his study in this university under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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Date: June, 2017

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JUNE, 2017 ***(SHWETHA A.)***

Affectionately dedicated to

My Beloved Parents

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LIST OF ABBREVATIONS

σ^2	: Variance
σ^2g	: Variance due to general combining ability
σ^2s	: Variance due to specific combining ability
ANOVA	: Analysis of variance
BP	: Heterosis over better parent
BTP	: Heterosis over the best parent
CC	: Heterosis over the commercial check (Arka Anamika and MHY-10)
CD at 0.01	: Critical Difference at 1 per cent
CD at 0.05	: Critical Difference at 5 per cent
cm	: Centimeter
DAS	: Days after sowing
df	: Degrees of freedom
et al.	: and others
g	: Gram
gca	: General Combining Ability (effect)
GCA	: General Combining Ability (variance)
ha	: Hectare
kg	: Kilogram
mm	: Millimeter
PDI	: Percentage disease index
Per se	: As such with mean
RBD	: Randomized Block Design
sca	: Specific Combining Ability (effect)
SCA	: Specific Combining Ability (variance)
SE ±m	: Standard error of mean±
t	: Tonne
Viz.,	: Namely
vs	: Aganist
YVMV	: Yellow Vein Mosaic Virus
OP	: Open pollinated

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1. INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is a fast growing annual which has captured a prominent position among the vegetables and is commonly known as bhendi or lady's finger in India. Being a native of Tropical Africa it is grown for its tender fruits in tropics, sub-tropics and warmer seasons of the temperate areas in the world. India is the largest producer of okra in the world with an annual production of 63.46 lakh tonnes from an area of 5.32 lakh hectare with a productivity of 11.9 tonnes per hectare (Anon., 2014). West Bengal, Bihar, Gujarat, Andhra Pradesh, Odisha, Jharkhand, Chhatisgarh, Telangana, Madhya Pradesh, Maharashtra, Haryana, Assam, Uttar Pradesh and Karnataka are the major okra growing states. In Karnataka, okra occupies an area of 9,113 hectares with an annual production of 75,101 tonnes and an average productivity of 8.24 tonnes per hectare (Anon., 2013a).

Okra is an annual herbaceous plant and belongs to the family *Malvaceae* under the order *Malvales*, having a somatic chromosome number 2n=130 in most of the Indian cultivars and is considered to be an amphidiploid showing variations in chromosome number. Okra is being an often cross-pollinated crop, outcrossing to an extent of 20 per cent by insects is reported (Patil, 1995), which renders a considerable amount of variability. Emasculation and pollination processes are easier in okra due to large flower and monoadelphous stamens.

Okra is being cultivated for its fibrous fruits or pods. It has multiple uses, where tender fruits are used as vegetable, eaten boiled or in culinary preparations as sliced and fried pieces. It is also used in thickening of soups and gravies because of its high mucilage content. Okra fruits are sliced and sundried or canned and dehydrated for off-season use. The ripe and dried seeds are roasted, powdered and used as a substitute for coffee. The roots and stem of okra are used for cleaning the sugar cane juice from which jaggery is prepared. Mature fruits and stems containing crude fibre are used in the paper industry. The seeds of okra contain edible oil and protein. It is rich in vitamin C (13 mg/100g), calcium (66 mg/100 g) and iron (1.5 mg/100 g) (Aykroyd, 1963). Fruit is a rich source of iodine which is helpful in curing goitre. Leaves are also used as remedy for dysentery. Green fruits are also rich sources of protein, vitamin A and vitamin B.

Although India is the leading country in okra production, but the productivity is very low due to poor yielding varieties and high incidence of pests (fruit borer, leaf hopper, *etc.*) and diseases (Yellow vein mosaic virus, Enation leaf curl virus and Powdery mildew). Frequent pickings, high operational cost and residues of pesticide entering the food chain are the limiting factors for the control of pests and diseases by chemical means. One of the methods for overcoming these difficulties is development of varieties or hybrids resistant to pests and diseases. Hybrid breeding has helped in overcoming the yield barriers accelerating the increase in productivity. Hybrid vigour in okra has been first reported by Vijayaraghavan and Warier (1946). Despite high cost of hybrid seeds, there is inclination among farmers for cultivation of hybrids because under optimum crop production and protection management, the crops raised from F_1 hybrids show higher yield due to increase in fruit size and fruit number. Besides F_1 hybrids are early maturing and uniform than varieties and thereby reducing cost in grading and harvesting. F_1 hybrids also possess wider adaptability and resistance to insect pests and diseases. Thus, heterosis breeding in this crop offers quantum jump in yield and quality in short time. The ease in emasculation followed by hand pollination due to large flower size, very high percentage of fruit setting and good number of seeds (50 to 70) per fruit offer greater scope for commercial exploitation of heterosis in okra.

Combining ability analysis helps in the evaluation of inbreds in terms of their genetic value and the selection of suitable parents for hybridization and helps in the identification of superior cross combination, which ultimately helps in deciding about exploitation of heterosis using the specific cross combination. The knowledge of the relative importance of general combining ability and specific combining ability for yield and its component traits is very useful in selecting parents for production of superior hybrids. Several biometrical methods are available for studying the combining ability, heterosis and genetics. Diallel analysis technique developed by Jinks and Hayman (1953) has been extensively used to estimate GCA and SCA variances and to understand the nature of gene action involved in the expression of various quantitative traits.

Keeping in view of the above facts, the present investigation was thus undertaken to study the extent of heterosis and combining ability in okra lines developed at K. R. C. College of Horticulture, Arabhavi with the following objectives:

1. To assess the magnitude and direction of heterosis for growth, yield and quality parameters in okra.

2. To identify good general combiners for growth, yield and quality parameters in okra.

3. To identify good specific combiners for growth, yield and quality parameters in okra.

2. REVIEW OF LITERATURE

Information on genetic architecture of various quantitative traits, particularly of those that contributed yield would be most useful in planning the breeding programme to make effective selection. Such information can be used for developing more sophisticated and efficient approach to select and test the parents that will produce superior hybrids. A brief review of the work done in the light of the present investigation, pertaining to heterosis and combining ability in okra has been reviewed and presented in this chapter.

2.1 Heterosis

The impulse of progress in crop improvement through plant breeding was propelled by a better understanding and an appropriate exploitation of heterosis. The term heterosis coined by Shull (1908) which refers to the phenomena in which the F_1 hybrid obtained by crossing the two genetically dissimilar homozygous individuals shows increased or decreased vigour over the parental values. The expression of heterosis may be due to factors such as heterozygosity, allelic interaction such as dominance or over-dominance, non-allelic or epistasis and maternal interactions. The degree of heterosis depends upon the number of heterozygous alleles. Higher the number of heterozygous alleles, more is the heterosis expected (East and Hayes, 1912). The term heterobeltiosis was coined by Fonseka and Patterson (1968), which refers to the increased or decreased vigour of F_1 over its better parent. The utilization of hybrid vigour is commercially feasible only when vigour is in excess of the better parent (heterobeltiosis). Hybrids offer opportunities for improvement in productivity, earliness, uniformity, quality and wider adaptability and for rapid deployment of dominance genes for resistance to diseases and pests (Riggs, 1988).

A considerable degree of heterosis has been documented in okra for various characters which is presented in tabular form here under (Table 1).

Table 1. Review of literature on extent of heterobeltiosis and standard heterosis for various traits of okra

Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
1	Plant height	28 crosses	-7.95 to 26.75	-	Ahmed *et al.* (1999)
		80 crosses	-	17.7 to 30.80	Dhankar and Dhankar (2001)
		5 x 6 LT	19.37 to 61.55	22.13 to 64.67	Thippeswamy (2001)
		14 x 3 LT	-15.50 to 38.15	-26.83 to 33.74	Jaiprakashnarayan (2003)
		9 x 7 LT	-22.58 to 12.94	-	Rewale *et al.* (2003b)
		7 x 7 HD	-10.33 to 8.97	-	Bhalekar *et al.* (2004)
		15 x 4 LT	9.47 to 56.69	-	Singh *et al.* (2004)
		4 x 4 HD	-	15.84 to 3.96	Tripathi *et al.* (2004)
		6 Crosses	-16.60 to 14.24	-43.60 to 14.24	Kumar *et al.* (2004)
		5 x 2 LT	4.29 to 13.72	4.28 to 10.14	Shoba and Mariappan (2005)
		2 Crosses	-7.77 to 8.54	-7.77 to 5.31	Senthil *et al.* (2005)
		8 x 8 HD	Upto 15.48	-	Borgaonkar *et al.* (2005)
		12 x 12 HD	-2.95 to 11.55	-	Singh and Syamal (2006)
		8 x 3 LT	-6.84 to 7.80	-10.75 to 8.82	Weerasekara (2006)
		8 x 8 HD	-38.10 to 78.80	-	Desai *et al.* (2007)
		10 x 10 HD	0.64 to 69.44	-	Manivannan *et al.* (2007a)
		6 x 6 FD	-	-23.36 to -17.88	Eswaran *et al.* (2007)
		14 x 3 LT	Upto 34.33	-	Mehta *et al.* (2007)
		8 x 3 LT	-3.24 to 8.17	-	Weerasekara *et al.* (2007)
		5 x 2 LT	Upto 13.70	Upto 10.10	Shoba and Mariappan (2007)
		3 x 8 LT	-36.19 to 29.11	-17.89 to 38.48	Hosamani *et al.* (2008)
		6 x 4 LT	25.70 to 19.37	-	Singh and Sharma (2009)

Contd…

Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
1	Plant height	9 x 9 HD	-41.72 to 20.46	-	Udengwu (2009)
		12 x 12 HD	0.88 to 39.71	Upto 16.22	Jindal *et al*. (2009)
		10 x 10 HD	-20.77 to 69.09	-	Kalpande *et al*. (2009)
		6 x 4 LT	Upto 100.52	-	Singh and Sanwal (2010)
		6 Crosses	-23.73 to 20.00	-	Khanorkar and Kathiria (2010)
		6 x 6 FD	-	0.01 to 27.14	Senthil and Sreeparvathy (2010)
		17 x 3 LT	-23.24 to 7.67	-22.32 to 18.51	Solankey and Singh (2011)
		10 x 10 HD	-20.17 to 8.70	-23.65 to -0.14	Medagam *et al*. (2012)
		6 Crosses	-7.12 to 4.37	-	Mistry (2012)
		5 x 3 LT	-3.92 to 26.25	1.69 to 36.18	Ashwani *et al*. (2013)
		8 x 8 FD	-40.37 to 35.77	-15.56 to 85.02	Reddy *et al.* (2013b)
		10 x 10 HD	-21.91 to 10.38	-25.55 to 0.16	Medagam *et al*. (2013a)
		10 x 10 HD	-21.12 to 10.38	-23.85 to 1.00	Medagam *et al*. (2013b)
		10 x 10 HD	-66.57 to 49.038	-28.74 to 40.46	Singh *et al*. (2013)
		5 x 3 LT	-31.64 to 1.99	-22.60 to 17.69	Kishor *et al*. (2013)
		18 x 4 LT	33.37 to 48.20	-17.01 to 56.07	Lyngdoh *et al*. (2013)
		6 crosses	6.86 to 18.07	6.86 to 28.46	Aware *et al*. (2014)
		7 x 7 HD	-	-15.65 to 6.02	Jethava *et al*. (2014)
		17 x 4 LT	Upto 40.23	Upto 64.17	Patel (2015)
		7 x 7 HD	-14.80 to 33.16	-14.80 to 17.04	Kumar *et al.* (2015)
		8 x 3 LT	-	-35.20 to 27.92	Patel *et al.* (2015)
		8 x 8 HD	-	-21.4 to 41.3	Verma and Sood (2015)
		12 x 3 LT	-49.19 to 53.99	-43.84 to 36.19	Neetu *et al.* (2015)
		5 x5 FD	-21.95 to 15.25	-21.89 to 8.97	Tiwari *et al.* (2015)
		8 x 8 HD	-21.80 to 15.92	-41.08 to 13.77	Bhatt *et al*. (2016)
		3 crosses	-4.88 to 2.34	1.71to14.75	Sabesan *et al*. (2016)
		6 x 6 HD	-18.69 to 21.59	Upto 18.60	Kumar and Reddy (2016b)

Contd…

Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
2	Number of leaves	10 x 10 HD	-73.0 to 38.60	-	Patil (1995)
		8 x 8 HD	-15.81 to 36.07	-	Sood and Kalia (2001)
		14 x 3 LT	-18.14 to 20.98	-9.76 to 29.06	Jaiprakashnarayan (2003)
		10 x 10 HD	-6.50 to 49.98	-	Manivannan *et al.* (2007a)
		21 x 3 LT	-31.88 to 23.90	-21.02 to 47.59	Lyngdoh *et al*. (2013)
3	Internodal length	28 crosses	-26.11 to 20.53	-	Ahmed *et al.* (1999)
		80 crosses	-	-34.00 to 16.00	Dhankar and Dhankar (2001)
		8 x 8 HD	-14.00 to 16.09	-	Sood and Kalia (2001)
		5 x 6 LT	-24.98 to 41.78	31.41 to 34.89	Thippeswamy (2001)
		14 x 3 LT	-18.18 to 37.84	-16.13 to 42.73	Jaiprakashnarayan (2003)
		7 x 7 HD	-3.67 to 13.20	-	Bhalekar *et al.* (2004)
		15 x 4 LT	-11.07 to -1.80	-	Singh *et al.* (2004)
		4 x 4 HD	-	-14.63 to 87.80	Tripathi *et al.* (2004)
		8 x 8 HD	Upto -26.70	-	Borgaonkar *et al*. (2005)
		8 x 3 LT	-7.91 to 150.00	-18.51 to 4.93	Weerasekara (2006)
		3 x 8 LT	-38.46 to 90.91	-40.67 to 55.56	Hosamani *et al.* (2008)
		6 x 4 LT	13.39 to 51.76	-	Singh and Sharma (2009)
		6 x 4 LT	Upto -41.51	-	Singh and Sanwal (2010)
		12 x 12 HD	-25.68 to -0.44	Upto 31.06	Jindal *et al*. (2010)
		17 x 3 LT	-38.72 to 49.87	-14.29 to 46.54	Solankey and Singh (2011)
		10 x 10 HD	-29.63 to 28.09	-22.49 to 11.03	Medagam *et al*. (2012)
		18 x 4 LT	-43.05 to 64.29	-11.34 to 89.69	Lyngdoh *et al*. (2013)
		8 x 8 FD	-27.12 to 37.21	27.72 to 103.96	Reddy *et al*. (2013b)
		10 x 10 HD	-39.42 to 40.09	-30.35 to 15.65	Medagam *et al*. (2013a)
		10 x 10 HD	-27.95 to 27.23	-23.06 to 10.54	Medagam *et al*. (2013b)
		5 x 3 LT	-26.67 to 9.30	-15.38 to 20.51	Ashwani *et al*. (2013)
		7 x 7 HD	-	-23.14 to 3.93	Jethava *et al*. (2014)

Contd…

Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
3	Internodal length	8 x 8 HD	-	-20.0 to 25.3	Verma and Sood (2015)
		8 x 3 LT	-	-3.45 to 43.17	Patel *et al.* (2015)
		5 x5 FD	-36.47 to 13.03	-17.31 to 54.95	Tiwari *et al.* (2015)
		8 x 8 HD	-17.68 to 25.08	17.38 to 32.20	Bhatt *et al.* (2016)
		3 crosses	12.12 to 16.08	9.38 to 13.56	Sabesan *et al.* (2016)
		6 x 6 HD	-24.98 to 20.89	Upto -28.58	Kumar and Reddy (2016b)
4	Number of branches per plant	28 crosses	-5.82 to 52.50	-	Ahmed *et al.* (1999)
		10 x 10 HD	-15.38 to 40.74	-	Pawar *et al.* (1999)
		80 crosses	-	80.00 to 130.00	Dhankar and Dhankar (2001)
		5 x 6 LT	55.56 to 83.33	76.70 to 165.06	Thippeswamy (2001)
		14 x 3 LT	-38.28 to 18.10	-33.33 to 8.33	Jaiprakashnarayan (2003)
		9 x 7 LT	-33.30 to 121.21	-	Rewale *et al.* (2003b)
		4 x 4 HD	-	-6.50 to 43.50	Tripathi *et al.* (2004)
		15 x 4 LT	6.98 to 17.61	-	Singh *et al.* (2004)
		6 Crosses	-3.60 to 96.60	21.90 to 281.81	Kumar *et al.* (2004)
		2 Crosses	-7.60 to 3.60	44.09 to 50.00	Senthil *et al.* (2005)
		8 x 4 LT	42.64 to 60.31	-	Kumar *et al.* (2006)
		8 x 3 LT	-40.00 to -34.29	-49.80 to 37.15	Weerasekara (2006)
		12 x 12 HD	-16.67 to 45.10	-	Singh and Syamal (2006)
		8 x 8 HD	-43.00 to 139.10	-	Desai *et al.* (2007)
		6 x 6 FD	-	118.09 to 122.34	Eswaran *et al.* (2007)
		8 x 3 LT	-17.50 to 34.29	-	Weerasekara *et al.* (2007)
		3 x 8 LT	-28.64 to 71.44	-27.75 to 66.50	Hosamani *et al.* (2008)
		6 x 4 LT	50.00 to 150.00	-	Singh and Sharma (2009)
		10 x 10 HD	-84.62 to 128.57	-	Kalpande *et al.* (2009)
		6 x 6 FD	-	-1.69 to 10.17	Senthil and Sreeparvathy (2010)
		17 x 3 LT	-54.24 to -4.46	-29.81to 40.62	Solankey and Singh (2011)

Contd…

Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
4	Number of branches per plant	10 x 10 HD	-41.46 to 25.00	-45.45 to 63.64	Medagam *et al*. (2012)
		6 Crosses	4.38 to 8.03	-	Mistry (2012)
		18 x 4 LT	Upto -164.88	-23.08 to 30.07	Lyngdoh *et al*. (2013)
		10 x 10 HD	-36.84 to 30.06	-29.78 to 45.62	Singh *et al*. (2013)
		7 x 7 FD	-31.59 to 12.71	-	Rani and Veeraragavathatham (2013)
		4 x 15 LT	106.46 to 80.85	-	Jagan *et al*. (2013b)
		8 x 8 FD	-36.36 to 62.50	-33.33 to 44.44	Reddy *et al*. (2013b)
		10 x 10 HD	-40.48 to 32.14	-50.00 to 50.00	Medagam *et al*. (2013a)
		10 x 10 HD	-54.76 to 26.09	-41.94 to 64.52	Medagam *et al*. (2013b)
		6 crosses	11.3 to 34.52	17.97 to 38.24	Aware *et al*. (2014)
		7 x 7 HD		-18.90 to 23.30	Jethava *et al*. (2014)
		7 x 7 HD	-18.60 to 28.57	-23.26 to 4.65	Kumar *et al*. (2015)
		8 x 3 LT	-	-68.25 to -39.68	Patel *et al*. (2015)
		10 x 4 LT	-	-17.24 to 19.40	More *et al*. (2015)
		12 x 3 LT	-55.36 to 78.84	-32.14 to 131.54	Neetu *et al*. (2015)
		5 x5 FD	-50.45 to 155.19	-53.13 to 53.85	Tiwari *et al*. (2015)
		8 x 8 HD	-49.64 to70.91	-16.67 to119.70	Bhatt *et al*. (2016)
		6 x 6 HD	-40.85 to 46.67	Upto 28.00	Kumar and Reddy (2016b)
5	Number of nodes on main stem	28 crosses	-18.82 to 36.41	-	Ahmed *et al*. (1999)
		10 x 10 HD	-10.28 to 10.36	-	Pawar *et al*. (1999)
		80 crosses	-	-15.50 to -11.60	Dhankar and Dhankar (2001)
		8 x 8 HD	-19.60 to 29.60	-	Sood and Kalia (2001)
		14 x 3 LT	-25.77 to 20.33	-29.99 to 24.35	Jaiprakashnarayan (2003)
		9 x 7 LT	41.77 to 258.52	-	Rewale *et al*. (2003b)
		7 x 7 HD	-12.15 to 10.88	-	Bhalekar *et al*. (2004)
		5 x 2 LT	22.00 to 33.66	21.97 to 35.97	Shoba and Mariappan (2005)
		2 Crosses	6.18 to 15.70	15.87 to 26.25	Senthil *et al*. (2005)

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Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
5	Number of nodes on main stem	8 x 8 HD	Upto 16.07	-	Borgaonkar *et al*. (2005)
		12 x 12 HD	33.01 to 38.22	-	Singh and Syamal (2006)
		8 x 8 HD	-18.90 to 226.10	-	Desai *et al*. (2007)
		5 x 2 LT	Upto 33.60	Upto 35.70	Shoba and Mariappan (2007)
		8 x 8 HD	Upto 22.13	Upto 11.80	Krushna *et al*. (2007)
		10 x 10 HD	-21.66 to 39.68	-	Kalpande *et al*. (2009)
		17 x 3 LT	-42.14 to 77.97	-48.78 to 2.64	Solankey and Singh (2011)
		18 x 4 LT	-24.26 to 35.21	-14.66 to 30.17	Lyngdoh *et al*. (2013)
		10 x 10 HD	-36.83to 30.94	-40.48 to 44.63	Singh *et al*. (2013)
		8 x 8 HD	-	-15.8 to 24.0	Verma and Sood (2015)
		8 x 8 HD	-31.36 to 22.38	-33.74 to 17.20	Bhatt *et al*. (2016)
		3 crosses	-10.17 to 30.30	67.78 to 115.09	Sabesan *et al*. (2016)
6	Days to first flowering	5 x 6 LT	-3.26 to 6.24	3.39 to 4.68	Thippeswamy (2001)
		14 x 3 LT	-9.53 to 10.18	-9.82 to 11.7	Jaiprakashnarayan (2003)
		9 x 7 LT	-8.37 to 8.01	-	Rewale *et al*. (2003b)
		4 x 4 HD	-	-8.43 to 13.25	Tripathi *et al*. (2004)
		6 Crosses	-22.42 to -0.01	-6.99 to 67.10	Kumar *et al*. (2004)
		5 x 2 LT	-4.10 to 9.40	-2.50 to -6.50	Shoba and Mariappan (2005)
		2 crosses	-3.49 to 1.04	-3.49 to -3.23	Senthil *et al*. (2005)
		8 x 3 LT	-40.00 to -34.29	-49.80 to 37.15	Weerasekara (2006)
		8 x 8 HD	-3.70 to 4.86	-	Desai *et al*. (2007)
		5 x 2 LT	Upto -4.10	Upto -6.50	Shoba and Mariappan (2007)
		14 x 3 LT	-4.03 to -11.10	-	Mehta *et al*. (2007)
		6 x 6 FD	-	-9.09 to -8.75	Eswaran *et al*. (2007)
		9 x 9 HD	-14.80 to 2.17	-	Udengwu (2009)
		10 x 10 HD	-17.23 to 17.48	-	Kalpande *et al*. (2009)
		6 x 4 LT	Upto -10.26	-	Singh and Sanwal (2010)

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Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
6	Days to first flowering	6 Crosses	-12.39 to 14.78	-	Khanorkar and Kathiria (2010)
		6 Crosses	-8.56 to 3.19	-	Mistry (2012)
		10 x 10 HD	-9.43 to 17.84	-11.46 to 67.74	Singh *et al*. (2013)
		5 x 3 LT	-52.70 to 7.02	-17.02 to 43.24	Kishor *et al*. (2013)
		5 x 3 LT	-29.08 to -5.19	-22.73 to -2.27	Ashwani *et al*. (2013)
		7 x 7 HD	-	-4.59 to 18.61	Jethava *et al*. (2014)
		17 x 4 LT	Upto -8.71	Upto -22.92	Patel (2015)
		8 x 8 HD	-	-8.2 to 5.0	Verma and Sood (2015)
		10 x 4 LT	-	-11.77 to 7.08	More *et al*. (2015)
		12 x 3 LT	-15.42 to 39.04	-22.90 to 32.35	Neetu *et al*. (2015)
		5 x5 FD	-25.95 to 2.94	-21.14 to 13.82	Tiwari *et al*. (2015)
		8 x 8 HD	-9.38 to 20.30	-19.11 to 1.91	Bhatt *et al*. (2016)
		3 crosses	-5.42 to -0.67	-5.50 to -4.61	Sabesan *et al*. (2016)
7	Days to 50 per cent flowering	8 x 8 HD	Upto -8.39	-	Borgaonkar *et al*. (2005)
		14 x 3 LT	Upto -8.79	-	Mehta *et al*. (2007)
		8 x 3 LT	-2.70 to 5.47	-	Weerasekara *et al*. (2007)
		6 x 4 LT	-10.00 to 9.80	-	Singh and Sharma (2009)
		6 x 6 FD	-	-4.05 to 2.70	Senthil and Sreeparvathy (2010)
		17 x 3 LT	-10.00 to 24.00	-6.25 to 29.17	Solankey and Singh (2011)
		10 x10 HD	-2.65 to 5.36	-4.35 to 2.61	Medagam *et al*. (2012)
		4 x 15 LT	-15.91 to 4.88	-	Jagan *et al*. (2013b)
		8 x 8 FD	-7.48 to 4.26	1.49 to 12.69	Reddy *et al*. (2013b)
		10 x10 HD	-4.92 to 3.42	-6.56 to 0.82	Medagam *et al*. (2013a)
		10 x10 HD	-3.42 to 4.39	-5.13 to 1.71	Medagam *et al*. (2013b)
		24 crosses	-1.92 to 26.49	-	Sawadogo *et al*. (2014)
		8 x 3 LT	-	-12.63 to 6.39	Patel *et al*. (2015)
		5 x5 FD	-25.71 to 2.78	-18.11 to 16.54	Tiwari *et al*. (2015)

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Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
7	Days to 50 per cent flowering	6 x 6 HD	-3.64 to 1.24	Upto -1.65	Kumar and Reddy (2016b)
8	Fruit length	10 x 10 HD	-77.77 to 10.89	-	Pawar *et al.* (1999)
		28 crosses	-18.78 to 17.92	-	Ahmed *et al.* (1999)
		8 x 8 HD	-18.44 to 12.64	-	Sood and Kalia (2001)
		5 x 6 LT	19.05 to 92.12	19.47 to 44.88	Thippeswamy (2001)
		14 x 3 LT	-20.96 to 8.00	-20.99 to 7.04	Jaiprakashnarayan (2003)
		7 x 7 HD	-10.96 to 13.08	-	Bhalekar *et al.* (2004)
		4 x 4 HD	-	-27.04 to 13.61	Tripathi *et al.* (2004)
		15 x 4 LT	7.06 to 14.72	-	Singh *et al.* (2004)
		5 x 2 LT	0.26 to 17.24	0.26 to 41.45	Shoba and Mariappan (2005)
		2 Crosses	4.61 to 13.51	4.61 to 16.75	Senthil *et al.* (2005)
		8 x 8 HD	Upto 22.22	-	Borgaonkar *et al.* (2005)
		8 x 4 LT	8.99 to 14.91	-	Kumar *et al.* (2006)
		8 x 3 LT	-10.57 to 11.74	-14.74 to 0.38	Weerasekara (2006)
		8 x 8 HD	-15.55 to 15.93	-10.83 to 17.35	Ghai and Arora (2006)
		8 x 8 HD	-48.30 to 19.40	-	Desai *et al.* (2007)
		5 x 2 LT	Upto 17.20	Upto 8.40	Shoba and Mariappan (2007)
		14 x 3 LT	Upto 16.88	-	Mehta *et al.* (2007)
		10 x 10 HD	-7.39 to 48.88	-	Manivannan *et al.* (2007a)
		3 x 8 LT	-54.16 to 13.20	-22.30 to 4.30	Hosamani *et al.* (2008)
		9 x 9 HD	-53.40 to 4.65	-	Udengwu (2009)
		6 x 4 LT	-29.25 to 54.49	-	Singh and Sharma (2009)
		6 Crosses	-6.37 to 26.04	-	Khanorkar and Kathiria (2010)
		6 x 6 FD	-	15.70 to 28.61	Senthil and Sreeparvathy (2010)
		6 x 4 LT	Upto 42.05	-	Singh and Sanwal (2010)
		7 x 7 FD	-	- 0.70 to 1.95	Ramya and Kumar (2010)

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Sl. No.	Character	No. Of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
8	Fruit length	6 Crosses	-6.85 to 26.37	-	Mistry (2012)
		10 x 10 HD	-15.04 to 9.81	-12.44 to 17.22	Medagam *et al*. (2012)
		4 x 15 LT	-22.87 to 16.00	-	Jagan *et al*. (2013b)
		10 x 10 HD	-6.93 to 24.83	-15.06 to 24.84	Singh *et al*. (2013)
		5 x 3 LT	-17.89 to 31.19	13.45 to 65.68	Kishor *et al*. (2013)
		7 x 7 FD	-12.91 to 2.56	-	Rani and Veeraragavathatham (2013)
		17 x 3 LT	Upto 26.26	Upto 18.38	Solankey *et al*. (2013)
		5 x 3 LT	-12.29 to 25.32	1.95 to 50.68	Ashwani *et al*. (2013)
		24 crosses	-80.18 to 79.78	-	Sawadogo *et al*. (2014)
		18 x 3 LT	-22.17 to 24.76	-28.29 to 20.44	Nagesh *et al*. (2014)
		6 crosses	5.89 to 9.41	5.64 to 11.53	Aware *et al*. (2014)
		7 x 7 HD	-	-15.90 to 7.83	Jethava *et al*. (2014)
		21 crosses	-5.37 to 15.56	-5.37 to 10.44	Kumar *et al*. (2015)
		8 x 8 HD	-	-5.4 to 9.5	Verma and Sood (2015)
		10 x 4 LT	-	-5.68 to 8.71	More *et al.* (2015)
		8 x 3 LT	-	-9.31 to 27.75	Patel *et al*. (2015)
		12 x 3 LT	-20.93 to 50.45	-26.56 to 55.88	Neetu *et al*. (2015)
		5 x5 FD	-14.55 to 5.88	-4.81 to 10.44	Tiwari *et al*. (2015)
		8 x 8 HD	-17.67 to 24.50	-6.78 to 27.27	Bhatt *et al*. (2016)
		3 crosses	3.60 to 71.72	18.74 to 96.82	Sabesan *et al*. (2016)
		6 x 6 HD	-7.04 to 13.97	Upto 3.34	Kumar and Reddy (2016b)
9	Fruit diameter	10 x 10 HD	-5.73 to 1.69	-	Pawar *et al*. (1999)
		28 crosses	-20.89 to 1.12	-	Ahmed *et al*. (1999)
		8 x 8 HD	-15.24 to 4.27	-	Sood and Kalia (2001)
		7 x 7 HD	-11.69 to 9.91	-	Bhalekar *et al*. (2004)
		4 x 4 HD	-	0.00 to 131.57	Tripathi *et al*. (2004)
		15 x 4 LT	4.68 to 8.75	-	Singh *et al*. (2004)

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Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
9	Fruit diameter	5 x 2 LT	2.88 to 7.56	2.35 to 7.56	Shoba and Mariappan (2005)
		8 x 8 HD	Upto 8.24	-	Borgaonkar *et al.* (2005)
		8 x 4 LT	1.14 to 1.49	-	Kumar *et al.* (2006)
		8 x 3 LT	-19.94 to 1.15	-14.66 to 5.76	Weerasekara (2006)
		10 x 10 HD	-8.09 to 53.64	-	Manivannan *et al.* (2007a)
		5 x 2 LT	Upto 7.60	Upto 7.60	Shoba and Mariappan (2007)
		3 x 8 LT	-28.57 to 337.14	-23.70 to 277.78	Hosamani *et al.* (2008)
		6 x 4 LT	-17.12 to 20.00	-	Singh and Sharma (2009)
		6 x 4 LT	Upto 41.18	-	Singh and Sanwal (2010)
		6 Crosses	-10.93 to 8.30	-	Khanorkar and Kathiria (2010)
		6 x 6 FD	-	-2.58 to 0.57	Senthil and Sreeparvathy (2010)
		12 x 12 HD	Upto 24.23	Upto 19.93	Jindal *et al.* (2010)
		6 Crosses	-5.05 to 15.14	-	Mistry (2012)
		10 x 10 HD	-14.15 to 4.38	-8.09 to 9.35	Medagam *et al.* (2012)
		10 x 10 HD	-5.46 to 18.49	-12.64 to 6.42	Singh *et al.* (2013)
		5 x 3 LT	-25.71 to 5.93	-14.28 to 15.71	Kishor *et al.* (2013)
		7 x 7 FD	-26.49 to - 15.55	-	Rani and Veeraragavathatham (2013)
		4 x 15 LT	-14.20 to 38.35	-	Jagan *et al.* (2013b)
		8 x 8 FD	-11.67 to 9.43	-7.27 to -7.27	Reddy *et al.* (2013b)
		10 x 10 HD	-14.22 to 4.40	-8.14 to 9.40	Medagam *et al.* (2013a)
		10 x 10 HD	-13.75 to 4.02	-8.80 to 7.36	Medagam *et al.* (2013b)
		17 x 3 LT	Upto to 12.50	Upto to 6.67	Solankey *et al.* (2013)
		5 x 3 LT	-12.50 to 6.67	-6.67 to 13.33	Ashwani *et al.* (2013)
		24 crosses	-50.98 to 95.56	-	Sawadogo *et al.* (2014)
		18 x 3 LT	-32.89 to 37.16	-36.25 to 7.50	Nagesh *et al.* (2014)
		6 crosses	1.98 to 37.72	14.13 to 62.61	Aware *et al.* (2014)
		7 x 7 HD	-	-4.73 to 8.35	Jethava *et al.* (2014)

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Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
9	Fruit diameter	17 x 4 LT	Upto 8.75	Upto 7.68	Patel (2015)
		8 x 8 HD	-	-0.6 to 21.3	Verma and Sood (2015)
		10 x 4 LT	-	-13.41 to 9.76	More *et al.* (2015)
		8 x 3 LT	-	-27.46 to 4.41	Patel *et al.* (2015)
		5 x5 FD	-11.61 to 21.21	-16.73 to 4.09	Tiwari *et al.* (2015)
		3 crosses	-1.72 to 24.63	0.18 to 31.63	Sabesan *et al.* (2016)
		6 x 6 HD	-12.57 to 2.17	Upto 6.37	Kumar and Reddy (2016b)
10	Average fruit weight	28 crosses	-46.17 to 62.59	-	Ahmed *et al.* (1999)
		5 x 6 LT	-18.87 to 35.86	-18.65 to 21.83	Thippeswamy (2001)
		14 x 3 LT	-25.78 to 12.96	-26.90 to 5.11	Jaiprakashnarayan (2003)
		7 x 7 HD	-6.46 to 2.78	-	Bhalekar *et al.* (2004)
		6 Crosses	-17.97 to 29.93	-11.42 to 29.93	Kumar *et al.* (2004)
		2 Crosses	-1.68 to 5.91	6.16 to 14.36	Senthil *et al.* (2005)
		8 x 8 HD	-22.36 to 4.10	-24.56 to 5.85	Ghai and Arora (2006)
		8 x 4 LT	9.68 to 13.53	-	Kumar *et al.* (2006)
		12 x 12 HD	-77.84 to 12.65	-	Singh and Syamal (2006)
		8 x 3 LT	-24.10 to 18.05	-11.26 to 34.15	Weerasekara (2006)
		8 x 8 HD	-16.50 to 19.40	-	Desai *et al.* (2007)
		10 x 10 HD	-2.57 to 23.94	-	Manivannan *et al.* (2007a)
		6 x 6 FD	-	36.87 to 47.87	Eswaran *et al.* (2007)
		5 x 3 LT	-24.1 to 7.07	-	Weerasekara *et al.* (2007)
		5 x 2 LT	Upto 23.10	Upto 34.90	Shoba and Mariappan (2007)
		14 x 3 LT	Upto 34.17	-	Mehta *et al.* (2007)
		3 x 8 LT	-37.67 to 21.20	-45.45 to 6.24	Hosamani *et al.* (2008)
		6 x 4 LT	-25.86 to 35.68	-	Singh and Sharma (2009)
		6 x 4 LT	Upto 34.50	-	Singh and Sanwal (2010)
		6 Crosses	-18.93 to 15.43	-	Khanorkar and Kathiria (2010)

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Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
10	Average fruit weight	6 x 6 FD	-	11.47 to 20.84	Senthil and Sreeparvathy (2010)
		7 x 7 FD	-	0.46 to 1.17	Ramya and Kumar (2010)
		12 x 12 HD	Upto 34.97	Upto 38.10	Jindal *et al*. (2010)
		10 x 10 HD	-16.37 to 9.88	-15.98 to 8.54	Medagam *et al*. (2012)
		5 x 3 LT	-48.87 to 15.75	-22.79 to 74.79	Kishor *et al*. (2013)
		7 x 7 FD	-38.70 to 12.00	-	Rani and Veeraragavthatham (2013)
		4 x 15 LT	-28.30 to 75.18	-	Jagan *et al*. (2013b)
		8 x 8 FD	-30.43 to 48.28	-23.81 to 47.62	Reddy *et al*. (2013b)
		10 x 10 HD	-16.61 to 9.85	-16.48 to 8.13	Medagam *et al*. (2013a)
		10 x 10 HD	-16.29 to 9.68	-16.10 to 8.09	Medagam *et al*. (2013b)
		17 x 3 LT	Upto 36.17	Upto 15.65	Solankey *et al*. (2013)
		5 x 3 LT	-6.73 to 15.80	-6.73 to 17.31	Ashwani *et al*. (2013)
		18 x 3 LT	-44.48 to 51.95	-40.63 to 40.12	Nagesh *et al*. (2014)
		7 x 7 HD	-	-12.76 to 5.18	Jethava *et al*. (2014)
		17 x 4 LT	Upto 30.21	Upto 28.96	Patel (2015)
		8 x 8 HD	-	-1.8 to 20.2	Verma and Sood (2015)
		10 x 4 LT	-	-10.51 to 11.07	More *et al.* (2015)
		8 x 3 LT	-	-18.32 to 52.36	Patel *et al.* (2015)
		5 x5 FD	-13.26 to 25.11	-4.16 to 28.26	Tiwari *et al.* (2015)
		8 x 8 HD	-34.27 to 22.07	-18.60 to 42.69	Bhatt *et al.* (2016)
		3 crosses	31.44 to 57.50	79.27 to 160.37	Sabesan *et al*. (2016)
		6 x 6 HD	-12.86 to 17.59	Upto 8.63	Kumar and Reddy (2016b)
11	Number of fruits per plant	28 crosses	-29.02 to 74.77	-	Ahmed *et al.* (1999)
		8 x 8 HD	-54.38 to 62.33	-28.41 to 67.36	Singh and Sood (1999)
		80 crosses	-	-5.40 to 15.60	Dhankar and Dhankar (2001)
		8 x 8 HD	-28.41 to 108.77	-	Sood and Kalia (2001)
		5 x 6 LT	21.18 to 108.77	23.13 to 65.95	Thippeswamy (2001)

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Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
11	Number of fruits per plant	14 x 3 LT	-25.83 to 14.06	-18.46 to 47.25	Jaiprakashnarayan (2003)
		9 x 7 LT	35.70 to 241.70	-	Rewale *et al.* (2003b)
		7 x 7 HD	-18.29 to 15.57	-	Bhalekar *et al.* (2004)
		4 x 4 HD	-	-25.00 to 31.35	Tripathi *et al.* (2004)
		15 x 4 LT	30.80 to 81.23	-	Singh *et al.* (2004)
		6 Crosses	-22.57 to 67.00	-10.05 to 44.41	Kumar *et al.* (2004)
		5 x 2 LT	-7.90 to 15.30	-22.37 to 24.64	Shoba and Mariappan (2005)
		2 Crosses	1.57 to 6.77	8.44 to 13.99	Senthil *et al*. (2005)
		8 x 8 HD	-14.27 to 20.17	-11.25 to 26.23	Ghai and Arora (2006)
		8 x 4 LT	16.37 to 23.58	-	Kumar *et al.* (2006)
		12 x 12 HD	-28.50 to 53.28	-	Singh and Syamal (2006)
		8 x 3 LT	-17.10 to 46.61	-30.57 to 50.73	Weerasekara (2006)
		8 x 8 HD	-3.80 to 243.80	-	Desai *et al.* (2007)
		10 x 10 HD	13.91 to 123.90	-	Manivannan *et al.* (2007a)
		6 x 6 FD	-	16.57 to 21.99	Eswaran *et al.* (2007)
		8 x 3 LT	-7.36 to 46.61	-	Weerasekara *et al*. (2007)
		5 x 2 LT	Upto 15.30	Upto 24.60	Shoba and Mariappan (2007)
		8 x 8 HD	Upto 17.87	Upto 15.37	Krushna *et al*. (2007)
		3 x 8 LT	-62.50 to 153.85	-56.52 to 17.39	Hosamani *et al.* (2008)
		9 x 9 HD	-13.40 to 61.45	-	Udengwu (2009)
		6 x 4 LT	-20.85 to 55.95	-	Singh and Sharma (2009)
		10 x 10 HD	-22.95 to 104.26	-	Kalpande *et al*. (2009)
		6 x 4 LT	Upto 41.11	-	Singh and Sanwal (2010)
		6 Crosses	-30.31 to 25.39	-	Khanorkar and Kathiria (2010)
		6 x 6 FD	-	15.72 to 35.85	Senthil and Sreeparvathy (2010)
		7 x 7 FD	-	0.53 to 2.44	Ramya and Kumar (2010)
		17 x 3 LT	-38.86 to 26.10	-22.32 to 18.51	Solankey and Singh (2011)

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Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
11	Number of fruits per plant	15 x 3 LT	Upto 33.65	-	Singh and Singh (2012)
		6 Crosses	-10.65 to 23.17	-	Mistry (2012)
		10 x 10 HD	-24.52 to 36.63	-32.9 to 6.88	Medagam *et al*. (2012)
		10 x 10 HD	-18.04 to 44.83	-11.98 to 24.33	Singh *et al*. (2013)
		5 x 3 LT	-61.48 to 5.24	-32.43 to 84.63	Kishor *et al*. (2013)
		4 x 15 LT	-34.43 to 23.64	-	Jagan *et al*. (2013b)
		7 x 7 FD	-9.87 to 21.59	-	Rani and Veeraragavathatham (2013)
		10 x 10 HD	-24.60 to 35.62	-33.92 to 5.22	Medagam *et al*. (2013a)
		10 x 10 HD	-22.73 to 35.65	-32.40 to 7.67	Medagam *et al*. (2013b)
		17 x 3 LT	Upto 61.27	Upto 12.25	Solankey *et al*. (2013)
		5 x 3 LT	-12.29 to 25.32	1.95 to 50.68	Ashwani *et al*. (2013)
		6 crosses	22.29 to 47.48	10.83 to 23.58	Aware *et al*. (2014)
		7 x 7 HD	-	-30.34 to 20.90	Jethava *et al*. (2014)
		18 x 3 LT	-45.39 to 51.66	-46.65 to 26.61	Nagesh *et al*. (2014)
		24 crosses	-57.78 to 92.39	-	Sawadogo *et al*. (2014)
		17 x 4 LT	Upto 38.59	Upto 46.85	Patel (2015)
		8 x 8 HD	-	-9.0 to 29.8	Verma and Sood (2015)
		10 x 4 LT	-	-30.13 to 23.51	More *et al.* (2015)
		8 x 3 LT	-	-4.52 to 25.34	Patel *et al.* (2015)
		21 crosses	-14.80 to 33.16	-14.80 to 17.04	Kumar *et al.* (2015)
		12 x 3 LT	-35.04 to 31.98	-36.11 to 20.37	Neetu *et al.* (2015)
		5 x5 FD	-27.56 to 61.97	-50.47 to 8.08	Tiwari *et al.* (2015)
		8 x 8 HD	-27.99 to 50.12	-40.42 to 24.64	Bhatt *et al.* (2016)
		6 x 6 HD	-7.42 to 48.32	Upto 18.09	Kumar and Reddy (2016b)
12	Total yield per plant	10 x 10 HD	5.37 to 35.42	-	Pawar *et al.* (1999)
		28 crosses	-8.91 to 36.66	-	Ahmed *et al.* (1999)
		8 x 8 HD	-44.97 to 80.50	23.28 to 122.24	Sood and Kalia (2001)

Contd…

Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
12	Total yield per plant	5 x 6 LT	35.52 to 94.60	25.70 to 93.40	Thippeswamy (2001)
		14 x 3 LT	-28.70 to 35.90	-32.79 to 42.07	Jaiprakashnarayan (2003)
		9 x 7 LT	66.23 to 208.50	-	Rewale *et al.* (2003b)
		7 x 7 HD	-19.54 to 19.29	-	Bhalekar *et al.* (2004)
		4 x 4 HD	-	-37.50 to 2.50	Tripathi *et al.* (2004)
		15 x 4 LT	35.59 to 67.57	-	Singh *et al.* (2004)
		5 x 2 LT	6.02 to 39.56	-	Shoba and Mariappan (2005)
		2 Crosses	-2.62 to 14.48	12.68 to 31.40	Senthil *et al.* (2005)
		8 x 8 HD	Upto 52.22	-	Borgaonkar *et al.* (2005)
		12 x 12 HD	-10.62 to 61.22	-	Singh and Syamal (2006)
		8 x 4 LT	143.05 to 317.76	-	Kumar *et al.* (2006)
		8 x 3 LT	-18.33 to 56.48	-40.19 to 51.85	Weerasekara (2006)
		8 x 8 HD	-37.33 to 29.29	-25.92 to 21.84	Ghai and Arora (2006)
		8 x 8 HD	-4.5 to 446.90	-	Desai *et al.* (2007)
		6 x 6 FD	-	54.55 to 67.97	Eswaran *et al.* (2007)
		5 x 2 LT	Upto 39.60	Upto 49.30	Shoba and Mariappan (2007)
		8 x 3 LT	10.47 to 56.48	-	Weerasekara *et al.* (2007)
		8 x 8 HD	Upto 24.36	Upto 13.93	Krushna *et al.* (2007)
		14 x 3 LT	Upto 55.67	-	Mehta *et al.* (2007)
		3 x 8 LT	-58.05 to 176.00	-65.91 to 6.36	Hosamani *et al.* (2008)
		10 x 10 HD	-21.55 to 108.58	-	Kalpande *et al.* (2009)
		6 Crosses	15.82 to 94.06	-	Khanorkar and Kathiria (2010)
		6 x 6 FD	-	29.63 to 65.23	Senthil and Sreeparvathy (2010)
		7 x 7 FD	-	35.98 to 70.28	Ramya and Kumar (2010)
		6 x 4 LT	Upto 77.6	-	Singh and Sanwal (2010)
		15 x 3 LT	Upto 31.52	-	Singh and Singh (2012)
		10 x 10 HD	-22.49 to 63.82	11.34 to 68.02	Singh *et al.* (2013)

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Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
12	Total yield per plant	5 x 3 LT	-71.87 to 23.82	-18.22 to 260.03	Kishor *et al*. (2013)
		4 x 15 LT	-30.11 to 72.94	-	Jagan *et al*. (2013b)
		8 x 8 FD	-35.22 to 89.13	-29.82 to 78.25	Reddy *et al*. (2013b)
		10 x 10 HD	-22.75 to 38.87	-35.51 to 9.32	Medagam *et al*. (2013a)
		10 x 10 HD	-23.77 to 35.87	-36.22 to 8.63	Medagam *et al*. (2013b)
		17 x 3 LT	Upto 55.00	Upto 11.98	Solankey *et al*. (2013)
		5 x 3 LT	-3.87 to 28.05	8.75 to 40.00	Ashwani *et al*. (2013)
		7 x 7 FD	1.64 to 39.97	-	Rani and Veeraragavathatham (2013)
		24 crosses	-50.76 to 77.57	-	Sawadogo *et al*. (2014)
		18 x 3 LT	-48.42 to 125.24	-48.56 to 129.23	Nagesh *et al*. (2014)
		6 crosses	17.91 to 31.54	20.21 to 39.74	Aware *et al*. (2014)
		21 crosses	1.87 to 51.75	-6.47 to 38.59	Kumar *et al*. (2015)
		17 x 4 LT	Upto 65.44	Upto 57.05	Patel (2015)
		8 x 8 HD	-	-3.0 to 40.5	Verma and Sood (2015)
		10 x 4 LT	-	-29.38 to 36.60	More *et al.* (2015)
		8 x 3 LT	-	-7.78 to 22.06	Patel *et al.* (2015)
		12 x 3 LT	-60.35 to 37.37	-52.40 to 23.15	Neetu *et al.* (2015)
		5 x5 FD	-24.50 to 53.61	-45.27 to 18.45	Tiwari *et al.* (2015)
		8 x 8 HD	21.80 to 62.12	-31.81 to 44.11	Bhatt *et al.* (2016)
		3 crosses	0.85 to 27.09	31.26 to 41.13	Sabesan *et al*. (2016)
		6 x 6 HD	-0.97 to 62.38	Upto 22.40	Kumar and Reddy (2016b)
13	Yield per hectare	6 x 4 LT	-04.24 to 45.41	-	Singh and Sharma (2009)
		8 x 8 FD	-24.42 to 89.10	-15.6 to 86.68	Reddy *et al*. (2013b)
		18 x 3 LT	-51.63 to 107.90	-42.95 to 92.42	Nagesh *et al*. (2014)
		10 x 4 LT	-	-34.94 to 36.60	More *et al.* (2015)
14	Number of ridges on fruit surface	9 x 3 LT	-7.62 to 25.00	-	Pathak *et al.* (1997)
		12 x 12 HD	-23.08 to -1.74	-	Wankhade *et al.* (1997)
		28 crosses	-16.45 to 19.99	-	More and Patel (1997)

Contd…

Sl. No.	Character	No. of hybrids and method	Heterobeltiosis (%)	Standard heterosis (%)	References
14	Number of ridges on fruit surface	15 crosses	-3.43 to 1.26	27.92 to 42.38	Sheela *et al.* (1998)
		8 x 8 HD	0.00 to 19.40	-	Sood and Kalia (2001)
		5 x 6 LT	15.91 to 21.97	19.23 to 42.30	Thippeswamy (2001)
		14 x 3 LT	-25.00 to -11.11	20.00 to 60.00	Jaiprakashnarayan (2003)
		8 x 4 LT	5.00 to 6.03	-	Kumar *et al.* (2006)
		8 x 3 LT	-3.80 to 35.50	-8.59 to 27.97	Weerasekara (2006)
		10 x 10 HD	-7.08 to 46.87	-	Manivannan *et al.* (2007a)
15	Number of seeds per fruit	17 x 3 LT	-	9.12 to 44.33	Dhankar *et al*. (1996)
		10 x 2 LT	-18.65 to 9.22	-	Panda and Singh (1998)
		28 crosses	-25.60 to 36.59	-	Ahmed *et al*. (1999)
		6 Crosses	-30.01 to 8.57	- 25.43 to 19.22	Kumar *et al*. (2004)
		5 x 2 LT	5.11 to 51.09	10.14 to 29.54	Shoba and Mariappan (2005)
		12 x 12 HD	-31.59 to 16.93	-	Singh and Syamal (2006)
		8 x 3 LT	-17.16 to 69.89	-11.81 to 115.43	Weerasekara (2006)
		8 x 3 LT	22.6 to 48.8	-	Weerasekara *et al*. (2007)
		5 x 2 LT	Upto 51.10	Upto 21.20	Shoba and Mariappan (2007)
		14 x 3 LT	Upto 27.39	-	Mehta *et al*. (2007)
		10 x 10 HD	-4.86 to 18.90	-	Manivannan *et al.* (2007a)
		9 x 9 HD	-97.72 to 25.54	-	Udengwu (2009)
		6 x 4 LT	-47.78 to 34.78	-	Singh and Sharma (2009)
		17 x 3 LT	Upto 62.18	Upto 1.66	Solankey *et al*. (2013)
		24 crosses	-69.34 to 37.57	-	Sawadogo *et al*. (2014)
		18 x 3 LT	-55.88 to 32.59	-47.67 to 52.33	Nagesh *et al*. (2014)
		7 x 7 HD	-	-20.15 to 8.98	Jethava *et al*. (2014)
		8 x 3 LT	-	-25.57 to 1.59	Patel *et al.* (2015)
		10 x 4 LT	-	-17.72 to 11.40	More *et al.* (2015)

HD – Half diallel FD – Full diallel PD – Partial diallel LT – Line x tester

2.2 Combining ability

Combining ability analysis is one of the efficient tools which helps in selecting parents and crosses for the improvement of particular characters. Selection of suitable parents is one of the most important steps in heterosis breeding. Selection of parents on the basis of phenotypic performance alone is not a sound procedure, since phenotypically superior lines may not lead to expected degree of heterosis. Thus, one of the potential tools for identifying prospective parents for hybridization and shifting productive hybrids from a set of crosses in F_1 generation is the analysis of combining ability (Griffing, 1956). Information regarding the general and specific combining ability and types of gene effects influencing various traits enables the plant breeder to evaluate parental material to decide a suitable breeding procedure for maximum character improvement. The most commonly used designs are line x tester and diallel analysis.

The combining ability concept was first proposed by Sprague and Tatum (1942) in corn. According to them, the general combining ability (gca) is the comparative ability of the parent to combine with other parents. It is the deviation of the mean performance of all the crosses involving a parent from overall mean. Specific combining ability (sca) was defined as the deviation in the performance of specific cross from the performance expected on the basis of general combining ability effects of parents involved in the crosses.

The general and specific combining ability effects and variances obtained from a set of F_1's enables the breeder to select desirable parents and crosses for each of the quantitative components separately. Sprague and Tatum (1942) from their results concluded that, the general combining ability was largely the result of additive gene action, while the specific combining ability due to dominance, epistasis and genotypic environment interaction. If the ratio of additive to non-additive gene action is more than unity indicates the major role of additive variance in controlling the expression of a character whereas, less than unity indicates importance of non-additive variance (Gardner, 1963).

Review of literature on combining ability and gene action in okra is presented in tabular form here under (Table 2).

Table 2. Review of literature on combining ability and gene action on various traits of okra

Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
1	Plant height	8 x 8 HD	HS	HS	-	-	Ahmed *et al.* (1997)
		20 x 4 LT	S	S	-	+	Dhankar and Dhankar (2001)
		6 x 6 HD	S	S	-	+	Sood and Kalia (2001)
		5 x 6 LT	NS	S	+	+	Thippeswamy (2001)
		6 x 6 FD	S	S	+	-	Rajani *et al*. (2001)
		14 x 3 LT	S	S	-	-	Jaiprakashnarayan (2003)
		9 x 7 LT	S	S	+	+	Rewale *et al.* (2003a)
		8 x 8 HD	HS	HS	+	-	Rani and Arora (2003)
		15 x 15 HD	HS	HS	-	-	Singh and Singh (2003)
		4 x 4 HD	HS	HS	-	+	Kumar *et al.* (2005)
		15 x 4 LT	HS	HS	-	+	Singh *et al.* (2006)
		4 x 2 LT	HS	HS	-	+	Biju *et al.* (2006)
		3 x 10 LT	S	NS	-	-	Naphade *et al.* (2006)
		14 x 3 LT	S	S	-	-	Mehta *et al*. (2007)
		10 x 10 HD	HS	HS	+	+	Manivannan *et al.* (2007b)
		10 x 10 HD	HS	HS	+	+	Srivastava *et al.* (2008)
		6 x 3 LT	HS	HS	-	+	Kumar *et al.* (2008)
		10 x 10 HD	-	-	-	+	Vachhani and Shekhat (2008)
		12 x 12 HD	HS	HS	-	+	Singh *et al.* (2009)
		12 x 12 HD	S	S	-	+	Jindal *et al*. (2009)
		12 x 12 HD	HS	HS	-	+	Pal and Sabesan (2009)
		4 x 9 LT	S	S	-	-	Javia *et al*. (2009)
		17 x 3 LT	HS	HS	-	+	Solankey and Singh (2010)
		6 x 4 LT	L	H	-	-	Singh and Sanwal (2010)
		15 x 3 LT	S	S	-	+	Pal *et al*. (2010)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
1	Plant height	6 x 6 HD	HS	HS	-	-	Singh *et al.* (2011)
		8 x 8 HD	HS	HS	-	+	Singh (2011)
		6 x 4 LT	S	S	+	+	Raghuvanshi *et al.* (2011)
		10 x 3 LT	S	-	+	-	Kumar and Pathania (2011)
		6 x 4 LT	S	S	-	-	Sharma and Singh (2012)
		8 x 5 LT	S	S	-	+	Joshi and Murugan (2012)
		15 x 3 LT	S	S	-	+	Singh *et al.* (2012)
		12 x 3 LT	HS	HS	+	+	Khatik *et al.* (2012)
		8 x 4 LT	S	S	-	-	Kumar *et al.* (2012)
		10 x 10 HD	HS	HS	-	+	Medagam *et al.* (2012)
		17 x 3 LT	-	-	-	+	Solankey *et al.* (2012)
		18 x 4 LT	S	S	+	+	Lyngdoh *et al.* (2013)
		8 x 8 FD	HS	HS	-	+	Reddy *et al.* (2013a)
		4 x 15 LT	S	S	-	+	Jagan *et al.* (2013a)
		10 x 10 FD	S	S	+	+	Laxman *et al.* (2013)
		40 x 3 LT	S	S	-	+	Sateesh *et al.* (2013)
		6 x 6 HD	HS	HS	+	-	Hazem *et al.* (2013)
		5 x 3 LT	S	S	-	-	Ashwani *et al.* (2013)
		5 x 3 LT	-	-	-	+	Kishor *et al.* (2013)
		8 x 8 HD	HS	HS	-	+	Akotkar *et al.* (2014)
		12 x12 HD	S	HS	-	+	Kumar *et al.* (2014)
		8 x 8 HD	HS	HS	+	+	Bhatt *et al.* (2015)
		8 x8 HD	HS	HS	+	-	Jonah *et al.* (2015)
		6 x 6 HD	HS	HS	-	+	Kumar and Reddy (2016a)
		7 x 7 FD	HS	S	-	+	Wakode *et al.* (2016)
		11 x11 HD	HS	HS	+	-	Paul *et al.* (2017)

Contd…

Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
2	Number of leaves	10 x 10 HD	S	S	-	+	Patil (1995)
		14 x 3 LT	S	S	+	-	Jaiprakashnarayan (2003)
		10 x 10 HD	HS	HS	-	+	Manivannan *et al.* (2007b)
		21 x 3 LT	S	S	-	+	Lyngdoh *et al.* (2013)
		8 x8 HD	HS	HS	-	+	Jonah *et al.* (2015)
3	Internodal length	8 x 8 HD	HS	HS	-	+	Ahmed *et al.* (1997)
		20 x 4 LT	S	S	-	+	Dhankar and Dhankar (2001)
		6 x 6 HD	S	S	+	-	Sood and Kalia (2001)
		5 x 6 LT	S	S	-	+	Thippeswamy (2001)
		14 x 3 LT	NS	NS	-	+	Jaiprakashnarayan (2003)
		15 x 4 LT	HS	HS	-	+	Singh *et al.* (2006)
		4 x 4 HD	HS	HS	-	+	Kumar *et al.* (2008)
		10 x 10 HD	-	-	-	+	Vachhani and Shekhat (2008)
		12 x 12 HD	S	S	-	+	Jindal *et al.* (2009)
		6 x 6 HD	S	S	+	-	Divya *et al.* (2009)
		4 x 9 LT	S	S	-	-	Javia *et al.* (2009)
		17 x 3 LT	HS	HS	-	+	Solankey and Singh (2010)
		15 x 3 LT	S	S	-	+	Pal *et al.* (2010)
		6 x 4 LT	L	H	-	-	Singh and Sanwal (2010)
		6 x 6 HD	HS	HS	-	-	Singh *et al.* (2011)
		6 x 4 LT	S	S	+	+	Raghuvanshi *et al.* (2011)
		10 x 3 LT	S	S	+	+	Kumar and Pathania (2011)
		6 x 4 LT	S	S	-	-	Sharma and Singh (2012)
		12 x3 LT	HS	HS	+	+	Khatik *et al.* (2012)
		8 x 4 LT	S	S	-	-	Kumar *et al.* (2012)
		10 x10 HD	HS	HS	-	+	Medagam *et al.* (2012)
		17 x 3 LT	-	-	-	+	Solankey *et al.* (2012)

Contd…

Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
3	Internodal length	8 x 8 FD	HS	HS	+	-	Reddy *et al*. (2013a)
		18 x 4 LT	S	S	-	-	Lyngdoh *et al*. (2013)
		40 x 3 LT	S	S	-	+	Sateesh *et al.* (2013)
		5 x 3 LT	S	S	-	-	Ashwani *et al*. (2013)
		10 x 10 FD	S	S	+	+	Laxman *et al*. (2013)
		8 x 8 HD	HS	HS	+	+	Bhatt *et al*. (2015)
		6 x 6 HD	HS	HS	-	+	Kumar and Reddy (2016a)
		7 x 7 FD	HS	HS	-	+	Wakode *et al*. (2016)
		11 x11 HD	HS	HS	+	+	Paul *et al.* (2017)
4	Number of branches per plant	8 x 8 HD	NS	HS	-	+	Ahmed *et al.* (1997)
		5 x 5 HD	H	H	+	+	Dhankar *et al.* (1998)
		20 x 4 LT	S	S	-	+	Dhankar and Dhankar (2001)
		5 x 6 LT	NS	S	-	+	Thippeswamy (2001)
		6 x 6 FD	S	S	+	-	Rajani *et al*. (2001)
		14 x 3 LT	NS	NS	-	+	Jaiprakashnarayan (2003)
		9 x 7 LT	S	NS	-	-	Rewale *et al.* (2003a)
		4 x 4 HD	S	HS	+	+	Kumar *et al.* (2005)
		15 x 4 LT	HS	HS	-	+	Singh *et al.* (2006)
		4 x 2 LT	HS	S	-	+	Biju *et al.* (2006)
		3 x 10 LT	S	S	-	-	Naphade *et al.* (2006)
		10 x 10 HD	HS	HS	-	-	Srivastava *et al.* (2008)
		10 x 10 HD	-	-	-	+	Vachhani and Shekhat (2008)
		12 x 12 HD	HS	HS	+	+	Singh *et al.* (2009)
		4 x 9 LT	S	S	-	-	Javia *et al.* (2009)
		15 x 3 LT	S	S	-	+	Pal *et al*. (2010)
		17 x 3 LT	HS	HS	+	+	Solankey and Singh (2010)

Contd…

Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
4	Number of branches per plant	6 x 6 HD	HS	HS	-	+	Singh *et al*. (2011)
		8 x 8 HD	HS	HS	-	+	Singh (2011)
		17 x 3 LT	-	-	-	+	Solankey *et al*. (2012)
		6 x 4 LT	S	S	-	-	Sharma and Singh (2012)
		8 x 5 LT	S	S	-	+	Joshi and Murugan (2012)
		15 x 3 LT	S	S	-	+	Singh *et al*. (2012)
		8 x 4 LT	S	S	-	-	Kumar *et al*. (2012)
		10 x 10 HD	HS	HS	+	-	Medagam *et al*. (2012)
		12 x 3 LT	HS	HS	+	+	Khatik *et al*. (2012)
		18 x 4 LT	S	S	+	+	Lyngdoh *et al*. (2013)
		8 x 8 FD	HS	HS	+	-	Reddy *et al*. (2013a)
		4 x 15 LT	S	S	-	+	Jagan *et al*. (2013a)
		10 x 10 FD	S	S	+	+	Laxman *et al*. (2013)
		40 x 3 LT	S	S	-	+	Sateesh *et al*. (2013)
		6 x 6 HD	HS	HS	+	-	Hazem *et al*. (2013)
		5 x 3 LT	-	-	-	+	Kishor *et al*. (2013)
		8 x 8 HD	HS	HS	+	+	Akotkar *et al*. (2014)
		12 x12 HD	S	HS	-	+	Kumar *et al*. (2014)
		8 x 8 HD	HS	HS	+	+	Bhatt *et al*. (2015)
		8 x8 HD	HS	HS	+	-	Jonah *et al*. (2015)
		6 x 6 HD	HS	HS	-	+	Kumar and Reddy (2016a)
		7 x 7 FD	HS	HS	+	-	Wakode *et al*. (2016)
		11 x11 HD	HS	HS	+	-	Paul *et al*. (2017)
5	Number of nodes on main stem	8 x 8 HD	HS	HS	+	-	Ahmed *et al*. (1997)
		6 x 6 HD	S	S	+	-	Sood and Kalia (2001)
		14 x 3 LT	S	S	+	-	Jaiprakashnarayan (2003)
		12 x 12 HD	HS	HS	-	+	Pal and Sabesan (2009)

Contd…

Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additi ve	
5	Number of nodes on main stem	6 x 6 HD	S	S	-	+	Divya *et al*. (2009)
		4 x 9 LT	S	S	-	-	Javia *et al*. (2009)
		17 x 3 LT	HS	HS	-	+	Solankey and Singh (2010)
		10 x 3 LT	S	S	+	+	Kumar and Pathania (2011)
		8 x 8 HD	HS	HS	-	+	Singh (2011)
		12 x 3 LT	HS	HS	+	+	Khatik *et al*. (2012)
		17 x 3 LT	-	-	-	+	Solankey *et al.* (2012)
		18 x 4 LT	S	S	+	+	Lyngdoh *et al*. (2013)
		8 x 8 HD	S	HS	+	+	Bhatt *et al*. (2015)
		7 x 7 FD	HS	HS	-	+	Wakode *et al.* (2016)
6	Days to first flowering	5 x 6 LT	NS	S	+	-	Thippeswamy (2001)
		14 x 3 LT	S	S	-	+	Jaiprakashnarayan (2003)
		8 x 8 HD	S	H	-	+	Rani and Arora (2003)
		15 x 15 HD	HS	HS	-	+	Singh and Singh (2003)
		4 x 4 HD	HS	HS	-	+	Kumar *et al.* (2005)
		3 x 10 LT	S	NS	-	-	Naphade *et al.* (2006)
		14 x 3 LT	S	S	-	-	Mehta *et al*. (2007)
		12 x 12 HD	HS	HS	+	+	Singh *et al.* (2009)
		12 x 12 HD	S	S	-	+	Jindal *et al*. (2009)
		12 x 12 HD	HS	HS	-	+	Pal and Sabesan (2009)
		6 x 6 HD	S	S	-	+	Divya *et al*. (2009)
		17 x 3 LT	HS	HS	-	+	Solankey and Singh (2010)
		6 x 4 LT	L	H	-	-	Singh and Sanwal (2010)
		6 x 6 HD	HS	HS	-	-	Singh *et al.* (2011)
		8 x 8 HD	HS	HS	-	+	Singh (2011)
		6 x 4 LT	S	S	+	+	Raghuvanshi *et al*. (2011)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
6	Days to first flowering	8 x 5 LT	S	S	-	+	Joshi and Murugan (2012)
		17 x 3 LT	-	-	-	+	Solankey *et al.* (2012)
		10 x 10 HD	HS	HS	-	+	Medagam *et al.* (2012)
		5 x 3 LT	S	S	-	-	Ashwani *et al.* (2013)
		10 x 10 FD	S	S	+	+	Laxman *et al.* (2013)
		5 x 3 LT	-	-	+	-	Kishor *et al.* (2013)
		8 x 8 HD	HS	HS	-	+	Akotkar *et al.* (2014)
		12 x 12 HD	HS	HS	-	+	Kumar *et al.* (2014)
		8 x 8 HD	HS	HS	+	+	Bhatt *et al.* (2015)
		8 x8 HD	HS	HS	+	-	Jonah *et al.* (2015)
		7 x 7 FD	HS	HS	+	+	Wakode *et al.* (2016)
		11 x11 HD	HS	HS	+	-	Paul *et al.* (2017)
7	Days to 50 per cent flowering	14 x 3 LT	S	S	-	-	Mehta *et al.* (2007)
		10 x 10 HD	-	-	-	+	Vachhani and Shekhat (2008)
		15 x 3 LT	S	S	-	+	Singh *et al.* (2012)
		6 x 4 LT	S	S	-	-	Sharma and Singh (2012)
		17 x 3 LT	-	-	-	+	Solankey *et al.* (2012)
		10 x 10 HD	HS	HS	-	+	Medagam *et al.* (2012)
		4 x 15 LT	S	S	-	+	Jagan *et al.* (2013a)
		10 x 10 FD	S	S	+	+	Laxman *et al.* (2013)
		40 x 3 LT	S	S	-	+	Sateesh *et al.* (2013)
		6 x 6 HD	HS	HS	+	-	Hazem *et al.* (2013)
		8 x 8 HD	HS	HS	-	+	Akotkar *et al.* (2014)
		8 x8 HD	HS	HS	+	-	Jonah *et al.* (2015)
		6 x 6 HD	NS	NS	-	+	Kumar and Reddy (2016a)
8	Fruit length	8 x 8 HD	NS	NS	+	-	Ahmed *et al.* (1997)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
8	Fruit length	5 x 6 LT	S	S	-	+	Thippeswamy (2001)
		6 x 6 HD	S	S	+	-	Sood and Kalia (2001)
		6 x 6 FD	S	S	-	+	Rajani *et al*. (2001)
		14 x 3 LT	S	S	+	-	Jaiprakashnarayan (2003)
		9 x 7 LT	S	NS	+	-	Rewale *et al*. (2003a)
		15 x 15 HD	S	NS	-	+	Singh and Singh (2003)
		4 x 4 HD	HS	HS	-	+	Kumar *et al*. (2005)
		15 x 4 LT	HS	HS	-	+	Singh *et al*. (2006)
		4 x 2 LT	NS	NS	-	-	Biju *et al*. (2006)
		3 x 10 LT	S	NS	-	-	Naphade *et al*. (2006)
		14 x 3 LT	S	S			Mehta *et al*. (2007)
		7 x 7 HD	S	S	-	+	Adeniji and Kehinde (2007)
		10 x 10 HD	HS	HS	-	+	Manivannan *et al*. (2007b)
		10 x 10 HD	HS	HS	+	-	Srivastava *et al*. (2008)
		10 x 10 HD	-	-	-	+	Vachhani and Shekhat (2008)
		6 x 3 LT	HS	HS	-	+	Kumar *et al*. (2008)
		6 x 6 HD	S	S	-	+	Divya *et al*. (2009)
		12 x 12 HD	HS	HS	-	+	Pal and Sabesan (2009)
		4 x 9 LT	S	S	-	-	Javia *et al*. (2009)
		6 x 4 LT	L	H	-	-	Singh and Sanwal (2010)
		17 x 3 LT	HS	HS	-	+	Solankey and Singh (2010)
		15 x 3 LT	S	S	-	+	Pal *et al*. (2010)
		7 x 7 FD	S	S	-	-	Ramya and Kumar (2010)
		12 x 12 HD	S	S	-	-	Jindal *et al*. (2010)
		8 x 8 HD	HS	HS	-	+	Singh (2011)
		6 x 6 HD	HS	HS	-	-	Singh *et al*. (2011)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
8	Fruit length	6 x 4 LT	S	S	+	+	Raghuvanshi *et al*. (2011)
		10 x 3 LT	S	-	+	-	Kumar and Pathania (2011)
		6 x 4 LT	S	S	-	-	Sharma and Singh (2012)
		12 x 3 LT	HS	HS	+	+	Khatik *et al*. (2012)
		15 x 3 LT	S	S	-	+	Singh *et al*. (2012)
		8 x 4 LT	S	S	-	-	Kumar *et al*. (2012)
		10 x 10 HD	HS	HS	-	+	Medagam *et al*. (2012)
		17 x 3 LT	-	-	-	+	Solankey *et al*. (2012)
		8 x 8 FD	HS	HS	+	-	Reddy *et al*. (2013a)
		10 x 10 FD	S	S	+	+	Laxman *et al*. (2013)
		4 x 15 LT	S	S	-	+	Jagan *et al*. (2013a)
		40 x 3 LT	S	S	-	+	Sateesh *et al*. (2013)
		5 x 3 LT	S	S	-	-	Ashwani *et al*. (2013)
		6 x 6 HD	HS	HS	+	-	Hazem *et al*. (2013)
		5 x 3 LT	-	-	-	+	Kishor *et al*. (2013)
		18 x 3 LT	HS	HS	-	+	Nagesh *et al*. (2014)
		8 x 8 HD	NS	S	-	+	Bhatt *et al*. (2015)
		8 x8 HD	HS	HS	+	-	Jonah *et al*. (2015)
		6 x 6 HD	NS	HS	-	+	Kumar and Reddy (2016a)
		7 x 7 FD	HS	HS	-	+	Wakode *et al*. (2016)
		11 x11 HD	HS	HS	+	+	Paul *et al*. (2017)
9	Fruit diameter	8 x 8 HD	HS	HS	+	-	Ahmed *et al*. (1997)
		5 x 6 LT	NS	NS	-	-	Thippeswamy (2001)
		6 x 6 HD	S	S	+	-	Sood and Kalia (2001)
		6 x 6 FD	-	S	-	+	Rajani *et al*. (2001)
		15 x 15 HD	NS	NS	-	+	Singh and Singh (2003)
		4 x 4 HD	HS	HS	-	+	Kumar *et al*. (2005)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
9	Fruit diameter	15 x 4 LT	S	S	-	-	Singh *et al.* (2006)
		4 x 2 LT	HS	HS	-	+	Biju *et al.* (2006)
		10 x 10 HD	NS	NS	-	-	Manivannan *et al.* (2007b)
		6 x 3 LT	HS	HS	-	+	Kumar *et al.* (2008)
		10 x 10 HD	HS	HS	+	-	Srivastava *et al.* (2008)
		10 x 10 HD	-	-	-	+	Vachhani and Shekhat (2008)
		12 x 12 HD	HS	HS	+	-	Pal and Sabesan (2009)
		4 x 9 LT	S	S	-	-	Javia *et al.* (2009)
		17 x 3 LT	HS	HS	-	+	Solankey and Singh (2010)
		6 x 4 LT	L	H	-	-	Singh and Sanwal (2010)
		15 x 3 LT	S	S	-	+	Pal *et al*. (2010)
		12 x 12 HD	S	S	-	-	Jindal *et al*. (2010)
		8 x 8 HD	HS	HS	-	+	Singh (2011)
		6 x 4 LT	S	S	+	+	Raghuvanshi *et al*. (2011)
		6 x 6 HD	NS	NS	-	-	Singh *et al*. (2011)
		10 x 3 LT	S	-	+	-	Kumar and Pathania (2011)
		15 x 3 LT	S	S	-	+	Singh *et al*. (2012)
		17 x 3 LT	-	-	-	+	Solankey *et al.* (2012)
		8 x 4 LT	S	S	-	-	Kumar *et al*. (2012)
		12 x 3 LT	HS	HS	+	+	Khatik *et al*. (2012)
		8 x 8 FD	HS	HS	+	-	Reddy *et al*. (2013a)
		4 x 15 LT	S	S	-	+	Jagan *et al*. (2013a)
		10 x 10 FD	S	S	+	+	Laxman *et al*. (2013)
		40 x 3 LT	S	S	-	+	Sateesh *et al.* (2013)
		5 x 3 LT	S	S	-	-	Ashwani *et al*. (2013)
		6 x 6 HD	HS	HS	+	-	Hazem *et al*. (2013)
		5 x 3 LT	-	-	+	-	Kishor *et al.* (2013)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
9	Fruit diameter	18 x 3 LT	HS	HS	-	+	Nagesh *et al*. (2014)
		12 x12 HD	S	HS	-	+	Kumar *et al*. (2014)
		8 x 8 HD	HS	HS	+	-	Akotkar *et al*. (2014)
		8 x 8 HD	HS	HS	+	+	Bhatt *et al*. (2015)
		8 x8 HD	HS	HS	-	+	Jonah *et al*. (2015)
		6 x 6 HD	S	S	-	+	Kumar and Reddy (2016a)
		11 x11 HD	HS	HS	+	+	Paul *et al*. (2017)
10	Average fruit weight	8 x 8 HD	HS	HS	-	+	Ahmed *et al*. (1997)
		5 x 6 LT	NS	S	-	+	Thippeswamy (2001)
		6 x 6 FD	S	S	+	+	Rajani *et al*. (2001)
		14 x 3 LT	S	S	-	+	Jaiprakashnarayan (2003)
		9 x 7 LT	NS	S	-	+	Rewale *et al*. (2003a)
		8 x 8 HD	HS	S	-	+	Rani and Arora (2003)
		15 x 4 LT	HS	HS	-	+	Singh *et al*. (2006)
		4 x 2 LT	S	S	-	+	Biju *et al*. (2006)
		3 x 10 LT	HS	HS	-	-	Naphade *et al*. (2006)
		14 x 3 LT	S	S	-	-	Mehta *et al*. (2007)
		10 x 10 HD	NS	NS	-	-	Manivannan *et al*. (2007b)
		10 x 10 HD	HS	HS	-	+	Srivastava *et al*. (2008)
		10 x 10 HD	-	-	-	+	Vachhani and Shekhat (2008)
		12 x 12 HD	HS	NS	+	+	Singh *et al*. (2009)
		12 x 12 HD	HS	HS	-	+	Pal and Sabesan (2009)
		6 x 6 HD	S	S	-	+	Divya *et al*. (2009)
		17 x 3 LT	HS	HS	-	+	Solankey and Singh (2010)
		7 x 7 FD	S	S	-	-	Ramya and Kumar (2010)
		12 x 12 HD	S	S	-	-	Jindal *et al*. (2010)
		6 x 4 LT	S	S	+	+	Raghuvanshi *et al*. (2011)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
10	Average fruit weight						
		10 x 3 LT	S	S	+	+	Kumar and Pathania (2011)
		15 x 3 LT	S	S	-	+	Singh *et al*. (2012)
		6 x 4 LT	S	S	-	-	Sharma and Singh (2012)
		8 x 5 LT	S	S	-	+	Joshi and Murugan (2012)
		8 x 4 LT	S	S	-	-	Kumar *et al*. (2012)
		10 x 10 HD	HS	HS	-	+	Medagam *et al*. (2012)
		17 x 3 LT	-	-	-	+	Solankey *et al*. (2012)
		8 x 8 FD	HS	HS	+	-	Reddy *et al*. (2013a)
		4 x 15 LT	S	S	-	+	Jagan *et al*. (2013a)
		10 x 10 FD	S	S	+	+	Laxman *et al*. (2013)
		40 x 3 LT	S	S	-	+	Sateesh *et al*. (2013)
		5 x 3 LT	S	S	-	-	Ashwani *et al*. (2013)
		6 x 6 HD	HS	HS	+	-	Hazem *et al*. (2013)
		5 x 3 LT	-	-	-	+	Kishor *et al*. (2013)
		8 x 8 HD	HS	HS	+	-	Akotkar *et al*. (2014)
		18 x 3 LT	HS	HS	-	+	Nagesh *et al*. (2014)
		8 x 8 HD	HS	HS	+	+	Bhatt *et al*. (2015)
		6 x 6 HD	NS	S	-	+	Kumar and Reddy (2016a)
		7 x 7 FD	HS	HS	-	+	Wakode *et al*. (2016)
		11 x11 HD	HS	NS	+	-	Paul *et al*. (2017)
11	Number of fruits per plant	8 x 8 HD	HS	HS	+	+	Ahmed *et al*. (1997)
		5 x 5 HD	H	H	+	+	Dhankar *et al*. (1998)
		20 x 4 LT	S	S	-	+	Dhankar and Dhankar (2001)
		6 x 6 HD	S	S	-	+	Sood and Kalia (2001)
		5 x 6 LT	NS	NS	-	+	Thippeswamy (2001)
		14 x 3 LT	NS	NS	+	-	Jaiprakashnarayan (2003)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
11	Number of fruits per plant	9 x 7 LT	NS	S	-	+	Rewale *et al.* (2003a)
		8 x 8 HD	HS	HS	-	+	Rani and Arora (2003)
		15 x 15 HD	HS	HS	+	-	Singh and Singh (2003)
		4 x 4 HD	HS	HS	-	+	Kumar *et al.* (2005)
		15 x 4 LT	HS	HS	-	+	Singh *et al.* (2006)
		4 x 2 LT	S	S	-	+	Biju *et al.* (2006)
		3 x 10 LT	S	S	-	-	Naphade *et al.* (2006)
		10 x 10 HD	HS	HS	+	-	Manivannan *et al.* (2007b)
		6 x 3 LT	HS	HS	-	+	Kumar *et al.* (2008)
		10 x 10 HD	HS	HS	+	-	Srivastava *et al.* (2008)
		10 x 10 HD	-	-	-	+	Vachhani and Shekhat (2008)
		12 x 12 HD	HS	HS	+	+	Singh *et al.* (2009)
		12 x 12 HD	HS	HS	-	+	Pal and Sabesan (2009)
		6 x 6 HD	S	S	-	+	Divya *et al.* (2009)
		4 x 9 LT	S	S	-	-	Javia *et al.* (2009)
		17 x 3 LT	S	HS	-	+	Solankey and Singh (2010)
		7 x 7 FD	S	S	-	-	Ramya and Kumar (2010)
		12 x 12 HD	S	S	-	-	Jindal *et al.* (2010)
		15 x 3 LT	S	S	-	+	Pal *et al.* (2010)
		6 x 6 HD	HS	HS	-	-	Singh *et al.* (2011)
		6 x 4 LT	S	S	+	+	Raghuvanshi *et al.* (2011)
		8 x 8 HD	HS	HS	-	+	Singh (2011)
		10 x 3 LT	S	S	+	+	Kumar and Pathania (2011)
		15 x 3 LT	S	S	-	+	Singh *et al.* (2012)
		6 x 4 LT	S	S	-	-	Sharma and Singh (2012)
		8 x 5 LT	S	S	-	+	Joshi and Murugan (2012)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
11	Number of fruits per plant	8 x 4 LT	S	S	-	-	Kumar *et al*. (2012)
		10 x 10 HD	HS	HS	-	+	Medagam *et al*. (2012)
		12 x 3 LT	HS	HS	+	+	Khatik *et al*. (2012)
		8 x 8 FD	HS	HS	+	-	Reddy *et al*. (2013a)
		4 x 15 LT	S	S	-	+	Jagan *et al*. (2013a)
		10 x 10 FD	S	S	+	+	Laxman *et al*. (2013)
		40 x 3 LT	S	S	-	+	Sateesh *et al*. (2013)
		5 x 3 LT	S	S	-	-	Ashwani *et al*. (2013)
		6 x 6 HD	HS	HS	+	-	Hazem *et al*. (2013)
		5 x 3 LT	-	-	-	+	Kishor *et al*. (2013)
		18 x 3 LT	HS	HS	-	+	Nagesh *et al*. (2014)
		8 x 8 HD	HS	HS	-	-	Akotkar *et al*. (2014)
		12 x12 HD	S	HS	-	+	Kumar *et al*. (2014)
		8 x 8 HD	S	HS	+	+	Bhatt *et al*. (2015)
		8 x8 HD	HS	HS	+	-	Jonah *et al*. (2015)
		6 x 6 HD	HS	HS	-	+	Kumar and Reddy (2016a)
		7 x 7 FD	HS	HS	-	+	Wakode *et al*. (2016)
		11 x11 HD	HS	HS	+	+	Paul *et al*. (2017)
12	Total yield per plant	8 x 8 HD	HS	HS	-	+	Ahmed *et al*. (1997)
		5 x 5 HD	H	H	+	+	Dhankar *et al*. (1998)
		20 x 4 LT	S	S	-	+	Dhankar and Dhankar (2001)
		6 x 6 HD	S	S	-	+	Sood and Kalia (2001)
		5 x 6 LT	S	S	-	+	Thippeswamy (2001)
		6 x 6 FD	S	S	-	+	Rajani *et al*.(2001)
		14 x 3 LT	S	S	-	+	Jaiprakashnarayan (2003)
		9 x 7 LT	S	S	-	+	Rewale *et al*. (2003a)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
12	Total yield per plant	8 x 8 HD	HS	HS	-	+	Rani and Arora (2003)
		15 x 15 HD	HS	HS	+	+	Singh and Singh (2003)
		15 x 4 LT	HS	HS	-	+	Singh *et al.* (2006)
		4 x 2 LT	HS	HS	-	+	Biju *et al.* (2006)
		3 x 10 LT	HS	S	-	-	Naphade *et al.* (2006)
		14 x 3 LT	S	S	-	-	Mehta *et al.* (2007)
		10 x 10 HD	HS	HS	-	+	Manivannan *et al.* (2007b)
		10 x 10 HD	HS	HS	+	-	Srivastava *et al.* (2008)
		6 x 3 LT	HS	HS	-	+	Kumar *et al.* (2008)
		10 x 10 HD	-	-	-	+	Vachhani and Shekhat (2008)
		12 x 12 HD	NS	HS	+	+	Singh *et al.* (2009)
		12 x 12 HD	HS	HS	-	+	Pal and Sabesan (2009)
		6 x 6 HD	S	S	-	+	Divya *et al.* (2009)
		4 x 9 LT	S	S	-	-	Javia *et al.* (2009)
		17 x 3 LT	HS	HS	-	+	Solankey and Singh (2010)
		6 x 4 LT	L	H	-	-	Singh and Sanwal (2010)
		7 x 7 FD	S	S	-	-	Ramya and Kumar (2010)
		12 x 12 HD	S	S	-	-	Jindal *et al.* (2010)
		6 x 4 LT	S	S	+	+	Raghuvanshi *et al.* (2011)
		8 x 8 HD	HS	HS	-	+	Singh (2011)
		6 x 6 HD	HS	HS	-	-	Singh *et al.* (2011)
		10 x 3 LT	S	S	+	+	Kumar and Pathania (2011)
		8 x 5 LT	S	S	-	+	Joshi and Murugan (2012)
		8 x 4 LT	S	S	-	-	Kumar *et al.* (2012)
		10 x 10 HD	HS	HS	-	+	Medagam *et al.* (2012)
		12 x 3 LT	HS	HS	+	+	Khatik *et al.* (2012)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
12	Total yield per plant	15 x 3 LT	S	S	-	+	Singh *et al*. (2012)
		10 x 10 FD	S	S	+	+	Laxman *et al*. (2013)
		4 x 15 LT	S	S	-	+	Jagan *et al*. (2013a)
		40 x 3 LT	S	S	-	+	Sateesh *et al.* (2013)
		8 x 8 FD	HS	HS	+	-	Reddy *et al*. (2013a)
		5 x 3 LT	S	S	-	-	Ashwani *et al.* (2013)
		5 x 3 LT	-	-	-	+	Kishor *et al.* (2013)
		8 x 8 HD	HS	HS	-	+	Akoktar *et al*. (2014)
		18 x 3 LT	HS	HS	-	+	Nagesh *et al*. (2014)
		8 x 8 HD	S	HS	+	+	Bhatt *et al*. (2015)
		6 x 6 HD	HS	HS	-	+	Kumar and Reddy (2016a)
		7 x 7 FD	HS	HS	-	+	Wakode *et al.* (2016)
		11 x11 HD	HS	HS	+	+	Paul *et al.* (2017)
13	Total yield per hectare	6 x 4 LT	S	S	-	-	Sharma and Singh (2012)
		8 x 8 FD	HS	HS	+	-	Reddy *et al*. (2013a)
		4 x 15 LT	S	S	-	+	Jagan *et al*. (2013a)
		10 x 10 FD	S	S	+	+	Laxman *et al*. (2013)
		40 x 3 LT	S	S	-	+	Sateesh *et al.* (2013)
		8 x8 HD	HS	HS	+	-	Jonah *et al.* (2015)
14	Number of ridges on fruit surface	6 x 6 HD	S	S	+	-	Sood and Kalia (2001)
		5 x 6 LT	N S	S	-	+	Thippeswamy (2001)
		14 x 3 LT	S	S	-	+	Jaiprakashnarayan (2003)
		10 x 10 HD	NS	NS	-	+	Manivannan *et al.* (2007b)
		12 x 12 HD	HS	HS	+	-	Pal and Sabesan (2009)
		6 x 6 HD	S	S	-	+	Divya *et al*. (2009)
		8 x 4 LT	S	S	-	-	Kumar *et al*. (2012)

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Sl. No.	Character	Material and method used	Combining ability		Gene action		References
			GCA	SCA	Additive	Non - additive	
14	Number of ridges on fruit surface	17 x 3 LT	-	-	-	+	Solankey *et al.* (2012)
		8 x 8 HD	HS	HS	-	+	Akotkar *et al*. (2014)
15	Number of seeds per fruit	8 x 8 HD	HS	HS	-	+	Ahmed *et al.* (1997)
		9 x 7 LT	S	S	-	+	Rewale *et al.* (2003a)
		4 x 2 LT	HS	HS	+	-	Biju *et al.* (2006)
		3 x 10 LT	HS	S	-	-	Naphade *et al.* (2006)
		14 x 3 LT	S	S	-	-	Mehta *et al*. (2007)
		10 x 10 HD	HS	HS	-	+	Manivannan *et al.* (2007b)
		6 x 3 LT	HS	HS	-	+	Kumar *et al.* (2008)
		10 x 10 HD	HS	HS	+	-	Srivastava *et al.* (2008)
		12 x 12 HD	HS	N S	+	+	Singh *et al.* (2009)
		17 x 3 LT	S	HS	-	+	Solankey and Singh (2010)
		6 x 4 LT	S	S	-	-	Sharma and Singh (2012)
		17 x 3 LT	-	-	-	+	Solankey *et al.* (2012)
		10 x 10 FD	S	S	+	+	Laxman *et al*. (2013)
		18 x 3 LT	HS	HS	-	+	Nagesh *et al*. (2014)

HD – Half diallel FD – Full diallel PD – Partial diallel LT – Line x tester HS- Highly significant NS- Non significant
S- Significant H- High L- Low

2.3 Pests and Diseases

The major constraints in okra cultivation are occurrence of fruit borer, sucking pests (leaf hopper and white fly), Yellow Vein Mosaic Virus (YVMV), powdery mildew and *Fusarium* wilt incidence.

2.3.1 Fruit borer and sucking pests

Koujalagi *et al*. (2009) evaluated the performance of 37 single cross hybrids and 56 varieties to fruit borer. None of the hybrids and varieties was immune to the borer attack. Nineteen hybrids reacted as susceptible, 12 as moderately susceptible, five as susceptible and only one hybrid Saloni (4.39 %) reacted as resistant with higher standard heterosis for fruit yield over the commercial check (Mahaveer).

Four okra varieties of cultivated species (*Abelmoschus esculentus*) and two varieties of semi-domesticated species (*A. caillei*) were crossed in all possible combinations, the resultant hybrids along with parents were evaluated for resistance against fruit and shoot borer (*Earias vittella* Fab.) and revealed that parents AC 5 and KL 9 and the hybrid Sel 2 xAC5 were resistance to shoot and fruit borer (Divya and Sreenivasan, 2013).

Thirty one genotypes of okra were evaluated for resistance to shoot and fruit borer and revealed that Nedumangad local as a suitable genotype with respect to shoot and fruit borer resistance (Duggi *et al*., 2013).

Prabhu *et al*. (2009) screened wild *Abelmoschus moschatus* lines 1, 2, 3, 4 and 5 for three seasons and found that these lines have least jassid (nymph) population per leaf, while *A. moschatus* lines 1, 2, 3, 4 and 5 and *A. angulosus* were found to have minimum mean whitefly (adult) population per leaf. However, none of the cultivated *A. esculentus* cultivars screened for three seasons was found resistant to jassids and white fly.

2.3.2 Yellow vein mosaic virus, powdery mildew and *Fusarium* wilt

Tiwari *et al.* (2012) screened five varieties of okra for resistance to infection by YVMV under field conditions. He found that only one variety *i.e.,* VRO-6 was found resistant to yellow vein mosaic virus disease. Moderately resistance was observed in three varieties in VRO-3 (31.3 per cent), HRB-9-2 (35.5 per cent) and Pusa Makhmali (53.2 per cent). Pusa Sawani (90.2 per cent) showed high susceptibility.

Bhendi Yellow Vein Delhi Virus (BYVDV), a new bipartite begomo virus species, was recently found to be associated with Yellow Vein Mosaic Delhi Virus (YVMDV) on okra (Venkataravanappa *et al*., 2012).

Venkataravanappa *et al*. (2013) reported that new begomo virus (OYBHU isolate) infecting okra showing yellow vein symptoms from Bhubhaneswar, India was characterized. The complete genome sequence (homologous to DNA-A) was determined and it comprised 2757 nucleotides.

The okra germplasm consisting of 85 accessions which included cultivars, related species and their inter-specific hybrids were screened for two seasons (*Kharif* and summer) against powdery mildew resistance. Only the wild species were found highly resistant to powdery mildew in both the seasons (Prabhu *et al.,* 2007).

Atiq *et al.* (2014) evaluated fifteen okra varieties/lines/hybrids to determine their response aganist powdery mildew. No cultivar was found immune. Variety Sabzpari and Hybrid-133 expressed resistant response (2-3%), while Okra-7100, Adventa selection, Okra-1548 and Kirn exhibited moderately resistant (7-9%), Super star, PMF-Beauty and OH-152 were found moderately susceptible (23-29%), Pusa Sawani, JK-Tetra-6, Laxmy and Green water were susceptible (42-47%) and Sanam and Click-5769 were highly susceptible with 76-85 per cent disease incidence.

Younus and Elyousr (2014) evaluated 14 okra genotypes for resistance aganist powdery mildew disease for their yield and yield-components. All screened genotypes showed varied degrees of susceptibility to the artificial inoculation with the tested pathogen. Out of which, varieties like Beheira, A-Aiat,Giza (a), Seds, Beni-Suef landraces and Gold Coast cultivar are more tolerant to powdery mildew disease while others varied from highly susceptible to moderate susceptible. The most susceptible genotype was Pusa Sawani.

Fifty-four okra accessions were evaluated for resistance to *Fusarium* wilt. Twelve accessions were rated as highly to intermediately resistant to ‘Fus-194’ during the dry/moderate temperature season, whereas nine accessions were classified as highly to intermediately resistant to ‘Fus-201’. The accessions Santa Cruz-47, BR- 2399 and BR-1449 were the most promising resistance sources (Aguiar *et al.*, 2013).

3. MATERIAL AND METHODS

The investigation on diallel analysis in okra was undertaken during the year 2016-2017. The details of the experiment, materials used and techniques adopted in the present investigation are presented in this chapter.

3.1 Experimental site

The experiment on diallel analysis was conducted in the field of Vegetable Science unit of Kittur Rani Channamma College of Horticulture, Arabhavi, Belgaum District (Karnataka).

Arabhavi is situated in Northern Dry Zone of Karnataka state at 16° 15' N latitude, 74° 45' E longitude and at an altitude of 612.03 meters above the mean sea level. Arabhavi, which comes under the Zone-3 of Region-2 among the agro-climatic zones of Karnataka, has benefits of both the South-West and North-East monsoons. The average rainfall of this area is about 650 mm, distributed over a period of five to six months (June to November) with peaks during October. The command area receives water from Ghataprabha Left Bank Canal from mid-July to mid-March. The meterological data recorded during the period of experimentation is given in Appendix I.

3.2 Experimental material

The experimental material comprised of 8 parents and their 28 F_1 hybrids along with two commercial checks. Each of the 8 parents crossed among each other in half diallel fashion without reciprocal crosses to derive 28 F_1 hybrids.

3.2.1 Selection of parents

The parental materials available at the Department of Vegetable Science, Kittur Rani Channamma College of Horticulture, Arabhavi were utilized for the study. The parents were selected based on their *per se* performance for yield and quality attributes. Details of the parents used in the study are presented in Table 3 and Plate 1.

Table 3. Details of okra entries with their sources

Sl. No.	Genotypes	Pedigree	Source	Description
1.	KO1601	1568-6/3	K. R. C. C. H. Arabhavi	Plants having dwarf stature with early flowering and moderately free from fruit borer incidence.
2.	KO1602	1571-2/6	K. R. C. C. H. Arabhavi	Plants with shorter internodal length, more number of branches and more number of fruits per plant.
3.	KO1603	1573-8/11	K. R. C. C. H. Arabhavi	Fruits are long, tender and light green colour. Plants are free from YVMV and sucking pests incidence.
4.	KO1604	1578-3/9	K. R. C. C. H. Arabhavi	Medium sized fruits with dark green colour. Moderately free from sucking pests incidence.
5.	KO1605	1574-4/6	K. R. C. C. H. Arabhavi	Shorter internodal length, medium sized light green coloured fruits with smooth texture.
6.	KO1606	1614-15/6	K. R. C. C. H. Arabhavi	Fruits are small, tender, smooth and dark green colour.
7.	KO1607	1614-19/4	K. R. C. C. H. Arabhavi	Dark green coloured fruits having five ridges on the surface, tall plant height.
8.	KO1608	1573-20/2	K. R. C. C. H. Arabhavi	Plants with shorter internodal length, early flowering and more number of nodes on the surface main stem. Moderately free from fruit borer incidence.

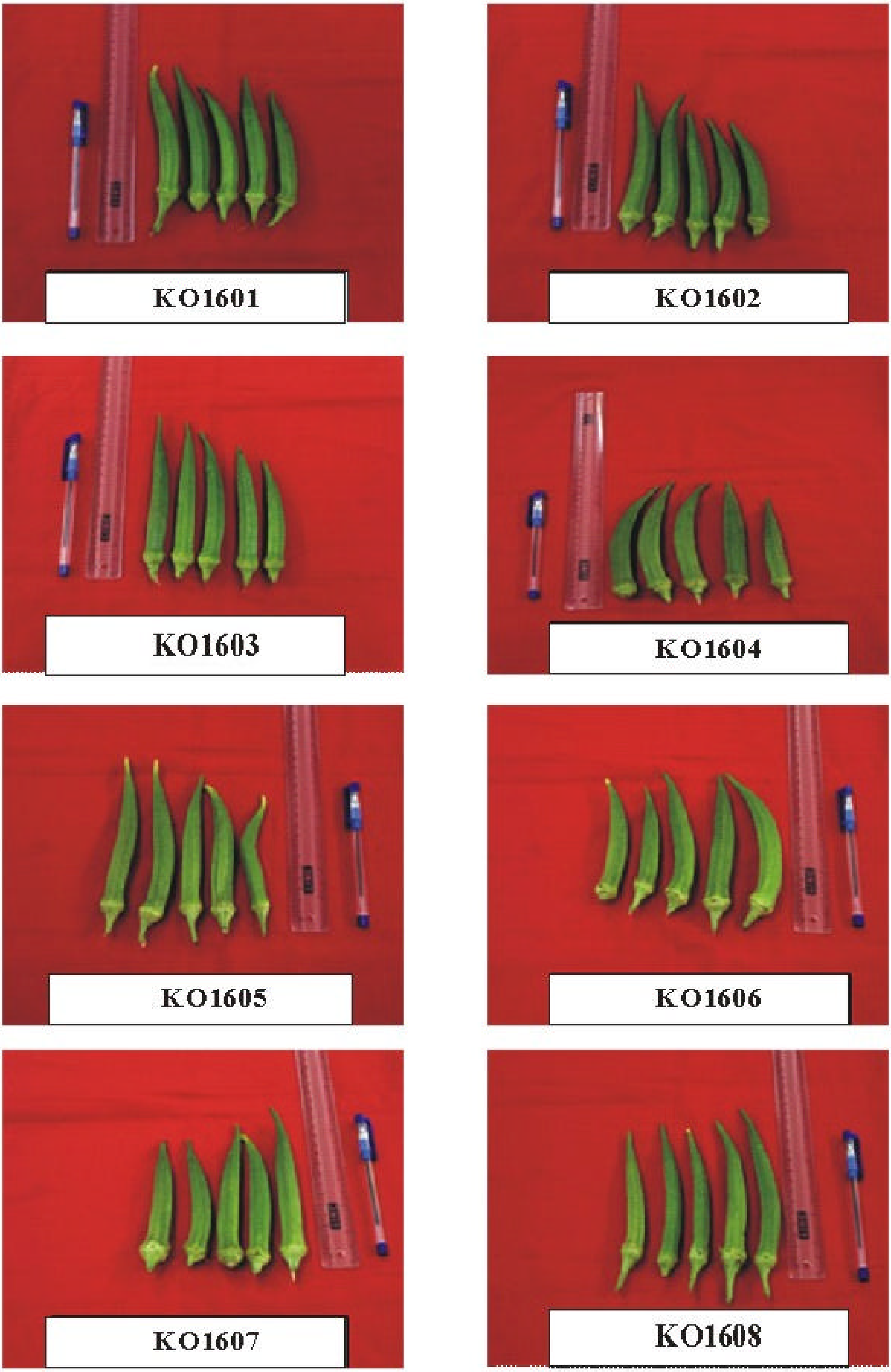


Plate 1. Fruits of parents used in the experiment

3.2.2 Hybridization Programme

Seeds of parents were sown during the month of November 2015 for attempting crosses in half diallel fashion without reciprocal crosses. Sowing was done on 60 cm apart ridges at a spacing of 30 cm between plants for easy movement. All the recommended cultivation practices were followed to raise a good crop. A total of 28 hybrids were developed by crossing among themselves. Flower buds of male and female parents were selected on the previous evening prior to the day of their opening. The selected flower buds of male parents were covered with butter paper bags to avoid contamination of pollens by other parents. Flower buds of female parents were emasculated and covered with butter paper bag to avoid outcrossing. Pollination was carried out on the next day morning between 6.00 am and 11.00 am by using pollens of desired male parents. After pollination, the female flower buds were again covered with butter paper bags to avoid contamination and tagged with the details of male parent and date of pollination. Simultaneously, the parents were selfed by bagging the flower buds with butter paper bags prior to the day of flower opening. Crossed and selfed fruits were harvested separately at full maturity stage. The seeds were hand extracted and preserved in butter paper bags and labeled with the details of cross or entry number.

3.3 Evaluation of F_1's, Parents and commercial hybrids

Design: Half diallel with Randomised Block Design.

Genotypes: Parents – 08

F_1 Hybrids - 28

Commercial Check – 02 (Arka Anamika and MHY-10)

Total – 38

Replications: 02

3.3.1 Layout of the experiment

Experimental plot was ploughed repeatedly and land was brought to a fine tilth. About 25 tonnes of FYM per hectare and the recommended basal dose of fertilizers (62.5:75:62.5 kg NPK/ha) were incorporated into the soil just before sowing. The remaining 62.5 kg of nitrogen was applied as a top dress at 45 days after sowing. Ridges and furrows were opened at a distance of 60 cm apart. Two to three seeds of each genotype per hill were dibbled at a distance of 30 cm in a row. The plants were thinned to one seedling per hill after germination. Irrigation, weed control and other cultural practices were followed as per the package of practices of UHS Bagalkot (Anon., 2013b). General view of the experimental plot is presented in Plate 2.

3.3.2 Observations recorded

The following observations were recorded on the five plants chosen at random in each genotype and in each replication. The mean of five plants was taken for analysis. The characters studied and techniques adopted to record the observations are given below.

3.3.2.1 Growth parameters

3.3.2.1.1 Plant height (cm)

Height of the plant was measured from ground level to the tip of the plant at 45, 60 and 90 days after sowing (DAS).

3.3.2.1.2 Number of leaves

Number of leaves per plant was counted at 45, 60 and 90 DAS.

3.3.2.1.3 Internodal length (cm)

Length of the internode was measured at third internode from the tip of the plant on 60 DAS.

3.3.2.1.4 Number of branches per plant

Total number of branches on main stem was counted on 90th DAS.

3.3.2.1.5 Number of nodes on the main stem

Number of nodes on main stem was counted on 90th DAS.

Plate 2. General view of the experimental plot

3.3.2.2 Earliness

3.3.2.2.1 Days to first flowering

Number of days taken from the date of sowing to the day of first flower opening was counted.

3.3.2.2.2 Days to 50 per cent flowering

Number of days taken from the date of sowing to day on which 50 per cent of plants in a plot flowered was counted.

3.3.2.3 Yield parameters

3.3.2.3.1 Fruit length (cm)

Length of the fruit was measured from the fruit base (basal cap) to its tip at edible maturity stage and average of five randomly selected fruits was worked out at third picking.

3.3.2.3.2 Fruit diameter (mm)

The diameter at middle of the fruit was measured by using digital vernier calipers at edible maturity stage and average of five randomly selected fruits was worked out at third picking.

3.3.2.3.3 Average fruit weight (gm)

Average fruit weight was calculated for randomly selected five fruits at edible maturity stage at third picking.

3.3.2.3.4 Number of fruits per plant

Number of fruits per plant was computed by adding the number of fruits of all the pickings in each plant of observation and average of five plants was worked out.

3.3.2.3.5 Total yield per plant (g)

Total yield per plant was computed by adding the fruit weight of all the pickings in tagged plants and divided by number of plants and expressed in grams per plant.

3.3.2.3.6 Total yield per plot (kg)

Total yield per plot was computed by adding the plot yield of all the pickings and expressed in kilograms per plot.

3.3.2.3.7 Total yield per hectare (t)

Total yield per hectare was computed by using the plot yield of all the pickings and expressed in tonnes per hectare.

3.3.2.4 Quality parameters

3.3.2.4.1 Number of ridges on fruit surface

Number of ridges present on the fruit surface was recorded at edible maturity stage and average of five fruits was worked out.

3.3.2.4.2 Number of seeds per fruit

Fully matured and dried five fruits were harvested and the numbers of seeds per fruit was computed.

3.3.2.4.3 Fruit pubescence

Fruit pubescence was judged by moving the fingers on fruit surface and categorized into downy or smooth, rough and prickly and is presented in Appendix II.

3.3.2.4.4 Fruit colour

The colour of the fruit was recorded at edible maturity stage based on visual appearance as dark green or light green and is presented in Appendix II.

3.3.2.4.5 Fruit tenderness

Tenderness of the fruit was recorded at edible maturity stage by just bending the tip of the fruit with the finger and presented in Appendix II.

3.3.2.5 Pests and disease incidence

3.3.2.5.1 Fruit borer incidence (*Earias* sp)

Total number of fruits and number of fruits infested with spotted borer were counted at each harvest. Fruit number over all the harvests were added to get total and infested fruits per plot. Per cent incidence of borer was computed by using the following formula.

$$\text{Fruit borer incidence} = \frac{\text{Number of fruits infested}}{\text{Total number of fruits}} \times 100$$

Further genotypes were grouped in to different categories based on per cent of fruit infestation as given below.

Per cent fruit infestation	Reaction categories
0 – 10	Resistant
11 – 20	Moderately resistant
21 – 30	Moderately susceptible
31 – 60	Susceptible
> 61	Highly susceptible

3.3.2.5.2 Sucking pests

Leaf hopper and white fly incidence recorded based on severity of population as Low, Moderate and Severe.

3.3.2.5.3 Yellow Vein Mosaic Virus (YVMV) incidence

Under natural disease pressure condition, each plant in a genotype of each replication was scored for YVMV by using the score card given below.

Severity grade	Reaction	Description
0	Highly Resistant	Plants free from YVMV
1	Resistant	Upto 25 per cent leaves affected
2	Moderately Resistant	26-50 per cent leaves affected
3	Moderately susceptible or susceptible	51-74 per cent leaves affected
4	Highly Susceptible	>75 per cent leaves affected

3.3.2.5.4 Incidence of powdery mildew

The Percentage disease incidence of powdery mildew was calculated by using the following scale (Atiq *et al.*, 2014).

Scale	Description	PDI (%)	Reaction
0	No infection	0	Immune
1	Traces of infection on lower leaves covering up to 1 per cent leaf area	1-5	Resistant
2	1 to 10 per cent of leaf area is covered	6-10	Moderately resistant
3	11 to 25 per cent of leaf area is covered	11-30	Moderately susceptible
4	26 to 50 per cent of leaf area is covered	31-50	Susceptible
5	More than 51 per cent of leaf area is covered	51-100	Highly susceptible

Percentage Disease Index (PDI) was calculated as follows:

$$\text{PDI} = \frac{\text{Total numerical rating}}{\text{Total plants observed} \times \text{Maximum rating}} \times 100$$

3.3.2.5.5 *Fusarium* wilt incidence

Fusarium wilt incidence was measured by using 1-5 scale (Reis *et al.*, 2004).

Original grade	Description	Disease index scale	Reaction
1	Symptom free plant	1	Immune
2	Plants showing slight wilt symptoms	1.01-2.00	Resistance
3	Plants showing severe wilt symptoms	2.01-3.00	Moderately resistance
4	Severe wilting associated with the presence of foliar necrosis and chlorosis	3.01-4.00	Susceptible
5	Dead plant	4.01-5.00	Highly susceptible

Disease index (DI) was calculated by using the formulae:

$$\text{Disease Index} = \frac{\text{Sum of individual plant grade}}{\text{Total number plants}}$$

3.4 Statistical analysis

Replication means of various characters of parents and hybrids were subjected to diallel analysis with randomised block design (Griffing’s 1956).

3.4.1 Analysis of variance

Source	D. F.	SS	MSS	Cal. F
Replication	r-1	RSS	RSS/(r-1)	RMSS/EMSS
Treatments	t-1	TrSS	TrSS/(t-1)	TrMSS/EMSS
Error	(r-1)(t-1)	ESS	ESS/[(r-1)(t-1)]	
Total	(rt-1)	TSS		

Where,

t = Number of treatments (genotypes)

r = Number of replications

The standard error was calculated as,

$$\text{S. Em}\underline{+} = \sqrt{\frac{EMSS}{r}}$$

$$\text{C. D.} = \sqrt{\frac{EMSS}{r}} \times \text{t value}$$

The significance of treatments mean squares and replication mean squares were tested by comparing with error mean square referring to ‘F’ table values at 5 and 1 per cent level of probabilities.

3.4.2 Heterosis

The magnitude of heterosis was estimated in relation to better parent. They were thus, calculated as percentage increase or decrease of F_1 hybrids over better parent (BP) using the methods of Turner (1953) and Hayes *et al.* (1956). The mean of all the replications for each parents, hybrids and check for each of the characters was computed and used in estimation of heterosis. Heterosis was calculated as the percentage increase or decrease of F_1 performance (F_1) over the means of better parent (BP), the best parent (BTP) and the commercial check (CC).

Heterosis for each trait was computed by using following formula:

$$\text{Heterosis over better parent (\%)} = \frac{F_1 - BP}{BP} \times 100$$

(Heterobeltiosis)

Where, F_1 and BP are mean values of F_1 hybrids and better parent, respectively.

$$\text{Heterosis over best parent (\%)} = \frac{F_1 - BTP}{BTP} \times 100$$

Where, F_1 and BTP are mean values of F_1 hybrids and best parent, respectively.

$$\text{Heterosis over commercial check (\%)} = \frac{F_1 - CC}{CC} \times 100$$
(Standard Heterosis)

Where, CC is the mean of commercial check.

The significance of F_1 heterosis values were tested by comparing them with CD values obtained separately for BP, BTP and CC employing the formula given below.

$$CD = \sqrt{2 \times \frac{MSSe}{r}} \times \text{t value}$$

Where,

MSSe = Error mean sum of squares

r = Number of replications

t = table 't' value at error degrees of freedoms

3.4.3 Combining ability

The variation among the hybrids was further partitioned into genetic components attributed to general combining ability (GCA) variances and specific combining ability (SCA) variances and effects were analyzed by adopting Model-I, Method-2 of Griffing's (1956), since the present study includes parental lines and F_1 hybrids (without reciprocals).

The statistical procedure assumes the following mathematical model.

$$X_{ij} = \mu + g_i + g_j + S_{ij} + 1/bc \sum_k \sum_l e_{ijkl}$$

i, j = 1,2,……….., n

k = 1, 2,……….., b

l = 1, 2,……….., c

Where,

μ = population mean

n = number of inbred parent lines

i and j = the male and female parents of ij^{th} hybrid

b = number of replications

c = number of plants per family

g_i and g_j = the general combining ability (gca) effect for the cross between i^{th} and j^{th} parents.

S_{ij} = specific combining ability effect for the cross between i^{th} and j^{th} parents such that

$S_{ij} = S_{ji}$

E_{ijkl}= environmental effect associated with the $ijkl^{th}$ individual observation.

As only plot mean values were taken for analysis, Me' = Me/bc. Restriction imposed on the utility of this model was:

$$\sum_i g_i = 0 \text{ and } \sum_j S_{ij} + S_{ii} = 0 \text{ (for each i)}$$

3.4.3.1 Analysis of variance of combining ability

The variances due to general and specific combining ability were calculated as follows,

$$S_g = \frac{1}{n+2}\left[\Sigma(X_{i.} + X_{ii})^2 - \frac{4}{n} X^2 \ldots\right]$$

$$S_s = \sum X_{ij}^2 - \frac{1}{n+2}\Sigma(X_{i.} + X_{ii})^2 + \frac{2}{(n+1)(n+2)} X^2 \ldots$$

Where,

S_g= Sum of squares due to general combining ability

S_s= Sum of squares due to specific combining ability

n = Number of parents

X_i = Total of array of i^{th} parent in diallel table

X_{ii} = Mean of i^{th} parent

X... = Grand total of $\frac{n(n+1)}{2}$ values of the diallel table

X_{ij} = Value of each cell of $\frac{n(n+1)}{2}$

The analysis of variance table for combining ability is given below:

Source	**df**	**SS**	**MSS**
General combining ability	n-1	S_g	Mg
Specific combining ability	$\frac{n(n+1)}{2}$	S_s	Ms
Error	$\frac{(n-1)(n+2)(r-1)}{2}$		Me’

The error term in the table was obtained as Me’ = Me /r

Where, Me = Error variance of the experiment as determined by the general analysis of variance in the experiment and

r = number of replications

The two combining ability variances were tested for the ‘F’ ratio against Me’ to test the significance or otherwise.

3.4.3.2 Estimation of combining ability effects

The general combining ability effects (gca effect = gi) and specific combining ability effects (sca effects = Sij) were estimated as follows:

$$g_i = \frac{1}{n+2}\left[\Sigma(X_{i.} + X_{ii}) - \frac{2}{n}X_{...}\right]$$

$$S_{ij} = X_{ij} - \frac{1}{n+2}(X_{i.} + X_{ii} + X_{.j} + X_{jj}) + \frac{2}{(n+1)(n+2)} \times X_{...}$$

3.4.3.3 Testing the significance of the combining ability

The square root of variance of an estimate is its standard error. The variances of the different estimates were calculated by multiplying the error variance from the combining ability with their respective coefficients as shown below:

Error variance ($\hat{X}_{ij}$) = M_e' = σ^2_e = Error variance from the RCBD (Randomized Complete Block Design) analysis.

Variance of ($\hat{g}_i$) = $\frac{n-1}{n(n+2)}\sigma^2_e$ = Variance of gca effects

Varaince of ($\hat{s}_{ij}$) = $\frac{n^2+n+2}{(n+1)(n+2)}\sigma^2_e$ = Variance of sca effects

3.4.3.4 Testing of significance of differences between estimates

To test the significance of the difference between two estimates, least significant difference was calculated by the product of table value of ‘t’ at appropriate degree of freedom for error and the standard error of the difference of two estimates. The standard error of the difference was taken as the square root of the variance of difference between two estimates. The variance was obtained as follows:

For testing differences between two estimates of gca effects:

$$\text{Variance } (g_i - g_j) = \frac{2}{n+2}\sigma^2_e$$

For testing differences between two estimates of sca effects in the same array:

$$\text{Variance } (S_{ij} - S_{ik}) = \frac{2(n+1)}{n+2}\sigma^2_e$$

For testing differences between two estimates of sca effects in the different array:

$$\text{Variance } (S_{ij} - S_{kl}) = \frac{2n}{n+2}\sigma^2_e$$

3.4.3.5 Assumptions underlying diallel analysis

i. Diploid segregation

ii. Homozygosity of parents

iii. No difference between reciprocals

iv. Independent action of non-allelic genes

v. Independent or uncorrelated distribution of genes among the parents or no linkage

vi. Absence of multiple allelism

vii. Inbreeding co-efficient equals to one

4. EXPERIMENTAL RESULTS

The experiment on diallel analysis was carried out in okra. Twenty eight crosses were developed by crossing eight parents in half diallel fashion. All the crosses were evaluated along with their parents and commercial checks with the objective of assessing magnitude of heterosis and identifying good combiners for various traits. The results obtained in the present investigation are presented under the following headings.

4.1 Analysis of variance

4.2 *Per se* performance and magnitude of heterosis

4.3 Combining ability effects and variances

4.4 Pest and diseases

4.1 Analysis of variance

Results of analysis of variance for 20 characters under study are summarised in Table 4 and presented under different headings as components of variance.

4.1.1 Genotypes

Variance due to genotypes (crosses and parents) was highly significant (at p=0.01) for all the growth, earliness, yield and quality parameters, *viz*., plant height at 45, 60 and 90 days after sowing (DAS), number of leaves on 45, 60 and 90 DAS, internodal length at 60 DAS, number of branches per plant, number of nodes on the main stem, days to first flowering, days to 50 per cent flowering, fruit length, fruit diameter, average fruit weight, number of fruits per plant, total yield per plant, yield per plot, yield per hectare, number of ridges on fruit surface and number of seeds per fruit.

4.1.2 Parents

Parents differed significantly among themselves for all the growth, earliness, yield and quality parameters studied except for fruit diameter and average fruit weight.

Table 4. Analysis of variance (mean sum of squares) of diallel analysis for various characters in okra

Sl. No.	Character	Replications	Genotypes	Parents	Crosses	Parents vs Crosses	Error
	Degrees of freedom	**1**	**35**	**7**	**27**	**1**	**35**
a.	**Growth parameters**						
1.	Plant height at 45 DAS	281.08	55.40**	76.53**	42.53**	254.87**	17.26
2.	Plant height at 60 DAS	275.26	142.13**	58.75*	152.51**	445.47**	21.23
3.	Plant height at 90 DAS	43.56	157.27**	41.54*	192.19**	24.58NS	13.47
4.	Number of leaves at 45 DAS	2.33	2.89**	3.96**	2.33**	10.55**	0.04
5.	Number of leaves at 60 DAS	23.70	8.69**	8.49**	8.73**	8.74**	0.369
6.	Number of leaves at 90 DAS	31.98	13.42**	14.29**	13.56**	3.43**	0.937
7.	Internodal length at 60 DAS	0.78	3.65**	2.54*	3.94**	3.61*	0.82
8.	Number of branches per plant	0.06	0.18**	0.17*	0.19**	0.11NS	0.06
9.	Number of nodes on main stem	8.20	6.44**	3.36**	7.38**	2.59**	0.589
b.	**Earliness parameters**						
10.	Days to first flowering	1.68	3.55**	3.13*	3.77**	0.36NS	1.08
11.	Days to 50 per cent flowering	0.12	12.63**	8.71*	13.87**	6.67NS	2.95
c.	**Yield parameters**						
12.	Fruit length (cm)	0.80	2.94**	3.23**	2.83**	3.76*	0.89
13.	Fruit diameter (mm)	0.75	2.17**	1.53NS	2.36**	1.69NS	0.75
14.	Average fruit weight (g)	1.85	5.31**	1.31NS	6.36**	4.98*	1.03
15.	Number of fruits per plant	5.58	4.44**	6.77**	3.65**	9.43**	0.64
16.	Total yield per plant (kg)	0.001	0.003**	0.002**	0.003**	0.00NS	0.001
17.	Yield per plot (kg)	0.40	0.87**	0.73**	0.94**	0.07NS	0.16
18.	Yield per hectare (t)	3.14	6.73**	5.62**	7.25**	0.55NS	1.26
d.	**Quality parameters**						
19.	Number of ridges on fruit surface	0.03	0.08**	0.17**	0.06**	0.05*	0.01
20.	Number of seeds per fruit	7.74	82.12**	53.63**	92.46**	2.03NS	8.42

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAS: Days after sowing.

4.1.3 Crosses

There was highly significant (at p=0.01) difference among the crosses for all the growth, earliness, yield and quality parameters studied.

4.1.4 Parents vs Crosses

Variance due to parents vs crosses was significant for plant height at 45 and 60 DAS, number of leaves at 45, 60 and 90 DAS, internodal length at 60 DAS, number of nodes on main stem, fruit length, average fruit weight, number of fruits per plant and number of ridges on fruit surface and for all other parameters variance due to parents vs crosses was not significant.

4.2 *Per se* performance and magnitude of heterosis

Per se performance of parents, crosses and commercial checks and heterosis worked out over better parent, the best parent and the commercial checks (Arka Anamika and MHY-10) are presented for growth, earliness, yield and quality parameters. The variety Arka Anamika and the hybrid MHY-10 are selected as commercial checks, since these are commercially popular and widely grown in this area.

4.2.1 Plant height (Table 5 and 6)

Genotypes differed significantly among themselves for plant height at 45, 60 and 90 DAS. Plant height at 45 DAS varied from 41.57 cm (KO1603) to 58.56 cm (KO1608) among parents and 39.75 cm (KO1602 x KO1606) to 54.66 cm (KO1601 x KO1602) among crosses. Magnitude of heterosis over better parent and the commercial checks was highly significant in both the directions, whereas heterosis over the best parent was significant only in the negative direction. Maximum heterosis was observed in the cross KO1603 x KO1605 (13.41%) over better parent and the cross KO1601 x KO1602 exhibited maximum heterosis over the commercial checks Arka Anamika (21.76%) and MHY-10 (18.31%). Among 28 crosses, only one cross over better parent, six crosses over the commercial check Arka Anamika and five crosses over the commercial check MHY-10 showed significantly positive heterosis for plant height at 45 DAS. None of the crosses showed significantly positive heterosis over the best parent.

Table 5. *Per se* performance of parents and crosses for plant height and number of leaves in okra

Sl. No.	Genotypes	Plant height (cm)			Number of leaves		
		45 DAS	60 DAS	90 DAS	45 DAS	60 DAS	90 DAS
Parents							
1	KO1601	48.24	77.53	89.40	8.46	10.34	11.94
2	KO1602	55.78	75.06	89.30	11.37	15.84	18.98
3	KO1603	41.57	75.70	91.50	8.22	13.36	16.34
4	KO1604	45.95	77.72	88.10	9.46	13.52	15.41
5	KO1605	45.65	83.30	95.40	9.94	10.40	11.77
6	KO1606	56.32	78.50	92.70	9.64	12.63	14.91
7	KO1607	46.54	91.00	101.10	8.24	13.89	14.94
8	KO1608	58.56	84.30	97.60	11.97	15.61	18.68
Hybrids							
9	KO1601 x KO1602	54.66	80.80	94.20	8.43	13.87	15.99
10	KO1601 x KO1603	43.46	81.20	108.10	7.88	10.47	12.94
11	KO1601 x KO1604	42.12	77.15	87.30	10.57	14.41	16.67
12	KO1601 x KO1605	45.18	73.12	89.40	8.56	10.31	12.16
13	KO1601 x KO1606	44.62	77.15	90.60	8.50	10.72	12.34
14	KO1601 x KO1607	43.49	60.55	99.90	7.74	10.09	14.60
15	KO1601 x KO1608	46.99	75.90	83.90	8.24	13.44	15.35
16	KO1602 x KO1603	43.86	76.80	90.80	7.47	10.09	11.46
17	KO1602 x KO1604	43.50	83.95	95.00	8.29	12.82	14.17
18	KO1602 x KO1605	49.73	74.25	80.70	8.34	11.51	12.48
19	KO1602 x KO1606	39.75	56.55	73.20	8.13	10.90	13.58
20	KO1602 x KO1607	40.97	70.14	83.30	10.11	13.95	16.75
21	KO1602 x KO1608	44.16	68.60	92.60	7.76	12.43	16.43
22	KO1603 x KO1604	41.03	67.53	90.00	9.03	10.32	13.39
23	KO1603 x KO1605	51.77	82.40	102.00	8.69	12.13	13.55
24	KO1603 x KO1606	42.12	74.82	89.60	11.45	16.03	20.36
25	KO1603 x KO1607	32.65	57.55	74.10	7.10	10.20	11.68
26	KO1603 x KO1608	52.44	82.52	96.50	7.93	12.78	14.62
27	KO1604 x KO1605	41.42	61.34	71.90	8.81	10.01	10.86
28	KO1604 x KO1606	51.16	87.43	102.50	8.30	13.15	14.36
29	KO1604 x KO1607	48.45	64.90	85.80	10.48	10.48	13.70
30	KO1604 x KO1608	45.93	88.71	106.80	8.87	16.97	20.39
31	KO1605 x KO1606	44.00	77.40	99.20	9.87	13.48	17.28
32	KO1605 x KO1607	47.80	66.91	87.50	8.70	10.22	12.44
33	KO1605 x KO1608	48.02	84.80	94.20	10.76	15.28	16.97
34	KO1606 x KO1607	44.02	78.53	95.60	7.78	13.75	16.70
35	KO1606 x KO1608	50.92	75.85	108.90	8.09	10.59	14.77
36	KO1607 x KO1608	44.20	76.51	94.90	8.86	15.68	19.70
Commercial checks							
37	Arka Anamika	44.89	66.82	89.20	8.64	12.53	15.90
38	Mahyco-10	46.20	71.47	92.20	10.47	14.61	16.97
SEm±		2.94	3.26	2.60	0.15	0.43	0.68
CD at 5%		8.43	9.45	7.53	0.42	1.23	1.96
CD at 1%		11.31	12.50	9.99	0.57	1.65	2.63

DAS – Days after sowing

Table 6. Heterosis (%) over better parent, the best parent and the commercial check for plant height in okra

Sl. No.	Hybrids	Plant height at 45 DAS				Plant height at 60 DAS				Plant height at 90 DAS			
		BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2
1	KO1601 x KO1602	-2.01	-6.66	21.76**	18.31**	4.22	-11.21*	20.92**	13.05**	5.37	-6.82	5.61	2.17
2	KO1601 x KO1603	-9.91*	-25.79**	-3.19	-5.93	4.73	-10.77*	21.52**	13.61**	18.14**	6.92	21.19**	17.25**
3	KO1601 x KO1604	-12.69**	-28.07**	-6.17	-8.83*	-0.73	-15.22**	15.46**	7.95	-2.35	-13.65**	-2.13	-5.31
4	KO1601 x KO1605	-6.34	-22.85**	0.65	-2.21	-12.22*	-19.65**	9.43	2.31	-6.29	-11.57**	0.22	-3.04
5	KO1601 x KO1606	-20.77**	-23.80**	-0.60	-3.42	-1.72	-15.22**	15.46**	7.95	-2.27	-10.39**	1.57	-1.74
6	KO1601 x KO1607	-9.85*	-25.73**	-3.12	-5.87	-33.46**	-33.46**	-9.38	-15.28**	-1.19	-1.19	12.00**	8.35*
7	KO1601 x KO1608	-19.76**	-19.76**	4.68	1.71	-9.96*	-16.59**	13.59**	6.20	-14.04**	-17.01**	-5.94	-17.01**
8	KO1602 x KO1603	-21.37**	-25.10**	-2.29	-5.06	1.45	-15.60**	14.94**	7.46	-0.77	-10.19**	1.79	-1.52
9	KO1602 x KO1604	-22.02**	-25.72**	-3.10	-5.84	8.02	-7.75	25.64**	17.46**	6.38	-6.03	6.50	3.04
10	KO1602 x KO1605	-10.85*	-15.08**	10.78*	7.64	-10.86*	-18.41**	11.12*	3.89	-15.41**	-20.18**	-9.53*	-12.47**
11	KO1602 x KO1606	-29.42**	-32.12**	-11.45**	-13.96**	-27.96**	-37.86**	-15.37**	-20.88**	-21.04**	-27.60**	-17.94**	-20.61**
12	KO1602 x KO1607	-26.55**	-30.04**	-8.73*	-11.32**	-22.92**	-22.92**	4.97	-1.86	-17.61**	-17.61**	-6.61	-9.65*
13	KO1602 x KO1608	-24.59**	-24.59**	-1.63	-4.42	-18.62**	-24.62**	2.66	-4.02	-5.12	-8.41*	3.81	0.43
14	KO1603 x KO1604	-10.71*	-29.94**	-8.60*	-11.19*	-13.11**	-25.79**	1.06	-5.51	-1.64	-10.98**	0.90	-2.39
15	KO1603 x KO1605	13.41**	-11.59**	15.33**	12.06**	-1.08	-9.45*	23.32**	15.29**	6.92	0.89	14.35**	10.63**
16	KO1603 x KO1606	-25.21**	-28.07**	-6.17	-8.83*	-4.69	-17.78**	11.97*	4.69	-3.34	-11.37**	0.45	-2.82

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively. DAS – Days after sowing

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

Table 6 contd…..

Sl. No.	Hybrids	Plant height at 45 DAS				Plant height at 60 DAS				Plant height at 90 DAS			
		BP	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**
17	KO1603 x KO1607	-29.85**	-44.25**	-27.27**	-29.33**	-36.76**	-36.76**	-13.87**	-19.48**	-26.71**	-26.71**	-16.93**	-19.63**
18	KO1603 x KO1608	-10.45**	-10.45*	16.82**	13.51**	-2.11	-9.32	23.50**	15.46**	-1.13	-4.55	8.18*	4.66
19	KO1604 x KO1605	-9.86*	-29.27**	-7.73	-10.35*	-26.36**	-32.59**	-8.20	-14.17**	-24.63**	-28.88**	-19.39**	-22.02**
20	KO1604 x KO1606	-9.16*	-12.64**	13.97**	10.74*	11.38*	-3.92	30.84**	22.33**	10.57**	1.38	14.91**	11.17**
21	KO1604 x KO1607	4.10	-17.26**	7.93	4.87	-28.68**	-28.68**	-2.87	-9.19	-15.13**	-15.13**	-3.81	-6.94
22	KO1604 x KO1608	-21.57**	-21.57**	2.32	-0.58	5.23	-2.52	32.76**	24.12**	9.43*	5.64	19.73**	15.84**
23	KO1605 x KO1606	-21.88**	-24.86**	-1.98	-4.76	-7.08	-14.95**	15.83**	8.30	3.98	-1.88	11.21**	7.59*
24	KO1605 x KO1607	2.71	-18.37**	6.48	3.46	-26.47 **	-26.47**	0.13	-6.38	-13.45 **	-13.45 **	-1.91	-5.10
25	KO1605 x KO1608	-18.00**	-18.00**	6.97	3.94	0.59	-6.81	26.91**	18.65**	-3.48	-6.82	5.61	2.17
26	KO1606 x KO1607	-21.84**	-24.83**	-1.94	-4.72	-13.70 **	-13.70**	17.52**	9.88*	-5.44	-5.44	7.17	3.69
27	KO1606 x KO1608	-13.05**	-13.05**	13.43**	10.22*	-10.02*	-16.65**	13.51**	6.13	11.58 **	7.72 *	22.09 **	18.11 **
28	KO1607 x KO1608	-24.52**	-24.52**	-1.54	-4.33	-15.92 **	-15.92**	14.50 **	7.05	-6.13	-6.13	6.39	2.93
SEm±		2.94	2.94	2.94	2.94	3.26	3.26	3.26	3.26	2.60	2.60	2.60	2.60
CD at 5 %		8.43	8.43	8.43	8.43	9.45	9.45	9.45	9.45	7.53	7.53	7.53	7.53
CD at 1 %		11.31	11.31	11.31	11.31	12.50	12.50	12.50	12.50	9.99	9.99	9.99	9.99

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively. DAS – Day after sowing

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika)

CC 2: Heterosis over commercial check 2 (Mahyco 10)

Plant height at 60 DAS varied from 75.06 cm (KO1602) to 91.00 cm (KO1607) among parents and 56.55 cm (KO1602 x KO1606) to 88.71 cm (KO1604 x KO1608) among crosses. Magnitude of heterosis over better parent and the commercial checks was highly significant in both the directions, whereas heterosis over the best parent was significant only in the negative direction. Maximum heterosis was observed in the cross KO1604 x KO1606 (11.38%) over better parent and the cross KO1604 x KO1608 exhibited significant positive heterosis over the commercial checks Arka Anamika (32.76%) and MHY-10 (24.12%). Among 28 crosses, only one cross over better parent, 18 crosses over the commercial check Arka Anamika and nine crosses over the commercial check MHY-10 showed significantly positive heterosis for plant height at 60 DAS. None of the crosses showed significantly positive heterosis over the best parent.

Plant height at 90 DAS varied from 88.10 cm (KO1604) to 101.10 cm (KO1607) among parents and 71.90 cm (KO1604 x KO1605) to 108.90 cm (KO1606 x KO1608) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly significant in both the directions. Maximum heterosis was observed in the cross KO1601 x KO1603 (18.14%) over better parent and the cross KO1606 x KO1608 exhibited significant and positive heterosis over the best parent (7.72%) and the commercial checks Arka Anamika (22.09%) and MHY-10 (18.11%). Among 28 crosses, four crosses over better parent, one cross over the best parent, eight crosses over the commercial check Arka Anamika and seven crosses over the commercial check MHY-10 exhibited significantly positive heterosis for plant height at 90 DAS.

4.2.2 Number of leaves (Table 5 and 7)

Genotypes differed significantly among themselves for number of leaves on 45, 60 and 90 DAS. Number of leaves on 45 DAS varied from 8.22 (KO1603) to 11.97 (KO1608) among parents and 7.10 (KO1603 x KO1607) to 11.45 (KO1603 x KO1606) among crosses. Magnitude of heterosis over better parent and the commercial checks was highly significant in both the directions, whereas heterosis over the best parent was significant only in the negative direction. Maximum heterosis was observed in the cross KO1603 x KO1606 over better parent (18.73%) and the commercial checks Arka Anamika (32.47%) and MHY-10 (9.31%). Among

Table 7. Heterosis (%) over better parent, the best parent and the commercial check for number of leaves in okra

Sl. No.	Hybrids	Number of leaves at 45 DAS				Number of leaves at 60 DAS				Number of leaves at 90 DAS			
		BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2
1	KO1601 x KO1602	-25.84**	-29.59**	-2.45**	-19.50**	-12.41**	-12.44**	10.69**	-5.07**	-15.73**	-15.75**	0.56	-5.78**
2	KO1601 x KO1603	-6.86**	-34.17**	-8.80**	-24.74**	-21.63**	-33.90**	-16.44**	-28.34**	-20.77**	-31.80**	-18.59**	-23.73**
3	KO1601 x KO1604	11.74**	-11.70**	22.33**	0.95**	6.58**	-9.03**	15.00**	-1.37**	8.14**	-12.19**	4.81**	-1.79
4	KO1601 x KO1605	-13.81**	-28.46**	-0.88**	-18.21**	-0.87	-34.91**	-17.72**	-29.43**	1.87	-35.93**	-23.52**	-28.34**
5	KO1601 x KO1606	-11.82**	-28.99**	-1.62**	-18.82**	-15.12**	-32.32**	-14.45**	-26.63**	-17.26**	-35.00**	-22.41**	-27.30**
6	KO1601 x KO1607	-8.57**	-35.38**	-10.47**	-26.12**	-27.36**	-36.30**	-19.47**	-30.94**	-2.26*	-23.07**	-8.17**	-13.96**
7	KO1601 x KO1608	-31.13**	-31.16**	-4.63**	-21.30**	-13.90**	-15.15**	7.26**	-8.01**	-17.82**	-19.12**	-3.45**	-9.53**
8	KO1602 x KO1603	-34.23**	-37.56**	-13.49**	-28.61**	-36.28**	-36.30**	-19.47**	-30.94**	-39.63**	-39.64**	-27.95**	-32.49**
9	KO1602 x KO1604	-27.02**	-30.71**	-4.00**	-20.78**	-19.04**	-19.07**	2.31**	-12.25**	-25.31**	-25.33**	-10.86**	-16.48**
10	KO1602 x KO1605	-26.66**	-30.36**	-3.53**	-20.39**	-27.31**	-27.34**	-8.14**	-21.22**	-34.26**	-34.27**	-21.54**	-26.49**
11	KO1602 x KO1606	-28.46**	-32.08**	-5.90**	-22.35**	-31.17**	-31.19**	-13.01**	-25.39**	-28.44**	-28.45**	-14.60**	-19.98**
12	KO1602 x KO1607	-11.07**	-15.56**	16.98**	-3.46**	-11.90**	-11.93**	11.33**	-4.52**	-11.73**	-11.75**	5.35**	-1.30
13	KO1602 x KO1608	-35.14**	-35.16**	-10.18**	-25.88**	-21.50**	-21.53**	-0.80	-14.92**	-13.41**	-13.44**	3.33**	-3.18**
14	KO1603 x KO1604	-4.57**	-24.59**	4.48**	-13.78**	-23.67**	-34.85**	-17.64**	-29.36**	-18.02**	-29.44**	-15.77**	-21.08**
15	KO1603 x KO1605	-12.49**	-27.36**	0.64**	-16.95**	16.63**	-23.42**	-3.19**	-16.97**	-17.09**	-28.63**	-14.81**	-20.18**
16	KO1603 x KO1606	18.73**	-4.39**	32.47**	9.31**	26.92**	1.20	27.93**	9.72**	24.61**	7.26**	28.03**	19.96**

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively. DAS – Days after sowing

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

Table 7 contd…..

Sl. No.	Hybrids	Number of leaves at 45 DAS				Number of leaves at 60 DAS				Number of leaves at 90 DAS			
		BP	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**
17	KO1603 x KO1607	-13.92**	-40.73**	-17.88**	-32.23**	-26.57**	-35.61**	-18.60**	-30.18**	-28.53**	-38.48**	-26.57**	-31.20**
18	KO1603 x KO1608	-33.74**	-33.77**	-8.24**	-24.28**	-18.13**	-19.32**	2.00**	-12.53**	-21.73**	-22.96**	-8.04**	-13.84**
19	KO1604 x KO1605	-11.29**	-26.36**	2.02**	-15.81**	-25.96**	-36.81**	-20.11**	-31.49**	-29.54**	-42.79**	-31.71**	-36.01**
20	KO1604 x KO1606	-13.95**	-30.70**	-3.99**	-20.77**	-2.74**	-16.98**	4.95**	-9.99**	-6.81**	-24.34**	-9.68**	-15.37**
21	KO1604 x KO1607	10.75**	-12.48**	21.25**	0.06	-24.55**	-33.84**	-16.36**	-28.27**	-11.13**	-27.84**	-13.87**	-19.30**
22	KO1604 x KO1608	-25.84**	-25.87**	2.70**	-15.25**	8.71**	7.13**	35.43**	16.15**	9.14**	7.42**	28.23**	20.14**
23	KO1605 x KO1606	-0.69**	-17.56**	14.21**	-5.75**	6.73**	-14.90**	7.58**	-7.73**	15.87**	-8.97**	8.67**	1.81
24	KO1605 x KO1607	-12.44**	-27.32**	0.70**	-16.90**	-26.42**	-35.48**	-18.44**	-30.05**	-16.71**	-34.44**	-21.74**	-26.68**
25	KO1605 x KO1608	-10.10**	-10.14**	24.49**	2.73**	-2.11**	-3.54**	21.95**	4.59**	-9.14**	-10.57**	6.75**	0.02
26	KO1606 x KO1607	-19.27**	-34.99**	-9.93**	-25.67**	-1.01	-13.19**	9.74**	-5.89**	11.79**	-12.01**	5.03**	-1.59
27	KO1606 x KO1608	-32.37**	-32.40**	-6.35**	-22.72**	-32.16**	-33.14**	-15.48**	-27.52**	-20.94**	-22.19**	-7.11**	-12.97**
28	KO1607 x KO1608	-25.94**	-25.97**	2.56**	-15.36**	0.45	-1.01	25.14**	7.32**	5.46**	3.80**	23.91**	16.09**
SEm±		0.15	0.15	0.15	0.15	0.43	0.43	0.43	0.43	0.68	0.68	0.68	0.68
CD at 5 %		0.42	0.42	0.42	0.42	1.23	1.23	1.23	1.23	1.96	1.96	1.96	1.96
CD at 1 %		0.57	0.57	0.57	0.57	1.65	1.65	1.65	1.65	2.63	2.63	2.63	2.63

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.   DAS – Days after sowing

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika)

CC 2: Heterosis over commercial check 2 (Mahyco 10)

28 crosses, three crosses over better parent, 12 crosses over the commercial check Arka Anamika and three crosses over the commercial check MHY-10 showed significantly positive heterosis for number of leaves at 45 DAS. None of the crosses showed significantly positive heterosis over the best parent.

Number of leaves on 60 DAS varied from 10.34 (KO1601) to 15.84 (KO1602) among parents and 10.01 (KO1604 x KO1605) to 16.97 (KO1604 x KO1608) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly significant in both the directions. Maximum heterosis was observed in the cross KO1603 x KO1606 over better parent (26.92%) and the cross KO1604 x KO1608 exhibited significant and positive heterosis over the best parent (7.13 %) and the commercial checks Arka Anamika (35.43%) and MHY-10 (16.15%). Among 28 crosses, five crosses over better parent, one cross over the best parent, 13 crosses over the commercial check Arka Anamika and four crosses over the commercial check MHY-10 showed significantly positive heterosis for number of leaves at 60 DAS.

Number of leaves on 90 DAS varied from 11.77 (KO1605) to 18.98 (KO1602) among parents and 10.86 (KO1604 x KO1605) to 20.39 (KO1604 x KO1608) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly significant in both the directions. Maximum heterosis was observed in the cross KO1603 x KO1606 over better parent (24.61%) and the cross KO1604 x KO1608 exhibited significant and positive heterosis over the best parent (7.42 %) and the commercial checks Arka Anamika (28.23%) and MHY-10 (20.14%). Among 28 crosses, six crosses over better parent, three crosses over the best parent, nine crosses over the commercial check Arka Anamika and three crosses over the commercial check MHY-10 showed significantly positive heterosis for number of leaves at 90 DAS.

4.2.3 Internodal length (Table 8 and 9)

Genotypes differed significantly among themselves for internodal length and it varied from 5.79 cm (KO1602) to 8.92 cm (KO1601) among parents and 4.44 cm (KO1603 x KO1606) to 9.90 cm (KO1601 x KO1606) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly

Table 8. ***Per se*** **performance of parents and crosses for intermodal length, number of branches per plant, number of nodes on main stem and earliness parameters in okra**

Sl. No.	Genotypes	Intermodal Length (cm)	No. Of branches per plant	Number of nodes on main stem	Days to first flowering	Days to 50 per cent flowering
Parents						
1	KO1601	8.92	1.20	9.86	40.50	49.50
2	KO1602	5.79	1.60	11.32	40.00	48.50
3	KO1603	6.90	1.30	9.65	42.50	51.00
4	KO1604	6.04	1.10	10.98	41.00	49.50
5	KO1605	5.95	0.70	11.97	41.50	51.50
6	KO1606	7.47	1.20	9.10	40.50	50.00
7	KO1607	7.70	0.80	9.43	42.00	53.50
8	KO1608	5.90	1.30	12.64	38.50	46.50
Hybrids						
9	KO1601 x KO1602	8.85	1.40	8.94	39.50	44.50
10	KO1601 x KO1603	8.70	0.80	9.73	41.00	51.50
11	KO1601 x KO1604	4.95	1.10	13.64	43.00	54.50
12	KO1601 x KO1605	7.04	0.80	9.54	40.00	51.00
13	KO1601 x KO1606	9.15	1.10	8.20	42.50	53.50
14	KO1601 x KO1607	7.85	0.90	9.36	41.00	51.50
15	KO1601 x KO1608	7.95	1.70	9.15	41.50	49.00
16	KO1602 x KO1603	8.20	0.80	8.37	41.00	51.50
17	KO1602 x KO1604	7.35	0.90	10.23	40.50	50.00
18	KO1602 x KO1605	8.02	1.20	9.16	38.50	46.00
19	KO1602 x KO1606	8.70	1.40	7.71	42.50	51.00
20	KO1602 x KO1607	5.17	1.10	12.14	39.00	48.00
21	KO1602 x KO1608	7.80	1.30	9.17	38.00	47.00
22	KO1603 x KO1604	5.85	0.80	11.68	41.00	53.00
23	KO1603 x KO1605	8.31	0.60	9.57	42.00	53.00
24	KO1603 x KO1606	4.44	1.30	14.98	41.50	52.50
25	KO1603 x KO1607	8.97	0.80	7.05	38.00	49.50
26	KO1603 x KO1608	9.11	1.20	9.18	40.50	46.50
27	KO1604 x KO1605	6.22	0.50	8.86	42.00	56.00
28	KO1604 x KO1606	8.71	0.70	9.13	40.50	51.50
29	KO1604 x KO1607	5.85	0.90	11.97	39.00	50.00
30	KO1604 x KO1608	6.88	1.30	11.82	42.50	53.00
31	KO1605 x KO1606	5.74	1.00	12.58	41.50	51.50
32	KO1605 x KO1607	7.41	0.80	9.11	39.50	49.50
33	KO1605 x KO1608	5.55	1.00	13.27	40.50	53.00
34	KO1606 x KO1607	8.10	1.40	8.98	41.00	52.00
35	KO1606 x KO1608	8.70	1.10	9.72	39.50	49.50
36	KO1607 x KO1608	6.86	1.50	11.31	41.00	51.00
Commercial checks						
37	Arka Anamika	5.35	0.90	10.81	41.50	52.00
38	Mahyco-10	5.85	1.20	11.98	40.00	49.50
SEm±		0.64	0.17	0.54	0.73	1.21
CD at 5%		1.86	0.48	1.55	2.13	3.53
CD at 1%		2.47	0.65	2.09	2.83	4.68

Table 9. Heterosis (%) over better parent, the best parent and the commercial check for internodal length, number of branches and number of nodes on main stem in okra

Sl. No.	Hybrids	Intermodal length				Number of branches per plant				Number of nodes on main stem			
		BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2
1	KO1601 x KO1602	52.85**	52.85**	65.42**	51.28**	-12.50**	-12.50**	55.56**	16.67**	-21.02**	-29.27**	-17.30**	-25.38**
2	KO1601 x KO1603	26.09**	50.26**	62.62**	48.72**	-38.46**	-50.00**	-11.11**	-33.33**	-1.32	-23.02**	-9.99**	-18.78**
3	KO1601 x KO1604	-18.05**	-14.51**	-7.48**	-15.38**	-8.33**	-31.25**	22.22**	-8.33**	24.23**	7.91**	26.18**	13.86**
4	KO1601 x KO1605	18.32**	21.59**	31.59**	20.34**	-33.33**	-50.00**	-11.11**	-33.33**	-20.30**	-24.53**	-11.75**	-20.37**
5	KO1601 x KO1606	22.49**	58.03**	71.03**	56.41**	-8.33**	-31.25**	22.22**	-8.33**	-16.84**	-35.13**	-24.14**	-31.55**
6	KO1601 x KO1607	1.95*	35.58**	46.73**	34.19**	-25.00**	-43.75**	0.00	-25.00**	-5.07**	-25.95**	-13.41**	-21.87**
7	KO1601 x KO1608	34.75**	37.31**	48.60**	35.90**	46.15**	18.75**	88.89**	58.33**	-27.61**	-27.61**	-15.36**	-23.62**
8	KO1602 x KO1603	41.62**	41.62**	53.27**	40.17**	-50.00**	-50.00**	-11.11**	-33.33**	-26.06**	-33.78**	-22.57**	-30.13**
9	KO1602 x KO1604	26.94**	26.94**	37.38**	25.64**	-43.75**	-43.75**	0.00	-25.00**	-9.63**	-19.07**	-5.37**	-14.61**
10	KO1602 x KO1605	38.51**	38.51**	49.91**	37.09**	-25.00**	-25.00**	33.33**	0.00	-23.48**	-27.53**	-15.26**	-23.54**
11	KO1602 x KO1606	50.26**	50.26**	62.62**	48.72**	-12.50**	-12.50**	55.56**	16.67**	-31.89**	-39.00**	-28.68**	-35.64**
12	KO1602 x KO1607	-10.71**	-10.71**	-3.36**	-11.62**	-31.25**	-31.25**	22.22**	-8.33**	7.24**	-3.96**	12.30**	1.34
13	KO1602 x KO1608	34.72**	34.72**	45.79**	33.33**	-18.75**	-18.75**	44.44**	8.33**	-27.45**	-27.45**	-15.17**	-23.46**
14	KO1603 x KO1604	-3.15**	1.04*	9.35**	0.00	-38.46**	-50.00**	-11.11**	-33.33**	6.38**	-7.59**	8.05**	-2.50**
15	KO1603 x KO1605	39.66**	43.52**	55.33**	42.05**	-53.85**	-62.50**	-33.33**	-50.00**	-20.05**	-24.29**	-11.47**	-20.12**
16	KO1603 x KO1606	-35.65**	-23.32**	-17.01**	-24.10**	0.00	-18.75**	44.44**	8.33**	55.23**	18.51**	38.58**	25.04**

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

Table 9 contd…..

Sl. No.	Hybrids	Intermodal length				Number of branches per plant				Number of nodes on main stem			
		BP	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**
17	KO1603 x KO1607	30.00**	54.92**	67.66**	53.33**	-38.46**	-50.00**	-11.11**	-33.33**	-26.94**	-44.22**	-34.78**	-41.15**
18	KO1603 x KO1608	54.41**	57.34**	70.28**	55.73**	-7.69**	-25.00**	33.33**	0.00	-27.37**	-27.37**	-15.08**	-23.37**
19	KO1604 x KO1605	4.54**	7.43**	16.26**	6.32**	-54.55**	-68.75**	-44.44**	-58.33**	-25.98**	-29.91**	-18.04**	-26.04**
20	KO1604 x KO1606	44.21**	50.43**	62.80**	48.89**	-41.67**	-56.25**	-22.22**	-41.67**	-16.85**	-27.77**	-15.54**	-23.79**
21	KO1604 x KO1607	-3.15**	1.04*	9.35**	0.00	-18.18**	-43.75**	0.00	-25.00**	9.02**	-5.30**	10.73**	-0.08
22	KO1604 x KO1608	16.61**	18.83**	28.60**	17.61**	0.00	-18.75**	44.44**	8.33**	-6.49**	-6.49**	9.34**	-1.34
23	KO1605 x KO1606	-3.53**	-0.86	7.29**	-1.88*	-16.67**	-37.50**	11.11**	-16.67**	5.10**	-0.47	16.37**	5.01**
24	KO1605 x KO1607	24.54**	27.98**	38.50**	26.67**	0.00	-50.00**	-11.11**	-33.33**	-23.89**	-27.93**	-15.73**	-23.96**
25	KO1605 x KO1608	-5.93**	-4.15**	3.74**	-5.13**	-23.08**	-37.50**	11.11**	-16.67**	4.98**	4.98**	22.76**	10.77**
26	KO1606 x KO1607	8.43**	39.90**	51.40**	38.46**	16.67**	-12.50**	55.56**	16.67**	-4.77**	-28.96**	-16.93**	-25.04**
27	KO1606 x KO1608	47.46**	50.26**	62.62**	48.72**	-15.38**	-31.25**	22.22**	-8.33**	-23.10**	-23.10**	-10.08**	-18.86**
28	KO1607 x KO1608	16.27**	18.48**	28.22**	17.26**	15.38**	-6.25**	66.67**	25.00**	-10.52**	-10.52**	4.63**	-5.59**
SEm±		0.64	0.64	0.64	0.64	0.17	0.17	0.17	0.17	0.54	0.54	0.54	0.54
CD at 5 %		1.86	1.86	1.86	1.86	0.48	0.48	0.48	0.48	1.55	1.55	1.55	1.55
CD at 1 %		2.47	2.47	2.47	2.47	0.65	0.65	0.65	0.65	2.09	2.09	2.09	2.09

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika)

CC 2: Heterosis over commercial check 2 (Mahyco 10)

significant in both the directions. Negative heterosis is desirable for this trait as it helps in accommodating more number of nodes and fruits. Maximum negative heterosis was observed in the cross KO1603 x KO1606 over better parent (-35.65%), the best parent (-23.32%) and the commercial checks Arka Anamika (-17.01%) and MHY-10 (-24.10%). Among 28 crosses, seven crosses over better parent, four crosses over the best parent and three crosses over the commercial check Arka Anamika and five crosses over the commercial check MHY-10 showed significantly negative heterosis for intermodal length.

4.2.4 Number of branches per plant (Table 8 and 9)

Genotypes differed significantly among themselves for number of branches per plant and it varied from 0.70 (KO1605) to 1.60 (KO1602) among parents and 0.50 (KO1604 x KO1605) to 1.70 (KO1601 x KO1608) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly significant in both the directions. Maximum positive and significant heterosis was observed in the cross KO1601 x KO1608 over better parent (46.15%), the best parent (18.75%) and the commercial checks Arka Anamika (88.89%) and MHY-10 (58.33%). Among 28 crosses, three crosses over better parent, one cross over the best parent and 16 crosses over the commercial check Arka Anamika and eight crosses over the commercial check MHY-10 showed significantly positive heterosis for number of branches per plant.

4.2.5 Number of nodes on the main stem (Table 8 and 9)

Genotypes differed significantly among themselves for number of nodes on the main stem and it varied from 9.10 (KO1606) to 12.64 (KO1608) among parents and 7.05 (KO1603 x KO1607) to 14.98 (KO1603 x KO1606) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly significant in both the directions. Maximum positive and significant heterosis was observed in the cross KO1603 x KO1606 over better parent (55.23%), the best parent (18.51%) and the commercial checks Arka Anamika (38.58%) and MHY-10 (25.04%). Among 28 crosses, seven crosses over better parent, three crosses over the best parent and nine crosses over the commercial check Arka Anamika and four crosses over the commercial check MHY-10 showed significantly positive heterosis for number of nodes on the main stem.

4.2.6 Days to first flowering (Table 8 and 10)

Genotypes differed significantly among themselves for days to first flowering and it varied from 38.50 (KO1608) to 42.50 days (KO1603) among parents and 38.00 (KO1602 x KO1608 and KO1603 x KO1607) to 43.00 days (KO1601 x KO1604) among crosses. Magnitude of heterosis over better parent and the commercial checks was highly significant in both the directions, whereas heterosis over the best parent was significant only in the negative direction. Negative heterosis for this trait indicates earliness and is desirable. Maximum negative and significant heterosis was observed in the cross KO1603 x KO1607 over better parent (-10.59%) and the crosses KO1602 x KO1608 and KO1603 x KO1607 exhibited maximum negative and significant heterosis over the best parent (-10.59%) and the commercial checks Arka Anamika (-8.43%) and MHY-10 (-5.00%). Among 28 crosses, 18 crosses over better parent, 22 crosses over the best parent and 13 crosses over the commercial check Arka Anamika and five crosses over the commercial check MHY-10 showed significantly negative heterosis for days to first flowering.

4.2.7 Days to 50 per cent flowering (Table 8 and 10)

Genotypes differed significantly among themselves for days to 50 per cent flowering and it varied from 46.50 (KO1608) to 53.50 days (KO1607) among parents and 44.50 (KO1601 x KO1602) to 56.00 days (KO1604 x KO1605) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was significant in both the directions. Negative heterosis for this trait indicates earliness and is desirable. Maximum negative and significant heterosis was observed in the cross KO1602 x KO1605 over better parent (-10.68%) and the cross KO1601 x KO1602 exhibited maximum and significantly negative heterosis over the best parent (-16.82%) and the commercial checks Arka Anamika (-14.42%) and MHY-10 (-10.10%). Among 28 crosses, nine crosses over better parent, 19 crosses over the best parent and 11 crosses over the commercial check Arka Anamika and four crosses over the commercial check MHY-10 exhibited negative and significant heterosis for days to 50 per cent flowering.

Table 10. Heterosis (%) over better parent, the best parent and the commercial check for earliness parameters in okra

Sl. No.	Hybrids	Days to first flowering				Days to 50 per cent flowering			
		BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2
1	KO1601 x KO1602	-2.47*	-7.06**	-4.82**	-1.25	-10.10**	-16.82**	-14.42**	-10.10**
2	KO1601 x KO1603	-3.53**	-3.53**	-1.20	2.50*	0.98	-3.74*	-0.96	4.04*
3	KO1601 x KO1604	4.88**	1.18	3.61**	7.50**	10.10**	1.87	4.81**	10.10**
4	KO1601 x KO1605	-3.61**	-5.88**	-3.61**	0.00	-0.97	-4.67*	-1.92	3.03
5	KO1601 x KO1606	4.94**	0.00	2.41*	6.25**	7.00**	0.00	2.88	8.08**
6	KO1601 x KO1607	-2.38*	-3.53**	-1.20	2.50*	-3.74*	-3.74*	-0.96	4.04*
7	KO1601 x KO1608	2.47*	-2.35*	0.00	3.75**	-1.01	-8.41**	-5.77**	-1.01
8	KO1602 x KO1603	-3.53**	-3.53**	-1.20	2.50*	0.98	-3.74*	-0.96	4.04*
9	KO1602 x KO1604	-1.22	-4.71**	-2.41*	1.25	1.01	-6.54**	-3.85*	1.01
10	KO1602 x KO1605	-7.23 **	-9.41**	-7.23**	-3.75**	-10.68**	-14.02**	-11.54**	-7.07**
11	KO1602 x KO1606	4.94**	0.00	2.41*	6.25**	2.00	-4.67*	-1.92	3.03
12	KO1602 x KO1607	-7.14 **	-8.24**	-6.02**	-2.50*	-10.28**	-10.28**	-7.69**	-3.03
13	KO1602 x KO1608	-5.00**	-10.59**	-8.43**	-5.00**	-3.09	-12.15**	-9.62**	-5.05**
14	KO1603 x KO1604	-3.53**	-3.53**	-1.20	2.50*	3.92*	-0.93	1.92	7.07**
15	KO1603 x KO1605	-1.18	-1.18	1.20	5.00**	2.91	-0.93	1.92	7.07**
16	KO1603 x KO1606	-2.35*	-2.35*	0.00	3.75**	2.94	-1.87	0.96	6.06**

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

Table 10 contd…..

Sl. No.	Hybrids	Days to first flowering				Days to 50 per cent flowering			
		BP	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**
17	KO1603 x KO1607	-10.59**	-10.59**	-8.43**	-5.00**	-7.48**	-7.48**	-4.81**	0.00
18	KO1603 x KO1608	-4.71**	-4.71**	-2.41*	1.25	-8.82**	-13.08**	-10.58**	-6.06**
19	KO1604 x KO1605	1.20	-1.18	1.20	5.00**	8.74**	4.67*	7.69**	13.13**
20	KO1604 x KO1606	-1.22	-4.71**	-2.41*	1.25	3.00	-3.74*	-0.96	4.04*
21	KO1604 x KO1607	-7.14**	-8.24**	-6.02**	-2.50*	-6.54**	-6.54**	-3.85*	1.01
22	KO1604 x KO1608	3.66**	0.00	2.41*	6.25**	7.07**	-0.93	1.92	7.07**
23	KO1605 x KO1606	0.00	-2.35*	0.00	3.75**	0.00	-3.74*	-0.96	4.04*
24	KO1605 x KO1607	-5.95 *	-7.06 **	-4.82**	-1.25	-7.48**	-7.48**	-4.81**	0.00
25	KO1605 x KO1608	-2.41*	-4.71**	-2.41*	1.25	2.91	-0.93	1.92	7.07**
26	KO1606 x KO1607	-2.38*	-3.53**	-1.20	2.50*	-2.80	-2.80	0.00	5.05**
27	KO1606 x KO1608	-2.47*	-7.06 **	-4.82**	-1.25	-1.00	-7.48**	-4.81**	0.00
28	KO1607 x KO1608	-2.38*	-3.53**	-1.20	2.50*	-4.67*	-4.67*	-1.92	3.03
SEm±		0.73	0.73	0.73	0.73	1.21	1.21	1.21	1.21
CD at 5 %		2.13	2.13	2.13	2.13	3.53	3.53	3.53	3.53
CD at 1 %		2.83	2.83	2.83	2.83	4.68	4.68	4.68	4.68

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

4.2.8 Fruit length (Table 11 and 12)

Genotypes differed significantly among themselves for fruit length and it varied from 13.41 cm (KO1606) to 17.31 cm (KO1603) among parents and 13.64 cm (KO1602 x KO1606) to 17.94 cm (KO1606 x KO1607) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly significant in both the directions. The cross KO1606 x KO1607 exhibited maximum heterosis over better parent (21.22%), the best parent (3.67%) and the commercial checks Arka Anamika (8.37%) and MHY-10 (6.79%). Among 28 crosses, seven crosses over better parent, one cross over the best parent and 12 crosses over the commercial check Arka Anamika and seven crosses over the commercial check MHY-10 exhibited significant and positive heterosis for fruit length.

4.2.9 Fruit diameter (Table 11 and 12)

Genotypes differed significantly among themselves for fruit diameter and it varied from 14.83 mm (KO1602) to 16.95 mm (KO1604) among parents and 13.55 mm (KO1602 x KO1603) to 17.86 mm (KO1606 x KO1608) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly significant in both the directions. Maximum heterosis was observed in the cross KO1601 x KO1607 over better parent (9.00%) and the cross KO1606 x KO1608 exhibited significant and positive heterosis over the best parent (5.34%) and the commercial checks Arka Anamika (17.82%) and MHY-10 (8.34%). Among 28 crosses, 11 crosses over better parent, six crosses over the best parent and 21 crosses over the commercial check Arka Anamika and 11 crosses over the commercial check MHY-10 showed significantly positive heterosis for fruit diameter.

4.2.10 Average fruit weight (Table 11 and 13)

Genotypes differed significantly among themselves for average fruit weight and it varied from 12.82 (KO1601) to 15.04 g (KO1604) among parents and 9.40 (KO1601 x KO1602) to 16.42 g (KO1603 x KO1606) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly significant in both the directions. Maximum heterosis was observed in the cross KO1601 x KO1605 over better parent (13.82%) and the cross KO1603 x KO1606

Table 11. ***Per se*** **performance of parents and crosses for fruit and yield parameters in okra**

Sl. No.	Genotypes	Fruit length (cm)	Fruit diameter (mm)	Average Fruit weight (g)	Number of fruits per plant	Total yield per plant (g)	Yield per plot (kg)	Yield per hectare (t)	Number of ridges on fruit surface	Number of seeds per fruit
Parents										
1	KO1601	16.81	15.89	12.82	8.95	213	3.62	10.07	5.90	48.30
2	KO1602	15.95	14.83	13.51	13.44	281	4.77	13.25	5.40	40.60
3	KO1603	17.31	16.37	13.42	9.45	197	3.36	9.32	5.40	53.80
4	KO1604	14.53	16.95	15.04	9.15	210	3.57	9.91	5.20	39.10
5	KO1605	15.80	16.38	13.60	10.55	208	3.54	9.82	5.20	52.00
6	KO1606	13.41	15.03	14.96	12.65	286	4.87	13.52	5.10	44.90
7	KO1607	14.80	14.90	13.32	10.95	234	3.98	11.07	5.00	43.30
8	KO1608	16.06	16.85	13.32	13.19	265	4.50	12.49	5.00	45.40
Hybrids										
9	KO1601 x KO1602	15.58	15.20	9.40	13.55	196	3.34	9.27	5.00	36.30
10	KO1601 x KO1603	16.55	16.97	12.98	10.00	189	3.22	8.95	5.30	45.30
11	KO1601 x KO1604	15.16	16.22	11.04	12.85	166	2.83	7.86	5.40	48.60
12	KO1601 x KO1605	13.67	15.71	15.48	12.05	274	4.65	12.93	5.30	46.40
13	KO1601 x KO1606	16.29	16.81	10.52	11.15	211	3.59	9.98	5.40	60.80
14	KO1601 x KO1607	15.00	17.32	13.49	10.85	214	3.64	10.11	5.10	38.40
15	KO1601 x KO1608	16.46	16.77	12.60	13.85	257	4.37	12.14	5.60	43.30
16	KO1602 x KO1603	17.00	13.55	12.22	10.20	182	3.09	8.58	5.20	54.20
17	KO1602 x KO1604	14.11	15.21	13.40	11.10	218	3.71	10.30	5.30	38.50
18	KO1602 x KO1605	16.93	16.82	14.07	12.55	259	4.41	12.25	5.30	40.80
19	KO1602 x KO1606	13.64	14.95	13.28	12.80	260	4.42	12.27	5.40	43.50
20	KO1602 x KO1607	17.19	16.19	10.22	13.20	198	3.37	9.37	5.50	51.60
21	KO1602 x KO1608	15.81	14.56	13.13	12.99	293	4.98	13.83	5.00	42.20

Table 11 contd…..

Sl. No.	Genotypes	Fruit length (cm)	Fruit diameter (mm)	Average Fruit weight (g)	Number of fruits per plant	Total yield per plant (g)	Yield per plot (kg)	Yield per hectare (t)	Number of ridges on fruit surface	Number of seeds per fruit
22	KO1603 x KO1604	15.71	17.14	13.77	10.15	205	3.48	9.66	5.20	46.90
23	KO1603 x KO1605	17.53	16.60	13.99	10.95	225	3.82	10.62	5.30	56.30
24	KO1603 x KO1606	17.08	17.34	16.42	13.44	290	4.92	13.67	5.10	36.40
25	KO1603 x KO1607	16.91	15.69	15.14	10.45	232	3.94	10.93	5.00	58.70
26	KO1603 x KO1608	17.23	17.39	14.14	13.00	270	4.60	12.77	5.00	48.10
27	KO1604 x KO1605	17.14	16.57	10.54	9.90	152	2.59	7.20	5.00	44.10
28	KO1604 x KO1606	14.72	15.12	16.04	10.85	255	4.34	12.04	5.40	40.20
29	KO1604 x KO1607	17.18	16.08	12.22	10.20	185	3.14	8.72	5.40	41.20
30	KO1604 x KO1608	16.37	17.77	12.95	12.10	230	3.91	10.87	5.20	40.00
31	KO1605 x KO1606	15.80	16.05	10.89	12.93	228	3.88	10.78	5.20	46.60
32	KO1605 x KO1607	14.97	14.81	14.61	10.10	217	3.69	10.24	5.00	37.90
33	KO1605 x KO1608	15.46	17.80	12.82	13.08	244	4.15	11.52	5.00	53.10
34	KO1606 x KO1607	17.94	16.10	14.85	12.90	282	4.79	13.32	5.30	49.40
35	KO1606 x KO1608	16.95	17.86	14.18	12.35	307	5.22	14.51	5.00	48.30
36	KO1607 x KO1608	17.40	16.93	12.84	14.00	264	4.50	12.49	5.00	37.50
Commercial checks										
37	Arka Anamika	16.56	15.16	13.15	10.15	193	3.29	9.13	5.30	54.90
38	Mahyco-10	16.80	16.48	14.34	11.93	256	4.35	12.07	5.10	43.40
SEm±		0.67	0.61	0.72	0.56	16.81	0.28	0.79	0.07	2.05
CD at 5 %		1.93	1.78	2.08	1.62	48.25	0.83	2.30	0.21	5.95
CD at 1 %		2.57	2.36	2.77	2.18	64.73	1.10	3.05	0.27	7.90

Table 12. Heterosis (%) over better parent, the best parent and the commercial check for fruit parameters in okra

Sl. No.	Hybrids	Fruit length				Fruit diameter			
		BP	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**
1	KO1601 x KO1602	-7.32**	-10.00**	-5.92**	-7.29**	-4.31**	-10.32**	0.30	-7.77**
2	KO1601 x KO1603	-4.39**	-4.39**	-0.06	-1.52	3.67**	0.09	11.94**	2.94**
3	KO1601 x KO1604	-9.79**	-12.40**	-8.43**	-9.76**	-4.31**	-4.31**	7.03**	-1.58
4	KO1601 x KO1605	-18.66**	-21.01**	-17.43**	-18.63**	-4.12**	-7.35**	3.63**	-4.70**
5	KO1601 x KO1606	-3.09**	-5.89**	-1.63	-3.07**	5.82**	-0.83	10.92**	2.00*
6	KO1601 x KO1607	-10.77**	-13.35**	-9.42**	-10.74**	9.00**	2.15*	14.25**	5.07**
7	KO1601 x KO1608	-2.08*	-4.91**	-0.60	-2.05*	-0.50	-1.09	10.62**	1.73
8	KO1602 x KO1603	-1.76	-1.76	2.69**	1.19	-17.20**	-20.06**	-10.59**	-17.78**
9	KO1602 x KO1604	-11.57**	-18.49**	-14.80**	-16.04**	-10.27**	-10.27**	0.36	-7.71**
10	KO1602 x KO1605	6.14**	-2.17*	2.27*	0.77	2.69**	-0.77	10.99**	2.06*
11	KO1602 x KO1606	-14.48**	-21.18**	-17.61**	-18.81**	-0.53	-11.83**	-1.39	-9.31**
12	KO1602 x KO1607	7.74**	-0.69	3.81**	2.29*	8.62**	-4.51**	6.80**	-1.79*
13	KO1602 x KO1608	-1.59	-8.67**	-4.53**	-5.92**	-13.59**	-14.10**	-3.93**	-11.65**
14	KO1603 x KO1604	-9.25**	-9.25**	-5.13**	-6.52**	1.12	1.12	13.10**	4.00**
15	KO1603 x KO1605	1.30	1.30	5.89**	4.35**	1.34	-2.06*	9.53**	0.73
16	KO1603 x KO1606	-1.33	-1.33	3.14**	1.64	5.93**	2.27*	14.38**	5.19**

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

Table 12 contd…..

Sl. No.	Hybrids	Fruit length				Fruit diameter			
		BP	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**
17	KO1603 x KO1607	-2.31*	-2.31*	2.11*	0.63	-4.16**	-7.46**	3.50**	-4.82**
18	KO1603 x KO1608	-0.46	-0.46	4.05**	2.53*	3.20**	2.60**	14.75**	5.52**
19	KO1604 x KO1605	8.48**	-0.95	3.53**	2.02*	-2.27*	-2.27*	9.30**	0.52
20	KO1604 x KO1606	1.27	-14.97**	-11.11**	-12.41**	-10.80**	-10.80**	-0.23	-8.25**
21	KO1604 x KO1607	16.05**	-0.75	3.75**	2.23*	-5.16**	-5.16**	6.07**	-2.46**
22	KO1604 x KO1608	1.90	-5.43**	-1.15	-2.59**	4.84**	4.84**	17.26**	7.83**
23	KO1605 x KO1606	0.00	-8.70**	-4.56**	-5.95**	-2.05*	-5.34**	5.87**	-2.64**
24	KO1605 x KO1607	-5.25**	-13.49**	-9.57**	-10.89**	-9.62**	-12.65**	-2.31*	-10.16**
25	KO1605 x KO1608	-3.74**	-10.66**	-6.61**	-7.98**	5.61**	4.99**	17.42**	7.98**
26	KO1606 x KO1607	21.22**	3.67**	8.37**	6.79**	7.12**	-5.04**	6.20**	-2.34*
27	KO1606 x KO1608	5.51**	-2.08*	2.36*	0.86	5.96**	5.34**	17.82**	8.34**
28	KO1607 x KO1608	8.34**	0.55	5.10**	3.57**	0.47	-0.12	11.71**	2.73**
SEm±		0.67	0.67	0.67	0.67	0.61	0.61	0.61	0.61
CD at 5 %		1.93	1.93	1.93	1.93	1.78	1.78	1.78	1.78
CD at 1 %		2.57	2.57	2.57	2.57	2.36	2.36	2.36	2.36

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

Table 13. Heterosis (%) over better parent, the best parent and the commercial check for fruit and yield parameters in okra

Sl. No.	Hybrids	Average fruit weight				Number of fruits per plant				Total yield per plant			
		BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2
1	KO1601 x KO1602	-30.43**	-37.51**	-28.58**	-34.48**	0.82	0.82	33.50**	13.58**	-30.12**	-31.59**	1.55**	-23.29**
2	KO1601 x KO1603	-3.21**	-13.63**	-1.29	-9.45**	5.82**	-25.60**	-1.48	-16.18**	-11.03**	-33.86**	-1.81**	-25.83**
3	KO1601 x KO1604	-26.57**	-26.57**	-16.08**	-23.01**	40.44**	-4.39**	26.60**	7.71**	-21.83**	-41.88**	-13.73**	-34.83**
4	KO1601 x KO1605	13.82**	2.96**	17.67**	7.95**	14.22**	-10.34**	18.72**	1.01	28.64**	-4.36**	41.97**	7.24**
5	KO1601 x KO1606	-29.74**	-30.06**	-20.07**	-26.67**	-11.86**	-17.04**	9.85**	-6.54**	-26.35**	-26.35**	9.33**	-17.42**
6	KO1601 x KO1607	1.28	-10.28**	2.55*	-5.93**	-0.91	-19.27**	6.90**	-9.05**	-8.53**	-25.13**	11.14**	-16.05**
7	KO1601 x KO1608	-5.41**	-16.20**	-4.22**	-12.13**	5.00**	3.05**	36.45**	16.09**	-2.84**	-10.30**	33.16**	0.59**
8	KO1602 x KO1603	-9.52**	-18.72**	-7.11**	-14.78**	-24.11**	-24.11**	0.49	-14.50**	-35.29**	-36.65**	-5.96**	-28.96**
9	KO1602 x KO1604	-10.87**	-10.87**	1.86	-6.56**	-17.41**	-17.41**	9.36**	-6.96**	-22.10**	-23.73**	13.21**	-14.48**
10	KO1602 x KO1605	3.42**	-6.45**	6.92**	-1.92	-6.62**	-6.62**	23.65**	5.20**	-7.49**	-9.42**	34.46**	1.57**
11	KO1602 x KO1606	-11.29**	-11.71**	0.91	-7.43**	-4.76**	-4.76**	26.11**	7.29**	-9.42**	-9.42**	34.46**	1.57**
12	KO1602 x KO1607	-24.32**	-32.03**	-22.31**	-28.73**	-1.79*	-1.79*	30.05**	10.65**	-29.23**	-30.72**	2.85**	-22.31**
13	KO1602 x KO1608	-2.78**	-12.67**	-0.19	-8.44**	-3.35**	-3.35**	27.98**	8.89**	4.46**	2.27**	51.81**	14.68**
14	KO1603 x KO1604	-8.41**	-8.41**	4.68**	-3.97**	7.41**	-24.48**	0.00	-14.92**	-2.62**	-28.62**	5.96**	-19.96**
15	KO1603 x KO1605	2.87**	-6.95**	6.35**	-2.44*	3.79**	-18.53**	7.88**	-8.21**	8.17**	-21.47**	16.58**	-11.94**
16	KO1603 x KO1606	9.72**	9.21**	24.82**	14.50**	6.21**	-0.04	32.36**	12.62**	1.05**	1.05**	50.00**	13.31**

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika)

CC 2: Heterosis over commercial check 2 (Mahyco 10)

Table 13 contd…..

Sl. No.	Hybrids	Average fruit weight				Number of fruits per plant				Total yield per plant			
		BP	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**
17	KO1603 x KO1607	12.86**	0.70	15.09**	5.58**	-4.57**	-22.25**	2.96**	-12.41**	-1.28**	-19.20**	19.95**	-9.39**
18	KO1603 x KO1608	5.37**	-5.99**	7.45**	-1.43	-1.44	-3.27**	28.08**	8.97**	2.27**	-5.58**	40.16**	5.87**
19	KO1604 x KO1605	-29.93**	-29.93**	-19.92**	-26.53**	-6.16**	-26.34**	-2.46**	-17.02**	-27.38**	-46.77**	-20.98**	-40.31**
20	KO1604 x KO1606	6.68**	6.68**	21.93**	11.85**	-14.23**	-19.27**	6.90**	-9.05**	-10.99**	-10.99**	32.12**	-0.20**
21	KO1604 x KO1607	-18.72**	-18.72**	-7.11**	-14.78**	-6.85**	-24.11**	0.49	-14.50**	-21.11**	-35.43**	-4.15**	-27.59**
22	KO1604 x KO1608	-13.87**	-13.87**	-1.56	-9.69**	-8.26**	-9.97**	19.21**	1.42	-13.04**	-19.72**	19.17**	-9.98**
23	KO1605 x KO1606	-27.23**	-27.57**	-17.22**	-24.06**	2.21**	-3.79**	27.39**	8.38**	-20.42**	-20.42**	18.13**	-10.76**
24	KO1605 x KO1607	7.39**	-2.86**	11.02**	1.85	-7.76**	-24.85**	-0.49	-15.34**	-7.68**	-24.43**	12.18**	-15.26**
25	KO1605 x KO1608	-5.74**	-14.73**	-2.55*	-10.60**	-0.83	-2.68**	28.87**	9.64**	-7.94**	-15.01**	26.17**	-4.70**
26	KO1606 x KO1607	-0.77	-1.23	12.88**	3.56**	17.81**	-4.02**	27.09**	8.13**	-1.57**	-1.57**	46.11**	10.37**
27	KO1606 x KO1608	-5.28**	-5.72**	7.75**	-1.15	-6.37**	-8.11**	21.67**	3.52**	7.33**	7.33**	59.33**	20.35**
28	KO1607 x KO1608	-3.64**	-14.63**	-2.43*	-10.50**	6.14**	4.17**	37.93**	17.35**	0.00	-7.68**	37.05**	3.52**
SEm±		0.72	0.72	0.72	0.72	0.56	0.56	0.56	0.56	0.02	0.02	0.02	0.02
CD at 5 %		2.08	2.08	2.08	2.08	1.62	1.62	1.62	1.62	0.05	0.05	0.05	0.05
CD at 1 %		2.77	2.77	2.77	2.77	2.18	2.18	2.18	2.18	0.06	0.06	0.06	0.06

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika)

CC 2: Heterosis over commercial check 2 (Mahyco 10)

exhibited significant and positive heterosis over the best parent (9.21%) and the commercial checks Arka Anamika (24.82%) and MHY-10 (14.50%). Among 28 crosses, eight crosses over better parent, three crosses over the best parent and 12 crosses over the commercial check Arka Anamika and five crosses over the commercial check MHY-10 showed significantly positive heterosis for average fruit weight.

4.2.11 Number of fruits per plant (Table 11 and 13)

Genotypes differed significantly among themselves for number of fruits per plant and it varied from 8.95 (KO1601) to 13.44 (KO1602) among parents and 9.90 (KO1604 x KO1605) to 14.00 (KO1607 x KO1608) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was significant in both the directions. Maximum heterosis was observed in the cross KO1601 x KO1604 over better parent (40.44%) and the cross KO1607 x KO1608 exhibited significant and positive heterosis over the best parent (4.17%) and the commercial checks Arka Anamika (37.93%) and MHY-10 (17.35%). Among 28 crosses, 10 crosses over better parent, two crosses over the best parent and 22 crosses over the commercial check Arka Anamika and 14 crosses over the commercial check MHY-10 showed significantly positive heterosis for number of fruits per plant.

4.2.12 Total yield per plant (Table 11 and 13)

Genotypes differed significantly among themselves for total yield per plant and it varied from 197 (KO1603) to 286 g (KO1606) among parents and 152 (KO1604 x KO1605) to 307 g (KO1606 x KO1608) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was highly significant in both the directions. Maximum heterosis was observed in the cross KO1601 x KO1605 over better parent (28.64%) and the cross KO1606 x KO1608 exhibited significant and positive heterosis over the best parent (7.33%) and the commercial checks Arka Anamika (59.33%) and MHY-10 (20.35%). Among 28 crosses, six crosses over better parent, three crosses over the best parent and 23 crosses over the commercial check Arka Anamika and 10 crosses over the commercial check MHY-10 showed significantly positive heterosis for total yield per plant.

4.2.13 Total yield per plot (Table 11 and 14)

Genotypes differed significantly among themselves for total yield per plot and it varied from 3.36 (KO1603) to 4.87 kg (KO1606) among parents and 2.59 (KO1604 x KO1605) to 5.22 kg (KO1606 x KO1608) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was significant in both the directions. Maximum heterosis was observed in the cross KO1601 x KO1605 over better parent (28.41%) and the cross KO1606 x KO1608 exhibited significant and positive heterosis over the best parent (7.29%) and the commercial checks Arka Anamika (59.06%) and MHY-10 (20.25%). Among 28 crosses, six crosses over better parent, three crosses over the best parent and 23 crosses over the commercial check Arka Anamika and nine crosses over the commercial check MHY-10 showed significantly positive heterosis for total yield per plot.

4.2.14 Total yield per hectare (Table 11 and 14)

Genotypes differed significantly among themselves for total yield per hectare and it varied from 9.32 (KO1603) to 13.52 tonnes (KO1606) among parents and 7.20 (KO1604 x KO1605) to 14.51 tonnes (KO1606 x KO1608) among crosses. Magnitude of heterosis over better parent, the best parent and the commercial checks was significant in both the directions. Maximum heterosis was observed in the cross KO1601 x KO1605 over better parent (28.40%) and the cross KO1606 x KO1608 exhibited significant and positive heterosis over the best parent (7.32%) and the commercial checks Arka Anamika (58.98%) and MHY-10 (20.21%). Among 28 crosses, four crosses over better parent, two crosses over the best parent and 22 crosses over the commercial check Arka Anamika and seven crosses over the commercial check MHY-10 showed significantly positive heterosis for total yield per hectare.

4.2.15 Number of ridges on fruit surface (Table 11and 15)

Genotypes differed significantly among themselves for number of ridges on fruit surface and it varied from 5.00 (KO1607 and KO1608) to 5.90 (KO1601) among parents and 5.00 (KO1601 x KO1602, KO1602 x KO1608, KO1603 x KO1607,

Table 14. Heterosis (%) over better parent, the best parent and the commercial check for yield parameters in okra

Sl. No.	Hybrids	Yield per plot				Yield per hectare			
		BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2
1	KO1601 x KO1602	-29.98**	-31.42**	1.67**	-23.13**	-30.01**	-31.46**	1.53	-23.23**
2	KO1601 x KO1603	-11.17**	-33.88**	-1.98**	-25.89**	-11.17**	-33.86**	-2.03	-25.92**
3	KO1601 x KO1604	-21.93**	-41.89**	-13.85**	-34.87**	-22.00**	-41.92**	-13.96**	-34.95**
4	KO1601 x KO1605	28.41**	-4.41**	41.70**	7.13**	28.40**	-4.40**	41.62**	7.08**
5	KO1601 x KO1606	-26.18**	-26.18**	9.44**	-17.26**	-26.17**	-26.17**	9.36**	-17.31**
6	KO1601 x KO1607	-8.66**	-25.26**	10.81**	-16.23**	-8.67**	-25.25**	10.73**	-16.27**
7	KO1601 x KO1608	-2.89**	-10.27**	33.03**	0.58	-2.84*	-10.24**	32.97**	0.54
8	KO1602 x KO1603	-35.22**	-36.55**	-5.94**	-28.88**	-35.22**	-36.56**	-6.02**	-28.94**
9	KO1602 x KO1604	-22.22**	-23.82**	12.94**	-14.61**	-22.23**	-23.84**	12.81**	-14.70**
10	KO1602 x KO1605	-7.55**	-9.45**	34.25**	1.50**	-7.51**	-9.43**	34.17**	1.45
11	KO1602 x KO1606	-9.34**	-9.34**	34.40**	1.61**	-9.28**	-9.28**	34.39**	1.61
12	KO1602 x KO1607	-29.25**	-30.70**	2.74**	-22.32**	-29.22**	-30.68**	2.68*	-22.36**
13	KO1602 x KO1608	4.30**	2.16**	51.45**	14.50**	4.42**	2.30*	51.48**	14.53**
14	KO1603 x KO1604	-2.52**	-28.54**	5.94**	-19.91**	-2.47*	-28.54**	5.86**	-19.96**
15	KO1603 x KO1605	8.20**	-21.46**	16.44**	-11.97**	8.15**	-21.48**	16.32**	-12.05**
16	KO1603 x KO1606	1.13**	1.13**	49.92**	13.35**	1.11	1.11	49.78**	13.25**

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

Table 14 contd…..

Sl. No.	Hybrids	Yield per plot				Yield per hectare			
		BP	**BTP**	**CC 1**	**CC 2**	**BP**	**BTP**	**CC 1**	**CC 2**
17	KO1603 x KO1607	-1.25**	-19.20**	19.79**	-9.44**	-1.22	-19.15**	19.77**	-9.44**
18	KO1603 x KO1608	2.22**	-5.54**	40.03**	5.87**	2.20	-5.58**	39.87**	5.76**
19	KO1604 x KO1605	-27.45**	-46.82**	-21.16**	-40.39**	-27.35**	-46.77**	-21.14**	-40.37**
20	KO1604 x KO1606	-10.99**	-10.99**	31.96**	-0.23	-10.94**	-10.94**	31.93**	-0.25
21	KO1604 x KO1607	-21.20**	-35.52**	-4.41**	-27.73**	-21.23**	-35.53**	-4.49**	-27.78**
22	KO1604 x KO1608	-13.11**	-19.71**	19.03**	-10.01**	-13.05**	-19.67**	19.00**	-10.02**
23	KO1605 x KO1606	-20.33**	-20.33**	18.11**	-10.70**	-20.30**	-20.30**	18.07**	-10.72**
24	KO1605 x KO1607	-7.53**	-24.33**	12.18**	-15.19**	-7.54**	-24.33**	12.10**	-15.24**
25	KO1605 x KO1608	-7.89**	-14.89**	26.18**	-4.60**	-7.80**	-14.82**	26.18**	-4.60**
26	KO1606 x KO1607	-1.54**	-1.54**	45.97**	10.36**	-1.55	-1.55	45.84**	10.27**
27	KO1606 x KO1608	7.29**	7.29**	59.06**	20.25**	7.32**	7.32**	58.98**	20.21**
28	KO1607 x KO1608	-0.11	-7.70**	36.83**	3.45**	-0.04	-7.65**	36.80**	3.44**
SEm±		0.28	0.28	0.28	0.28	0.79	0.79	0.79	0.79
CD at 5 %		0.83	0.83	0.83	0.83	2.30	2.30	2.30	2.30
CD at 1 %		1.10	1.10	1.10	1.10	3.05	3.05	3.05	3.05

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika)

CC 2: Heterosis over commercial check 2 (Mahyco 10)

Table 15. Heterosis (%) over better parent, the best parent and the commercial check for number of ridges on fruit surface and number of seeds per fruit in okra

Sl. No.	Hybrids	Number of ridges on fruit surface				Number of seeds per fruit			
		BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2
1	KO1601 x KO1602	-15.25**	-15.25**	-5.66**	-1.96**	-24.84**	-32.53**	-33.88**	-16.36**
2	KO1601 x KO1603	-10.17**	-10.17**	0.00	3.92**	-15.80**	-15.80**	-17.49**	4.38
3	KO1601 x KO1604	-8.47**	-8.47**	1.89**	5.88**	0.62	-9.67**	-11.48**	11.98**
4	KO1601 x KO1605	-10.17**	-10.17**	0.00	3.92**	-10.77**	-13.75**	-15.48**	6.91*
5	KO1601 x KO1606	-8.47**	-8.47**	1.89**	5.88**	25.88**	13.01**	10.75**	40.09**
6	KO1601 x KO1607	-13.56**	-13.56**	-3.77**	0.00	-20.50**	-28.62**	-30.05**	-11.52**
7	KO1601 x KO1608	-5.08**	-5.08**	5.66**	9.80**	-10.35**	-19.52**	-21.13**	-0.23
8	KO1602 x KO1603	-3.70**	-11.86**	-1.89**	1.96**	0.74	0.74	-1.28	24.88**
9	KO1602 x KO1604	-1.85**	-10.17**	0.00	3.92**	-5.17	-28.44**	-29.87**	-11.29**
10	KO1602 x KO1605	-1.85**	-10.17**	0.00	3.92**	-21.54**	-24.16**	-25.68**	-5.99*
11	KO1602 x KO1606	0.00	-8.47**	1.89**	5.88**	-3.12	-19.14**	-20.77**	0.23
12	KO1602 x KO1607	1.85**	-6.78**	3.77**	7.84**	19.17**	-4.09	-6.01*	18.89**
13	KO1602 x KO1608	-7.41**	-15.25**	-5.66**	-1.96**	-7.05*	-21.56**	-23.13**	-2.76
14	KO1603 x KO1604	-3.70**	-11.86**	-1.89**	1.96**	-12.83**	-12.83**	-14.57**	8.06**
15	KO1603 x KO1605	-1.85**	-10.17**	0.00	3.92**	4.65	4.65	2.55	29.72**
16	KO1603 x KO1606	-5.56**	-13.56**	-3.77**	0.00	-32.34**	-32.34**	-33.70**	-16.13**

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent **BTP :** Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

Table 15 contd…..

Sl. No.	Hybrids	Number of ridges on fruit surface				Number of seeds per fruit			
		BP	BTP	CC 1	CC 2	BP	BTP	CC 1	CC 2
17	KO1603 x KO1607	-7.41**	-15.25**	-5.66**	-1.96**	9.11**	9.11**	6.92*	35.25**
18	KO1603 x KO1608	-7.41 **	-15.25**	-5.66**	-1.96**	-10.59**	-10.59**	-12.39**	10.83**
19	KO1604 x KO1605	-3.85**	-15.25**	-5.66**	-1.96**	-15.19**	-18.03**	-19.67**	1.61
20	KO1604 x KO1606	3.85**	-8.47**	1.89**	5.88**	-10.47**	-25.28**	-26.78**	-7.37*
21	KO1604 x KO1607	3.85**	-8.47**	1.89**	5.88**	-4.85	-23.42**	-24.95**	-5.07
22	KO1604 x KO1608	0.00	-11.86**	-1.89**	1.96**	-11.89**	-25.65**	-27.14**	-7.83*
23	KO1605 x KO1606	0.00	-11.86**	-1.89**	1.96**	-10.38**	-13.38**	-15.12**	7.37*
24	KO1605 x KO1607	-3.85**	-15.25**	-5.66**	-1.96**	-27.12**	-29.55**	-30.97**	-12.67**
25	KO1605 x KO1608	-3.85**	-15.25**	-5.66**	-1.96**	2.12	-1.30	-3.28	22.35**
26	KO1606 x KO1607	3.92**	-10.17**	0.00	3.92**	10.02**	-8.18**	-10.02**	13.82**
27	KO1606 x KO1608	-1.96**	-15.25**	-5.66**	-1.96**	6.39*	-10.22**	-12.02**	11.29**
28	KO1607 x KO1608	0.00	-15.25**	-5.66**	-1.96**	-17.40**	-30.30**	-31.69**	-13.59**
SEm±		0.07	0.07	0.07	0.07	2.05	2.05	2.05	2.05
CD at 5 %		0.21	0.21	0.21	0.21	5.95	5.95	5.95	5.95
CD at 1 %		0.27	0.27	0.27	0.27	7.90	7.90	7.90	7.90

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively.

BP : Heterosis over better parent

BTP : Heterosis over best parent

CC 1: Heterosis over commercial check 1 (Arka Anamika) and **CC 2:** Heterosis over commercial check 2 (Mahyco 10)

KO1603 x KO1608, KO1604 x KO1605, KO1605 x KO1607, KO1605 x KO1608, KO1606 x KO1608 and KO1607 x KO1608) to 5.60 (KO1601 x KO1608) among crosses. Magnitude of heterosis over better parent and the commercial checks was highly significant in both the directions, whereas heterosis over the best parent was significant only in the negative direction. For number of ridges negative heterosis is preferred as fruits with fewer ridges are preferred in the market. Maximum negative and significant heterosis was observed in the cross KO1601 x KO1602 over better parent (-15.25%) and the crosses KO1601 x KO1602, KO1602 x KO1608, KO1603 x KO1607, KO1603 x KO1608, KO1604 x KO1605, KO1605 x KO1607, KO1605 x KO1608, KO1606 x KO1608 and KO1607 x KO1608 exhibited maximum negative heterosis over the best parent (-15.25%) and the commercial checks Arka Anamika (-5.66%) and MHY-10 (-1.96%). Among 28 crosses, 20 crosses over better parent, 15 crosses over the commercial check Arka Anamika, nine crosses over the commercial check MHY-10 and all the crosses over the best parent exhibited negative and significant heterosis for number of ridges on fruit surface.

4.2.16 Number of seeds per fruit (Table 11 and 15)

Genotypes differed significantly among themselves for number of seeds per fruit and it varied from 39.10 (KO1604) to 53.80 (KO1603) among parents and 36.30 (KO1601 x KO1602) to 60.80 (KO1601 x KO1606) among crosses. Magnitude of heterosis was significant in both the directions over better parent, the best parent and the commercial checks. Maximum heterosis was observed in the cross KO1601 x KO1606 over better parent (25.88%), the best parent (13.01%) and the commercial checks Arka Anamika (10.75%) and MHY-10 (40.09%). Among 28 crosses, five crosses over better parent, two crosses over the best parent and two crosses over the commercial check Arka Anamika and 13 crosses over the commercial check MHY-10 exhibited positive and significant heterosis for number of seeds per fruit.

4.3 Combining ability

The variance due to general combining ability (GCA), specific combining ability (SCA) and GCA to SCA ratio for various characters are presented in Table 16. Moderately low GCA to SCA ratio was observed for yield per hectare (0.805), yield per plot (0.804), number of branches per plant (0.796), total yield per plant (0.795)

Table 16. Analysis of variance for combining ability in okra

Sl. No.	Character	Mean sum of square			s^{2}_{g}	s^{2}_{s}	s^{2}_{g}: s^{2}_{s}
		GCA	SCA	Error			
1.	Plant height at 45 DAS	38.402**	25.023**	8.628	2.977	16.395	0.182
2.	Plant height at 60 DAS	38.902**	79.104**	10.616	2.828	68.488	0.041
3.	Plant height at 90 DAS	60.933**	83.060**	6.736	5.419	76.324	0.071
4.	Number of leaves at 45 DAS	1.124**	1.524**	0.022	0.110	1.502	0.073
5.	Number of leaves at 60 DAS	12.749**	7.670**	0.370	1.238	7.300	0.170
6.	Number of leaves at 90 DAS	24.121**	10.737**	0.937	2.318	9.800	0.237
7.	Internodal length at 60 DAS	2.079**	1.759**	0.412	0.166	1.347	0.124
8.	Number of branches per plant	0.242**	0.055*	0.028	0.021	0.026	0.796
9.	Number of nodes on main stem	4.690**	6.877**	0.590	0.410	6.287	0.065
10.	Days to first flowering	2.241**	1.657**	0.540	0.170	1.116	0.152
11.	Days to 50 per cent flowering	12.169**	4.853**	1.477	1.069	3.376	0.317
12.	Fruit length (cm)	2.053**	1.324**	0.445	0.161	0.879	0.183
13.	Fruit diameter (mm)	2.327**	0.779*	0.377	0.195	0.402	0.485
14.	Average fruit weight (g)	2.794**	2.621**	0.516	0.228	2.104	0.108
15.	Number of fruits per plant	6.335**	1.193**	0.319	0.602	0.874	0.688
16.	Total yield per plant (kg)	0.004**	0.001**	0.0002	0.0004	0.0005	0.795
17.	Yield per plot (kg)	1.265**	0.229**	0.082	0.118	0.147	0.804
18.	Yield per hectare (t)	9.771**	1.766**	0.630	0.914	1.136	0.805
19.	Number of ridges on fruit surface	0.087**	0.033**	0.005	0.008	0.027	0.299
20.	Number of seeds per fruit	56.444**	37.211**	4.212	5.223	32.998	0.158

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively. NS: Non significant, DAS: Days after sowing.

and number of fruits per plant (0.688). Low GCA to SCA ratio was observed for fruit diameter (0.485), days to 50 per cent flowering (0.317), number of ridges on fruit surface (0.299), number of leaves at 90 DAS (0.237), fruit length (0.183), plant height at 45 DAS (0.182), number of leaves at 60 DAS (0.170), number of seeds per fruit (0.158), days to first flowering (0.152), intermodal length at 60 DAS (0.124) and average fruit weight (0.108). Very low GCA to SCA ratio was observed for number of leaves at 45 DAS (0.073), plant height at 90 DAS (0.071), number of nodes on main stem (0.065) and plant height at 60 DAS (0.041).

General combining ability effects and specific combining ability effects for various traits are presented in Tables 17 to 22.

4.3.1 Plant height (Table 17 and 18)

For plant height at 45 DAS, only one parent KO1608 (3.302) exhibited significantly positive gca effects. Among 28 crosses, four crosses showed significant positive sca effects and the maximum sca effects was observed in the cross KO1603 x KO1605 (7.846) followed by KO1601 x KO1602 (7.186).

For plant height at 60 DAS, only one parent KO1608 (3.987) exhibited significantly positive gca effects. Among 28 crosses, six crosses showed significant positive sca effects and the maximum sca effects was observed in the cross KO1604 x KO1606 (10.90) followed by KO1602 x KO1604 (9.772).

For plant height at 90 DAS, two parents *viz.*, KO1608 (4.46) and KO1606 (1.66) exhibited significantly positive gca effects. Among 28 crosses, nine crosses showed significant positive sca effects and the maximum sca effects was observed in the cross KO1601 x KO1603 (15.106) followed by KO1604 x KO1608 (11.586).

4.3.2 Number of leaves (Table 17 and 18)

For number of leaves at 45 DAS, four parents showed significantly positive gca effects and the maximum gca effects was observed in the parent KO1608 (0.394) followed by KO1605 (0.310). Among 28 crosses, six crosses showed significant positive sca effects and the maximum sca effects was observed in the cross KO1603 x KO1606 (2.863) followed by KO1601 x KO1604 (1.715).

Table 17. General combining ability effects of parents for growth and earliness parameters in okra

Sl. No.	Parent	Plant height			Number of leaves			Internodal length	No. Of branches per plant	Number of nodes on main stem	Days to first flowering	Days to 50 per cent flowering
		45 DAS	60 DAS	90 DAS	45 DAS	60 DAS	90 DAS					
1.	KO1601	0.024	-0.069	0.380	-0.366**	-0.893**	-1.073**	0.706**	0.070	-0.410*	0.338	-0.063
2.	KO1602	1.143	-2.041*	-4.000**	0.076	0.432**	0.415*	0.039	0.160*	-0.402*	-0.713**	-2.013**
3.	KO1603	-2.629**	-0.740	0.570	-0.452**	-0.418**	-0.398	0.211	-0.080	-0.252	0.388	0.438
4.	KO1604	-1.125	0.483	-1.290	0.277**	0.228	-0.030	-0.739**	-0.130*	0.691**	0.438	1.188**
5.	KO1605	0.246	0.520	-1.270	0.310**	-0.918**	-1.538**	-0.509*	-0.240**	0.365*	0.088	0.788*
6.	KO1606	1.247	0.311	1.660*	0.089*	0.096	0.455*	0.321	0.070	-0.288	0.388	0.638
7.	KO1607	-2.210*	-2.453*	-0.510	-0.327**	-0.077	0.079	0.033	-0.070	-0.360**	-0.363	0.338
8.	KO1608	3.302**	3.987**	4.460**	0.394**	1.547**	2.093**	-0.062	0.220**	0.652**	-0.563*	-1.313**
SEm±		0.869	0.964	0.767	0.044	0.127	0.202	0.190	0.049	0.161	0.217	0.359
CD at 5 %		1.764	2.279	1.815	0.089	0.258	0.412	0.449	0.117	0.329	0.514	0.850
CD at 1 %		2.367	3.373	2.686	0.120	0.347	0.552	0.665	0.174	0.441	0.761	1.258

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively

Table 18. Specific combining ability effects of crosses for growth parameters in okra

Sl. No.	Crosses	Plant height			Number of leaves		
		45 DAS	60 DAS	90 DAS	45 DAS	60 DAS	90 DAS
1	KO1601 x KO1602	7.186*	7.174*	5.776*	-0.224	1.784**	1.686*
2	KO1601 x KO1603	-0.242	6.273*	15.106**	-0.247	-0.766	-0.551
3	KO1601 x KO1604	-3.086	1.000	-3.834	1.715**	2.528**	2.811**
4	KO1601 x KO1605	-1.397	-3.067	-1.754	-0.324*	-0.426	-0.191
5	KO1601 x KO1606	-2.958	1.172	-3.484	-0.167	-1.030*	-2.004**
6	KO1601 x KO1607	-0.631	-12.664**	7.986**	-0.516**	-1.487**	0.632
7	KO1601 x KO1608	-2.643	-3.754	-12.984**	-0.732**	0.239	-0.632
8	KO1602 x KO1603	-0.961	3.845	2.186	-1.094**	-2.471**	-3.519**
9	KO1602 x KO1604	-2.825	9.772**	8.246**	-1.002**	-0.387	-1.177
10	KO1602 x KO1605	2.034	0.035	-6.074*	-0.996**	-0.551	-1.359*
11	KO1602 x KO1606	-8.947**	-17.456**	-16.504**	-0.979**	-2.175**	-2.252**
12	KO1602 x KO1607	-4.270	-1.102	-4.234	1.412**	1.048*	1.294*
13	KO1602 x KO1608	-6.592*	-9.082**	0.096	-1.654**	-2.096**	-1.040
14	KO1603 x KO1604	-1.523	-7.949*	-1.324	0.255	-2.037**	-1.144
15	KO1603 x KO1605	7.846**	6.884*	10.656**	-0.108	0.919*	0.524
16	KO1603 x KO1606	-2.805	-0.487	-4.674	2.863**	3.805**	5.341**
17	KO1603 x KO1607	-8.815**	-14.993**	-18.004**	-1.071**	-1.852**	-2.963**
18	KO1603 x KO1608	5.460*	3.537	-0.574	-0.957**	-0.896*	-2.037**
19	KO1604 x KO1605	-4.008	-15.399**	-17.584**	-0.717**	-1.847**	-2.534**
20	KO1604 x KO1606	4.731	10.900**	10.086**	-1.015**	0.279	-1.027
21	KO1604 x KO1607	5.478*	-8.866**	-4.444	1.581**	-2.218**	-1.311*
22	KO1604 x KO1608	-2.554	8.504*	11.586**	-0.740**	2.648**	3.365**
23	KO1605 x KO1606	-3.800	0.833	6.766**	0.526**	1.755**	3.401**
24	KO1605 x KO1607	3.457	-6.893*	-2.764	-0.228	-1.332**	-1.063
25	KO1605 x KO1608	-1.835	4.557	-1.034	1.106**	2.104**	1.453*
26	KO1606 x KO1607	-1.324	4.936	2.406	-0.926**	1.184**	1.204
27	KO1606 x KO1608	0.064	-4.184	10.736**	-1.337**	-3.600**	-2.740**
28	KO1607 x KO1608	-3.199	-0.760	-1.094	-0.151	1.663**	2.566**
SEm±		2.663	2.954	2.353	0.134	0.390	0.621
CD at 5 %		5.407	6.062	4.828	0.273	0.792	1.262
CD at 1 %		7.255	8.186	6.521	0.366	1.062	1.693

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively.
DAS: Days after sowing.

For number of leaves at 60 DAS, three parents showed significantly positive gca effects and the maximum gca effects was observed in the parent KO1608 (1.547) followed by KO1602 (0.432). Among 28 crosses, 10 crosses showed significant positive sca effects and the maximum sca effects was observed in the cross KO1603 x KO1606 (3.805) followed by KO1604 x KO1608 (2.648).

For number of leaves at 90 DAS, three parents showed significantly positive gca effects and the maximum gca effects was observed in the parent KO1608 (2.093) followed by KO1606 (0.455). Among 28 crosses, eight crosses showed significant positive sca effects and the maximum sca effects was observed in the cross KO1603 x KO1606 (5.361) followed by KO1605 x KO1606 (3.401).

4.3.3 Internodal length (Table 17 and 19)

The parents and crosses with negative gca and sca effects are desirable respectively. Among eight parents, two parents *viz.*, KO1604 (-0.739) and KO1605 (-0.509) showed significantly negative gca effects. Among 28 crosses, four crosses showed significant negative sca effects. The maximum negative sca effects was observed in the cross KO1603 x KO1606 (-3.344) followed by KO1601 x KO1604 (-2.270).

4.3.4 Number of branches per plant (Table 17 and 19)

For number of branches per plant, two parents *viz.*, KO1608 (0.22) and KO1602 (0.16) showed significantly positive gca effects. Among 28 crosses, only two crosses exhibited significant positive sca effects. The maximum sca effects was observed in the cross KO1601 x KO1608 (0.532) followed by KO1606 x KO1607 (0.322).

4.3.5 Number of nodes on the main stem (Table 17 and 19)

For number of nodes on the main stem, three parents exhibited significantly positive gca effects. The parent KO1604 (0.691) showed maximum positive and significant gca effects followed by KO1608 (0.652) and KO1605 (0.365). Among crosses, six crosses showed significant positive sca effects. The maximum sca effects was observed in the cross KO1603 x 1606 (5.255) followed by KO1601 x KO1604 (3.094).

Table 19. Specific combining ability effects of crosses for growth and earliness parameters in okra

Sl. No.	Crosses	Internodal length	Number of branches per plant	Number of nodes on main stem	Days to first flowering	Days to 50% flowering
1	KO1601 x KO1602	0.852	0.092	-0.513	-0.806	-3.994**
2	KO1601 x KO1603	0.531	-0.268	0.127	-0.406	0.556
3	KO1601 x KO1604	-2.270**	0.082	3.094**	1.544*	2.806*
4	KO1601 x KO1605	-0.410	-0.108	-0.680	-1.106	-0.294
5	KO1601 x KO1606	0.871	-0.118	-1.367**	1.094	2.356*
6	KO1601 x KO1607	-0.142	-0.178	-0.135	0.344	0.656
7	KO1601 x KO1608	0.054	0.532**	-1.357**	1.044	-0.194
8	KO1602 x KO1603	0.697	-0.358*	-1.241*	0.644	2.506*
9	KO1602 x KO1604	0.796	-0.208	-0.324	0.094	0.256
10	KO1602 x KO1605	1.236*	0.202	-1.068*	-1.556*	-3.344**
11	KO1602 x KO1606	1.087	0.092	-1.865**	2.144**	1.806
12	KO1602 x KO1607	-2.156**	-0.068	2.637**	-0.606	-0.894
13	KO1602 x KO1608	0.570	-0.158	-1.345*	-1.406*	-0.244
14	KO1603 x KO1604	-0.875	-0.068	0.976	-0.506	0.806
15	KO1603 x KO1605	1.355*	-0.158	-0.808	0.844	1.206
16	KO1603 x KO1606	-3.344**	0.232	5.255**	0.044	0.856
17	KO1603 x KO1607	1.473*	-0.128	-2.603**	-2.706**	-1.844
18	KO1603 x KO1608	1.709**	-0.018	-1.485**	-0.006	-3.194**
19	KO1604 x KO1605	0.214	-0.208	-2.461**	0.794	3.456**
20	KO1604 x KO1606	1.875**	-0.318*	-1.538**	-1.006	-0.894
21	KO1604 x KO1607	-0.698	0.022	1.374**	-1.756*	-2.094
22	KO1604 x KO1608	0.428	0.132	0.212	1.944**	2.556*
23	KO1605 x KO1606	-1.325*	0.092	2.238**	0.344	-0.494
24	KO1605 x KO1607	0.632	0.032	-1.160*	-0.906	-2.194
25	KO1605 x KO1608	-1.132	-0.058	1.988**	0.294	2.956*
26	KO1606 x KO1607	0.493	0.322*	-0.637	0.294	0.456
27	KO1606 x KO1608	1.189	-0.268	-0.909	-1.006	-0.394
28	KO1607 x KO1608	-0.364	0.272	0.753	1.244	1.406
SEm±		0.583	0.153	0.492	0.666	1.102
CD at 5 %		1.195	0.313	1.008	1.367	2.261
CD at 1 %		1.614	0.423	1.353	1.846	3.053

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively.

4.3.6 Days to first flowering (Table 17 and 19)

The parents and crosses with negative combining ability effects (gca and sca) are desirable. The maximum negative and significant gca effects was observed in the parent KO1602 (-0.713) followed by KO1608 (-0.563). Among 28 crosses, four crosses exhibited significant negative sca effects and the maximum negative sca effects was observed in the cross KO1603 x KO1607 (-2.706) followed by KO1604 x KO1607 (-1.756).

4.3.7 Days to 50 per cent flowering (Table 17 and 19)

The parents and crosses with negative combining ability effects (gca and sca) are desirable. The maximum negative and significant gca effects was observed in the parent KO1602 (-2.013) followed by KO1608 (-1.313). Among crosses, three crosses exhibited significant negative sca effects and the maximum negative sca effects was observed in the cross KO1601 x KO1602 (-3.994) followed by KO1602 x KO1605 (-3.344) and KO1603 x KO1608 (-3.194).

4.3.8 Fruit length (Table 20 and 21)

For fruit length, only one parent KO1603 (0.851) exhibited significantly positive gca effects. Among 28 crosses, three crosses showed significant positive sca effects. The maximum sca effects was observed in the cross KO1606 x KO1607 (2.209) followed by KO1604 x KO1605 (1.695) and KO1604 x KO1607 (1.423).

4.3.9 Fruit diameter (Table 20 and 21)

For fruit diameter, only one parent KO1608 (0.711) exhibited significantly positive gca effects. Among 28 crosses, three crosses showed significant positive sca effects. The maximum sca effects was observed in the cross KO1602 x KO1605 (1.446) followed by KO1601 x KO1607 (1.298) and KO1602 x KO1607 (1.231).

4.3.10 Average fruit weight (Table 20 and 21)

For average fruit weight, two parents *viz.*, KO1606 (0.68) and KO1603 (0.62) exhibited significant positive gca effects. Among 28 crosses, four crosses showed significantly positive sca effects. The maximum sca effects was observed in the cross

Table 20. General combining ability effects of parents for fruit characters, yield parameters, number of ridges on fruit surface and number of seeds per fruit in okra

Sl. No.	Parents	Fruit length	Fruit diameter	Average fruit weight	Number of fruits per plant	Yield per plant	Yield per plot	Yield per hectare	Number of ridges on fruit surface	Number of seeds per fruit
1.	KO1601	-0.179	0.109	-0.816**	-0.327*	-0.017**	-0.280**	-0.779**	0.187**	0.520
2.	KO1602	-0.195	-0.954**	-0.658**	0.780**	0.007	0.116	0.320	0.047*	-2.220**
3.	KO1603	0.851**	0.174	0.620**	-0.838**	-0.011*	-0.192*	-0.533*	-0.013	4.300**
4.	KO1604	-0.467*	0.234	0.073	-1.002**	-0.027**	-0.456**	-1.269**	0.027	-3.280**
5.	KO1605	-0.099	0.144	0.029	-0.281	-0.008	-0.144	-0.399	-0.052*	1.870**
6.	KO1606	-0.487*	-0.140	0.680**	0.625**	0.031**	0.521**	1.447**	-0.002	0.450
7.	KO1607	0.208	-0.277	0.071	-0.187	-0.004	-0.067	-0.184	-0.073**	-0.920
8.	KO1608	0.368	0.711**	-0.001	1.228**	0.030**	0.502**	1.396**	-0.123**	-0.720
SEm±		0.197	0.182	0.213	0.167	0.005	0.085	0.235	0.021	0.607
CD at 5 %		0.466	0.429	0.503	0.339	0.011	0.200	0.555	0.049	1.435
CD at 1 %		0.690	0.636	0.744	0.455	0.017	0.296	0.822	0.073	2.124

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively

Table 21. Specific combining ability effects of crosses for fruit and yield parameters in okra

Sl. No.	Crosses	Fruit length	Fruit diameter	Average fruit weight	Number of fruits per plant	Yield per plant	Yield per plot	Yield per hectare
1	KO1601 x KO1602	-0.061	-0.140	-2.386**	1.378**	-0.028	-0.462	-1.290
2	KO1601 x KO1603	-0.136	0.498	-0.074	-0.554	-0.016	-0.275	-0.761
3	KO1601 x KO1604	-0.204	-0.308	-1.472*	2.460**	-0.024	-0.400	-1.115
4	KO1601 x KO1605	-2.062**	-0.732	3.012**	0.939	0.066**	1.112**	3.089**
5	KO1601 x KO1606	0.941	0.657	-2.604**	-0.867	-0.036*	-0.613*	-1.702*
6	KO1601 x KO1607	-1.044	1.298*	0.980	-0.355	0.002	0.020	0.055
7	KO1601 x KO1608	0.256	-0.239	0.162	1.230*	0.011	0.181	0.505
8	KO1602 x KO1603	0.335	-1.854**	-0.997	-1.461**	-0.047**	-0.801**	-2.225**
9	KO1602 x KO1604	-1.244*	-0.255	0.730	-0.397	0.005	0.084	0.231
10	KO1602 x KO1605	1.214	1.446*	1.439*	0.332	0.028	0.472	1.310
11	KO1602 x KO1606	-1.688**	-0.145	-0.002	-0.324	-0.011	-0.188	-0.516
12	KO1602 x KO1607	1.162	1.231*	-2.448**	0.888	-0.038*	-0.641*	-1.779*
13	KO1602 x KO1608	-0.378	-1.381*	0.534	-0.737	0.023	0.391	1.096
14	KO1603 x KO1604	-0.689	0.548	-0.178	0.271	0.009	0.161	0.449
15	KO1603 x KO1605	0.769	0.098	0.086	0.350	0.011	0.194	0.534

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively

Table 21 contd.....

Sl. No.	Crosses	Fruit length	Fruit diameter	Average fruit weight	Number of fruits per plant	Yield per plant	Yield per plot	Yield per hectare
16	KO1603 x KO1606	0.702	1.117	1.865**	1.930**	0.037*	0.629*	1.743*
17	KO1603 x KO1607	-0.164	-0.396	1.195	-0.244	0.013	0.226	0.634
18	KO1603 x KO1608	-0.004	0.321	0.261	0.891	0.019	0.323	0.889
19	KO1604 x KO1605	1.695**	0.003	-2.822**	-0.536	-0.046**	-0.776**	-2.150**
20	KO1604 x KO1606	-0.341	-1.158*	2.032**	-0.492	0.018	0.304	0.849
21	KO1604 x KO1607	1.423*	-0.067	-1.179	-0.330	-0.018	-0.304	-0.845
22	KO1604 x KO1608	0.453	0.641	-0.377	0.155	-0.006	-0.102	-0.280
23	KO1605 x KO1606	0.376	-0.143	-3.074**	0.867	-0.027	-0.464	-1.287
24	KO1605 x KO1607	-1.149	-1.246*	1.250	-1.151*	-0.005	-0.071	-0.200
25	KO1605 x KO1608	-0.820	0.756	-0.463	0.414	-0.011	-0.180	-0.495
26	KO1606 x KO1607	2.209**	0.328	0.844	0.743	0.022	0.374	1.034
27	KO1606 x KO1608	1.054	1.100	0.241	-1.222*	0.014	0.235	0.654
28	KO1607 x KO1608	0.813	0.312	-0.490	1.240*	0.005	0.093	0.260
SEm±		0.605	0.557	0.652	0.512	0.015	0.259	0.719
CD at 5 %		1.241	1.143	1.337	1.040	0.031	0.532	1.476
CD at 1 %		1.675	1.543	1.805	1.395	0.042	0.718	1.994

* and ** indicates significance of value at p= 0.05 and p=0.01, respectively

KO1601 x KO1605 (3.012) followed by KO1604 x KO1606 (2.032), KO1603 x KO1606 (1.865) and KO1602 x KO1605 (1.439).

4.3.11 Number of fruits per plant (Table 20 and 21)

For number of fruits per plant, three parents exhibited significantly positive gca effects and the maximum gca effects was observed in the parent KO1608 (1.228) followed by KO1602 (0.78) and KO1606 (0.625). Among 28 crosses, five crosses exhibited significant positive sca effects. The maximum sca effects was observed in the cross KO1601 x KO1604 (2.46) followed by KO1603 x KO1606 (1.93).

4.3.12 Total yield per plant (Table 20 and 21)

For total yield per plant, two parents *viz.,* KO1606 (0.031) and KO1608 (0.030) exhibited significantly positive gca effects. Among 28 crosses, only two crosses showed significant positive sca effects. The maximum sca effects was observed in the cross KO1601 x KO1605 (0.066) followed by KO1603 x KO1606 (0.037).

4.3.13 Total yield per plot (Table 20 and 21)

For total yield per plot, two parents *viz.,* KO1606 (0.521) and KO1608 (0.502) exhibited significantly positive gca effects. Among 28 crosses, only two crosses exhibited significant positive sca effects. The maximum sca effects was observed in the cross KO1601 x KO1605 (1.112) followed by KO1603 x KO1606 (0.629).

4.3.14 Total yield per hectare (Table 20 and 21)

For total yield per hectare, only two parents exhibited significantly positive gca effects and the maximum gca effects was observed in the parent KO1606 (1.447) followed by KO1608 (1.396). Among 28 crosses, two crosses exhibited significant positive sca effects. The maximum sca effects was observed in the cross KO1601 x KO1605 (3.089) followed by KO1603 x KO1606 (1.743).

4.3.15 Number of ridges on fruit surface (Table 20 and 22)

The parents and crosses with negative combining ability effects (gca and sca) are Preferred. For number of ridges on fruit surface, three parents exhibited significantly negative gca effects and the maximum negative gca effects was observed in the parent KO1608 (-0.123) followed by KO1607 (-0.073) and KO1605 (-0.052). Among 28 crosses, five crosses exhibited significant negative sca effects. The maximum negative sca effects was observed in the cross KO1601 x KO1602 (-0.46) followed by KO1601 x KO1607 (-0.24).

4.3.16 Number of seeds per fruit (Table 20 and 22)

For number of seeds per fruit, two parents showed significantly positive gca effects and the maximum gca effects was observed in the parent KO1603 (4.30) followed by KO1605 (1.87). Among 28 crosses, eight crosses exhibited significant positive sca effects. The maximum sca effects was observed in the cross KO1601 x KO1606 (14.219) followed by KO1603 x KO1607 (9.709).

4.4 Pests and diseases

4.4.1 Fruit borer incidence and sucking pests severity (Table 23)

Per cent incidence of fruit borer ranged from 18.23 (KO1608) to 32.17 per cent (KO1605) among parents and 15.61 (KO1602 x KO1607) to 36.17 per cent (KO1604 x KO1605) among crosses. Out of eight parents, two were moderately free from incidence, five were moderately susceptible and only one was susceptible to fruit borer. Among 28 crosses, seven were moderately free from incidence, 17 were moderately susceptible and four crosses were susceptible to fruit borer. The commercial checks Arka Anamika and MHY-10 were found to be moderately susceptible.

The incidence of sucking pests (leaf hopper and white fly) is categorised as low, moderate and severe. Among eight parents, two recorded low, five were moderate and one was severely affected. Out of 28 crosses, nine recorded low, 16 were moderate and three crosses were severely affected. The commercial checks (Arka Anamika and MHY-10) were found to be moderately affected.

Table 22. Specific combining ability effects of crosses for number of ridges on fruit surface and number of seeds per fruit in okra

Sl. No.	Crosses	Number of ridges on fruit surface	Number of seeds per fruit
1	KO1601 x KO1602	-0.460**	-7.611**
2	KO1601 x KO1603	-0.100	-5.131*
3	KO1601 x KO1604	-0.040	5.749**
4	KO1601 x KO1605	-0.060	-1.601
5	KO1601 x KO1606	-0.010	14.219**
6	KO1601 x KO1607	-0.240**	-6.811**
7	KO1601 x KO1608	0.310**	-2.111
8	KO1602 x KO1603	-0.060	6.509**
9	KO1602 x KO1604	0.000	-1.611
10	KO1602 x KO1605	0.080	-4.461*
11	KO1602 x KO1606	0.130	-0.341
12	KO1602 x KO1607	0.300**	9.129**
13	KO1602 x KO1608	-0.150*	-0.471
14	KO1603 x KO1604	-0.040	0.269
15	KO1603 x KO1605	0.140*	4.519*
16	KO1603 x KO1606	-0.110	-13.961**
17	KO1603 x KO1607	-0.140*	9.709**
18	KO1603 x KO1608	-0.090	-1.091
19	KO1604 x KO1605	-0.200**	-0.101
20	KO1604 x KO1606	0.150*	-2.581
21	KO1604 x KO1607	0.220**	-0.211
22	KO1604 x KO1608	0.070	-1.611
23	KO1605 x KO1606	0.030	-1.331
24	KO1605 x KO1607	-0.100	-8.661**
25	KO1605 x KO1608	-0.050	6.339**
26	KO1606 x KO1607	0.150*	4.259*
27	KO1606 x KO1608	-0.100	2.959
28	KO1607 x KO1608	-0.030	-6.471**
SEm±		0.064	1.861
CD at 5 %		0.132	3.818
CD at 1 %		0.178	5.156

*and** indicate significance of values at p= 0.05 and p= 0.01, respectively.

Table 23. Reaction of okra genotypes to fruit borer and sucking pests incidence

Sl. No.	Genotypes	Fruit borer incidence (%)	Sucking pests severity
Parents			
1	KO1601	19.05	Moderate
2	KO1602	23.54	Moderate
3	KO1603	26.07	Low
4	KO1604	29.11	Low
5	KO1605	32.17	Moderate
6	KO1606	20.08	Moderate
7	KO1607	28.81	Severe
8	KO1608	18.23	Moderate
Hybrids			
9	KO1601 x KO1602	19.66	Moderate
10	KO1601 x KO1603	27.65	Low
11	KO1601 x KO1604	25.65	Low
12	KO1601 x KO1605	29.20	Low
13	KO1601 x KO1606	17.10	Moderate
14	KO1601 x KO1607	30.91	Moderate
15	KO1601 x KO1608	25.27	Moderate
16	KO1602 x KO1603	26.69	Low
17	KO1602 x KO1604	34.31	Severe
18	KO1602 x KO1605	22.43	Moderate
19	KO1602 x KO1606	19.22	Moderate
20	KO1602 x KO1607	15.61	Severe
21	KO1602 x KO1608	27.58	Moderate
22	KO1603 x KO1604	21.80	Low
23	KO1603 x KO1605	22.72	Moderate
24	KO1603 x KO1606	17.54	Low
25	KO1603 x KO1607	32.87	Moderate
26	KO1603 x KO1608	22.90	Moderate
27	KO1604 x KO1605	36.17	Moderate
28	KO1604 x KO1606	33.91	Low
29	KO1604 x KO1607	27.16	Severe
30	KO1604 x KO1608	28.79	Low
31	KO1605 x KO1606	25.34	Moderate
32	KO1605 x KO1607	30.14	Moderate
33	KO1605 x KO1608	22.52	Moderate
34	KO1606 x KO1607	29.23	Low
35	KO1606 x KO1608	18.31	Moderate
36	KO1607 x KO1608	19.94	Moderate
Commercial checks			
37	Arka Anamika	21.75	Moderate
38	Mahyco-10	25.83	Moderate
SEm±		1.89	-
CD at 5%		5.43	-
CD at 1%		7.28	-

4.4.2 Yellow vein mosaic virus, Powdery mildew and *Fusarium* wilt incidence (Table 24)

Yellow vein mosaic virus incidence among the parents indicated that, the parent KO1603 was highly resistant and KO1604 was susceptible to yellow vein mosaic virus disease. Among 28 crosses, four crosses (KO1601 x KO1603, KO1601 x KO1606, KO1602 x KO1607 and KO1604 x KO1608) showed no disease symptom and three crosses (KO1603 x KO1604, KO1605 x KO1607 and KO1606 x KO1607) were highly susceptible.

Powdery mildew disease severity ranged from 36.22 (KO1608) to 56.54 per cent (KO1602) among parents and 27.52 (KO1606 x KO1608) to 62.22 per cent (KO1605 x KO1608) among crosses. Out of eight parents, six were susceptible and two were highly susceptible. Among crosses, only one cross exhibited moderate susceptibility, 22 were susceptible and five crosses were highly susceptible. The commercial checks Arka Anamika and MHY-10 were susceptible to powdery mildew incidence.

For *Fusarium* wilt, all the parents were free from incidence. Among 28 crosses, only one cross (KO1603 x KO1607) showed moderate incidence and all others were free from wilt incidence. The commercial checks Arka Anamika and MHY-10 were also found to be free from *Fusarium* wilt incidence.

Table 24. Reaction of okra genotypes to Yellow Vein Mosaic Virus (YVMV), Powdery mildew and *Fusarium* wilt incidence

Sl. No.	Genotypes	YVMV incidence (Mean Severity Grade)	Powdery mildew incidence (PDI)	Fusarium wilt (DI)
Parents				
1	KO1601	3.50	43.45	1.27
2	KO1602	3.00	56.54	1.21
3	KO1603	0.50	47.10	1.50
4	KO1604	4.00	53.01	1.18
5	KO1605	1.50	44.64	1.35
6	KO1606	2.00	38.44	1.33
7	KO1607	3.00	42.30	1.36
8	KO1608	2.00	36.22	1.08
Hybrids				
9	KO1601 x KO1602	2.00	48.60	1.11
10	KO1601 x KO1603	0.50	49.13	1.29
11	KO1601 x KO1604	3.00	50.04	1.32
12	KO1601 x KO1605	1.50	35.32	1.26
13	KO1601 x KO1606	0.00	48.54	1.15
14	KO1601 x KO1607	2.50	46.24	1.22
15	KO1601 x KO1608	3.00	50.74	1.24
16	KO1602 x KO1603	1.50	49.63	1.10
17	KO1602 x KO1604	2.50	44.63	1.18
18	KO1602 x KO1605	3.50	54.21	1.16
19	KO1602 x KO1606	3.00	44.36	1.17
20	KO1602 x KO1607	0.00	50.69	1.06
21	KO1602 x KO1608	2.50	56.11	1.21
22	KO1603 x KO1604	4.00	43.16	1.16
23	KO1603 x KO1605	1.00	62.21	1.21
24	KO1603 x KO1606	2.00	38.99	1.06
25	KO1603 x KO1607	1.50	46.77	2.11
26	KO1603 x KO1608	3.50	39.06	1.10
27	KO1604 x KO1605	2.50	51.62	1.18
28	KO1604 x KO1606	2.50	46.77	1.04
29	KO1604 x KO1607	2.00	41.73	1.05
30	KO1604 x KO1608	0.50	33.95	1.24
31	KO1605 x KO1606	1.50	31.87	1.63
32	KO1605 x KO1607	4.00	50.33	1.16
33	KO1605 x KO1608	2.50	62.22	1.22
34	KO1606 x KO1607	4.00	49.46	1.11
35	KO1606 x KO1608	2.00	27.52	1.22
36	KO1607 x KO1608	3.00	46.97	1.16
Commercial checks				
37	Arka Anamika	2.00	43.44	1.49
38	Mahyco-10	1.50	56.58	1.11
SEm±		0.52	2.23	0.09
CD at 5%		1.50	6.40	0.27
CD at 1%		2.01	8.59	0.36

DI – Disease Index scale PDI – Percentage Disease Index

5. DISCUSSION

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the important vegetable crops grown for its immature non-fibrous edible pods in tropical and sub-tropical parts of the world. Increasing the productivity is the main aim of the plant breeder and it can be achieved by means of hybridization for the exploitation of heterosis or hybrid vigour. The reproductive biology of the okra offers good scope for exploitation of heterosis. Therefore, proper choice of parents for hybridization is essential in generating heterotic hybrids. Heterosis breeding is an important approach of crop improvement adopted in many of the crops all over the world. In practical plant breeding, superiority of the F_1 over mid parent is of little value, since it does not offer any advantage to exploit it commercially. The commercial usefulness of the hybrid would depend on its performance in comparison to the best existing commercial variety or hybrid. Hence, heterosis over better parent, the best parent and the commercial check was worked out in the present investigation for identification of superior hybrids.

For a systematic breeding programme, it is essential to identify the parents, as well as crosses which could be exploited in order to bring about further genetic improvement in economic characters. The diallel analysis is one of the techniques where number of genotypes could be tested for their combining ability. It is necessary to assess the genetic potentialities of the parents in hybrid combination through systematic studies in relation to general and specific combining abilities which are due to additive and non-additive gene effects respectively (Griffing, 1956). The diallel method developed by Jinks and Hayman (1953) has been used in the present study for estimating combining ability and other genetic parameters.

With the prime objective of increasing yield of the crop, an ideotype (ideal plant) has to be developed. The ideotype in okra should have more plant height, more number of branches and nodes on the main stem, short internodes, early flowering, good fruit shape, high fruit weight and more number of fruits per plant and less number of ridges per fruit. Therefore, the present study is an attempt to find out the magnitude of heterosis in the cross combinations and to make use of diallel analysis to estimate the combining ability keeping an ideotype in view.

Heterosis for growth parameters is an indication of heterosis for yield as growth and yield parameters are strongly associated (Bhatt *et al.,* 2016). Significant and high magnitude of heterobeltiosis and standard heterosis was observed in the desirable direction for all the growth parameters.

The maximum heterosis over better parent was observed in the cross KO1601 x KO1603 (18.14%) for plant height at 90 DAS, such magnitude of heterosis also reported by Bhatt *et al.,* 2016 (15.92%) and Aware *et al.,* 2014 (18.07%). The cross KO1606 x KO1608 exhibited maximum standard heterosis over commercial checks Arka Anamika (22.09%) and MHY-10 (18.11%) for plant height at 90 DAS which was higher compared to the reports of Jethava *et al*., 2014 (6.02%) and Medagam *et al.,* 2013b (1.00%). This could be attributed to difference in the genetic stocks used in these studies.

Magnitude of heterosis over the commercial checks Arka Anamika (28.23%) and MHY-10 (20.14%) was maximum in the cross KO1604 x KO1608 for number of leaves at 90 DAS and similar magnitude of heterosis was also reported by Jaiprakashnarayan, 2003 (29.06%). The cross KO1603 x KO1606 exhibited maximum heterobeltiosis (24.61%) for number of leaves at 90 DAS which was lower compared to the reports of Manivannan *et al.,* 2007b (47.59%) and it is attributed to use of different genetic stocks and varying environment.

Negative heterosis is considered to be desirable for the trait intermodal length as it can facilitates more number of nodes where one can expect more fruits per plant. The cross KO1603 x KO1606 exhibited maximum negative heterosis over better parent (-35.65%) and the commercial checks Arka Anamika (-17.01%) and MHY-10 (-24.10%) for intermodal length which is of similar magnitude as reported by Medagam *et al*., 2012 which ranged from -29.63 to 28.09 for heterobeltiosis and -22.49 to 11.03 for standard heterosis.

Maximum heterobeltiosis (46.15%) and maximum standard heterosis over Arka Anamika (88.89%) and MHY-10 (58.33%) was observed in the cross KO1601 x KO1608 for number of branches per plant which was lower compared to the reports of Bhatt *et al*., 2016 which ranged from -49.64 to 70.91 for heterobeltiosis and -16.67

to 119.70 for standard heterosis. It is attributed to difference in genetic stocks and standard checks used in these studies over the present investigation.

The cross KO1603 x KO1606 exhibited maximum heterosis over better parent (55.23%) and the commercial checks Arka Anamika (38.58%) and MHY-10 (25.04%) for number of nodes on main stem which was higher with respect to heterobeltiosis (30.94%) reported by Singh *et al*. (2013).

Farmers prefer to grow early and high yielding hybrids in order to get high profit and to avoid market glut therefore, earliness is an important trait in vegetable crop like okra. Days to first flowering and days to 50 per cent flowering are indicators of earliness and negative heterosis for these traits is desirable. The cross KO1603 x KO1607 exhibited maximum negative heterosis over better parent (-10.59%) and the commercial checks Arka Anamika (-8.43%) and MHY-10 (-5.00%) for days to first flowering which was lower compare to the reports of Tiwari *et al.*, 2015 which ranged from -25.95 to 2.94 for heterobeltiosis and -21.14 to 13.82 for standard heterosis. It is attributed to difference in genetic stocks and standard checks used in these studies over the present investigation.

For days to 50 per cent flowering, the maximum negative heterobeltiosis was observed in the cross KO1602 x KO1605 (-10.68%) which was higher compare to the reports of Kumar and Reddy, 2016b (-3.64%) and Sawadogo *et al*., 2014 (-1.92%). The cross KO1601 x KO1602 exhibited maximum standard heterosis over the commercial checks Arka Anamika (-14.42%) and MHY-10 (-10.10%) for days to 50 per cent flowering, such magnitude of heterosis also reported by Tiwari *et al.*, 2015 (-18.11%) and Patel *et al.*, 2015 (-12.63%).

Ultimate goal of the plant breeder is to develop high yielding varieties or hybrids. The yield components greatly influence yield and higher magnitude of heterosis was observed for the yield components in the present investigation. Fruit length, fruit diameter, average fruit weight and number of fruits per plant are very closely related to productivity parameters.

The maximum heterobeltiosis (21.22%) and standard heterosis over Arka Anamika (8.37%) and MHY-10 (6.79%) was observed in the cross KO1606 x KO1607 for fruit length and similar magnitude of heterosis was also reported by

Kumar *et al.,* 2015 which ranged from -5.37 to 15.56 for heterobeltiosis and -5.37 to 10.44 for standard heterosis.

The cross KO1606 x KO1608 exhibited maximum standard heterosis over commercial checks Arka Anamika (17.82%) and MHY-10 (8.34%) for fruit diameter, such magnitude of heterosis also reported by Verma and Sood, 2015 (21.30%). Maximum heterobeltiosis was observed in the cross KO1601 x KO1607 (9.00%) for fruit diameter which was lower compare to the reports of Sabesan *et al*., 2016 (24.63%) and Tiwari *et al.,* 2015 (21.21%). This could be attributed to difference in the genetic stocks used in these studies.

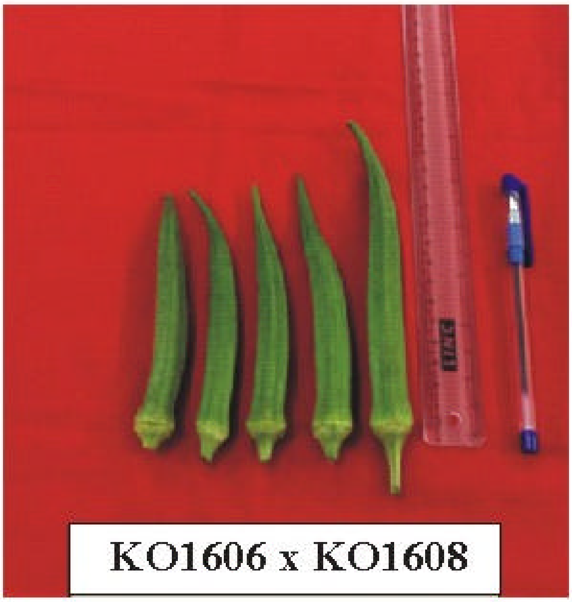
Magnitude of heterosis over the commercial checks Arka Anamika (24.82%) and MHY-10 (14.50%) was maximum in the cross KO1603 x KO1606 for average fruit weight which was higher compared to the reports of Kumar and Reddy, 2016b (8.63%), Jethava *et al*., 2014 (5.18%) and Medagam *et al*., 2013a (8.13%). The cross KO1601 x KO1605 exhibited maximum heterobeltiosis (13.82%) for average fruit weight, such magnitude of heterosis was also reported by Rani and Veeraragavathatham, 2013 (12.00%) and Ashwani *et al*., 2013 (15.80%).

The maximum heterosis over better parent was observed in the cross KO1601 x KO1604 (40.44%) for number of fruits per plant, such magnitude of heterosis also reported by Patel 2015 (38.59%) and Aware *et al.*, 2014 (47.48%). The cross KO1607 x KO1608 exhibited maximum standard heterosis over commercial checks Arka Anamika (37.93%) and MHY-10 (17.35%) for number of fruits per plant which was higher compared to the reports of Tiwari *et al*., 2015 (8.08%) and Solankey *et al.,* 2013 (12.25%).

Magnitude of heterosis over the commercial checks Arka Anamika (59.33%) and MHY-10 (20.35%) was maximum in the cross KO1606 x KO1608 for total yield per plant and similar magnitude of heterosis was also reported by Bhatt *et al.,* 2016 (44.11%) and Patel, 2015 (57.05%). The cross KO1601 x KO1605 exhibited maximum heterobeltiosis (28.64%) for total yield per plant, such magnitude of heterosis was also reported by Sabesan *et al.,* 2016 (27.09%) and Ashwani *et al*., 2013 (28.05%). The cross KO1606 x KO1608 exhibited maximum standard heterosis over the commercial checks Arka Anamika (58.98%) and MHY-10 (20.21%) for yield per hectare and similar magnitude of heterosis was also reported by More *et al.*, 2015 (36.60%).

Negative heterosis is considered to be desirable for the trait number of ridges on fruit surface as fruits with fewer ridges are preferred in the market. Maximum negative heterobeltiosis was observed in the cross KO1601 x KO1602 (-15.25%) for number of ridges on fruit surface which was higher compared to the reports of Weerasekara, 2006 (-3.80%). The cross KO1601 x KO1606 exhibited maximum positive heterosis over better parent (25.88%) and the commercial checks Arka Anamika (10.75%) and MHY-10 (40.09%) for number of seeds per fruit and similar magnitude of heterobeltiosis (32.59%) and standard heterosis (52.33%) was also reported by Nagesh *et al.*, 2014.

The cross KO1606 x KO1608 (Plate 3) was the best hybrid selected for yield per hectare as it exhibited maximum standard heterosis over the commercial checks Arka Anamika (58.98 %) and MHY-10 (20.21%). Performance of this hybrid with respect to total yield is attributed to its significant standard heterosis (Arka Anamika and MHY-10) observed in the desirable direction for plant height at 45 and 90 DAS, fruit diameter, number of fruits per plant, total yield per plant, yield per plot and yield per hectare. This hybrid is also identified as a good specific combiner for plant height at 90 DAS. The parent KO1606 involved in the development of this hybrid was found to be a good general combiner for plant height at 90 DAS, number of leaves at 45 and 90 DAS, average fruit weight, number of fruits per plant, total yield per plant, yield per plot and yield per hectare. The other parent KO1608 exhibited significant gca effects in the desirable direction for all the growth, earliness, yield and quality parameters except for internodal length, fruit length, average fruit weight and number of seeds per fruit. This hybrid (KO1606 x KO1608) was found to be moderately free from yellow vein mosaic virus symptom, fruit borer and sucking pests (leaf hopper and white fly) attack and also free from fusarium wilt incidence. Additive gene action influenced the above mentioned characters which suggested that selection in segregating generations of this hybrid could be more effective and better homogenous lines could be isolated from the segregating population. Therefore, conventional breeding methods such as pedigree, bulk or back cross methods could be more useful for improvement of characters using this hybrid. As this hybrid is high yielder than



KO1606 x KO1608

KO1602 x KO1608

KO1603 x KO1606

Plate 3. Fruits of top three F_1 hybrids identified for yield

commercial checks and also had fewer ridges on fruits, it can be commercially exploited till the superior lines are isolated.

The cross KO1602 x KO1608 (Plate 3) was the second best hybrid selected for yield per hectare as it exhibited significant standard heterosis over the commercial checks Arka Anamika (51.48 %) and MHY-10 (14.53%). Performance of this hybrid with respect to total yield is attributed to its significant standard heterosis (Arka Anamika and MHY-10) observed in the desirable direction for number of branches per plant, days to first flowering, days to 50 per cent flowering, number of fruits per plant, total yield per plant, yield per plot, yield per hectare and number of ridges on fruit surface. This hybrid is also identified as a good specific combiner for days to first flowering and number of ridges on fruit surface. The parent KO1602 involved in the development of this hybrid was found to be a good general combiner for number of leaves at 60 and 90 DAS, number of branches per plant, days to first flowering, days to 50 per cent flowering and number of fruits per plant. The other parent KO1608 exhibited significant gca effects in the desirable direction for all the growth, earliness, yield and quality parameters except for internodal length, fruit length, average fruit weight and number of seeds per fruit. This hybrid (KO1602 x KO1608) was found to be moderately free from yellow vein mosaic virus symptom and sucking pests (leaf hopper and white fly) attack and also free from fusarium wilt incidence. The above mentioned characters are most likely governed by additive gene action and hence it would be rewarding if selection is applied in segregating generations.

The next best hybrid was KO1603 x KO1606 (Plate 3) which exhibited significant standard heterosis over the commercial checks Arka Anamika (49.78%) and MHY-10 (13.25%) for yield per hectare. Performance of this hybrid with respect to total yield is attributed to its significant standard heterosis (Arka Anamika and MHY-10) observed in the desirable direction for number of leaves at 45, 60 and 90 DAS, internodal length, number of branches per plant, number of nodes on main the stem, average fruit weight, number of fruits per plant, total yield per plant, yield per plot and yield per hectare. This hybrid is also identified as a good specific combiner for number of leaves at 45, 60 and 90 DAS, internodal length and number of nodes on main the stem, average fruit weight, number of fruits per plant, total yield per plant, yield per plot and yield per hectare. The parent KO1603 involved in the development of this hybrid was found to be a good general combiner for fruit length, average fruit weight and number of seeds per fruit. The other parent KO1606 exhibited significant gca effects in the desirable direction for plant height at 90 DAS, number of leaves at 45 and 90 DAS, average fruit weight, number of fruits per plant, total yield per plant, yield per plot and yield per hectare. This hybrid (KO1603 x KO1606) was found to be moderately free from yellow vein mosaic virus symptom and fruit borer attack and low incidence of sucking pests (leaf hopper and white fly) and also free from fusarium wilt incidence. This hybrid (KO1603 x KO1606) was the best specific combiner for several characters including yield and also possessing significant standard heterosis for yield. Thus, it can be commercially exploited after assessing its stability for yield.

For exploitation of heterosis, the information on gca should be supplemented with sca and hybrid performance. Heterosis in F_1 indicates operation of non-additive gene effects, but it cannot give any idea about the relative magnitude of non-additive (dominance + epistasis) and additive gene action. Hence, analysis of combining ability is one of the potential tools for identifying prospective parents to develop commercial F_1 hybrids (Griffing, 1956). General and specific combining ability effects and variances obtained from a set of F_1's would enable a breeder to select desirable parents and crosses for each of the quantitative characters. General combining ability effects of parents and sca effects of crosses were significant for the characters studied. From the present investigation, it is evident that gca or sca effects in parents or crosses were in desirable direction for some characters and in undesirable direction for some other traits. Therefore it is important to ascertain the status of parent or hybrid with respect to combining ability effects over a number of component characters (Arunachalam and Bandopadhay, 1979).

An assessment was carried out by considering all the characters related to yield and other economic traits simultaneously to identify the potential parents and hybrids. For every character, a parent was scored '0' for non-significant gca effects and '+1' for significant gca effects in the desirable direction and '-1' for significant gca effects in undesirable direction. Similarly, for every character, a hybrid was scored '0' for non-significant standard heterosis and '+1' for significant standard heterosis in desirable direction and '-1' for significant standard heterosis in undesirable direction. All the parents and crosses were scored for each character and final score was computed by adding scores obtained in all the 20 characters. Finally, the parents or hybrids were classified as low, average and high based on the mean value of the total scores obtained over all the 20 characters and details are presented in Table 25 for parents and in Table 26 for F_1 hybrids.

Comprehensive assessment of parents by considering gca effects of 20 characters studied has resulted into identification of parents *viz*., KO1605, KO1606 and KO608 as good combiners for most of the characters and parents *viz*., KO1601, KO1602, KO1603, KO1604 and KO1607 were identified as poor combiners.

Comprehensive assessment of crosses by considering standard heterosis values of 20 characters revealed that, out of 28 crosses, 15 crosses were highly heterotic, five were average heterotic and eight were low heterotic. Among the 15 highly heterotic crosses, ten crosses involved high x low or low x high, three crosses involved high x high parental combinations (over all gca status) and two crosses involved low x low parental combinations over all gca status. Such studies were also carried out by Lyngdoh *et al*., 2013 and Nagesh *et al*., 2014 in okra. These results indicated that high frequency of highly heterotic hybrids could be obtained from parental combinations with high x low or low x high general combining ability which indicates that, the parental contribution to the heterosis is through non-additive gene effects also. Hence, exploitation of heterosis appears to be one of the strategies for improvement in okra. These crosses can also be improved through recurrent selection schemes.

Ratio of general combining ability variance (GCA) to specific combining ability variance (SCA) is an indication of predominance of additive or non-additive genetic variance. GCA to SCA ratio (Table 16) was very low for the traits number of leaves at 45 DAS (Manivannan *et al.*, 2007b), plant height at 60 and 90 DAS (Akotkar *et al*., 2014 and Kumar and Reddy, 2016a) and number of nodes on the main stem (Wakode *et al.*, 2016 and Solankey *et al.*, 2012) indicating preponderance of non-additive gene action and hence these traits can be improved through recurrent selection for specific combining ability or heterosis breeding. Non-additive component of genetic variance was higher than additive component for fruit diameter (Paul *et al.*, 2017 and Bhatt *et al.*, 2015), days to 50 per cent flowering (Laxman *et al*., 2013), number of ridges on fruit surface (Akotkar *et al*., 2014), number of leaves at 60 and 90 DAS (Jonah *et al.*,2015 and Lyngdoh *et al*., 2013), fruit length (Paul *et al.*, 2017),

Table 25. Over all analysis of general combining ability status of parents in okra

Sl. No.	Parents	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total		gca status
																						+ve	-ve	
1	KO1601	0	0	0	-1	-1	-1	-1	0	-1	0	0	0	0	-1	-1	-1	-1	-1	-1	0	0	11	L
2	KO1602	0	-1	-1	0	+1	+1	0	+1	-1	+1	+1	0	-1	-1	+1	0	0	0	-1	-1	6	7	L
3	KO1603	-1	0	0	-1	-1	0	0	0	0	0	0	+1	0	+1	-1	-1	-1	-1	0	+1	3	7	L
4	KO1604	0	0	0	+1	+1	0	+1	-1	+1	0	-1	-1	0	0	-1	-1	-1	-1	0	-1	4	8	L
5	KO1605	0	0	0	+1	-1	-1	+1	-1	+1	0	-1	0	0	0	0	0	0	0	+1	+1	5	4	H
6	KO1606	0	0	+1	+1	0	+1	0	0	0	0	0	-1	0	+1	+1	+1	+1	+1	0	0	8	1	H
7	KO1607	-1	-1	0	-1	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	+1	0	1	4	L
8	KO1608	+1	+1	+1	+1	+1	+1	0	+1	+1	+1	+1	0	+1	0	+1	+1	+1	+1	+1	0	16	0	H

1. Plant height at 45 DAS
2. Plant height at 60 DAS
3. Plant height at 90 DAS
4. Number of leaves at 45 DAS
5. Number of leaves at 60 DAS
6. Number of leaves at 90 DAS
7. Internodal length
8. Number of branches per plant
9. Number of nodes on main stem
10. Days to first flowering
11. Days to 50 per cent flowering
12. Fruit length
13. Fruit diameter
14. Average fruit weight
15. Number of fruits per plant
16. Total yield per plant
17. Yield per plot
18. Yield per hectare
19. Number of ridges on fruit surface
20. Number of seeds per fruit

0 – Non-significant gca effects
+1 – gca effects in desirable direction
-1 – gca effects in undesirable direction
H – High combiner
L – Low combiner
A – Average combiner
DAS – Days after sowing

Table 26. Overall analysis of standard heterosis status of crosses in okra

Sl. No.	Crosses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total		Status of	
																						+ve	-ve	CH	PG
1	KO1601 x KO1602	+1	+1	0	-1	+1	0	-1	+1	-1	+1	+1	-1	0	-1	+1	+1	-1	-1	+1	-1	9	8	H	L x L
2	KO1601 x KO1603	0	+1	+1	-1	-1	-1	-1	-1	-1	0	0	0	+1	0	0	-1	-1	-1	0	-1	3	10	L	L x L
3	KO1601 x KO1604	0	+1	0	+1	+1	+1	+1	+1	+1	-1	-1	-1	+1	-1	+1	-1	-1	-1	-1	-1	9	9	A	L x L
4	KO1601 x KO1605	0	0	0	-1	-1	-1	-1	-1	-1	+1	0	-1	+1	+1	+1	+1	+1	+1	0	-1	7	8	L	L x H
5	KO1601 x KO1606	0	+1	0	-1	-1	-1	-1	+1	-1	-1	0	0	+1	-1	+1	+1	+1	-1	-1	+1	7	9	L	L x H
6	KO1601 x KO1607	0	0	+1	-1	-1	-1	-1	0	-1	0	0	-1	+1	+1	+1	+1	+1	-1	+1	-1	7	8	L	L x L
7	KO1601 x KO1608	0	+1	0	-1	+1	-1	-1	+1	-1	0	+1	0	+1	-1	+1	+1	+1	0	-1	-1	8	7	H	L x H
8	KO1602 x KO1603	0	+1	0	-1	-1	-1	-1	-1	-1	0	0	+1	-1	-1	0	-1	-1	-1	+1	0	3	11	L	L x L
9	KO1602 x KO1604	0	+1	0	-1	+1	-1	-1	0	-1	+1	+1	-1	0	0	+1	+1	+1	-1	0	-1	7	7	A	L x L
10	KO1602 x KO1605	+1	+1	-1	-1	-1	-1	-1	+1	-1	+1	+1	+1	+1	+1	+1	+1	+1	0	0	-1	11	7	H	L x H
11	KO1602 x KO1606	-1	-1	-1	-1	-1	-1	-1	+1	-1	-1	0	-1	0	0	+1	+1	+1	0	-1	-1	4	12	L	L x H
12	KO1602 x KO1607	-1	0	0	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	+1	+1	+1	-1	-1	-1	13	5	H	L x L
13	KO1602 x KO1608	0	0	0	-1	0	+1	-1	+1	-1	+1	+1	-1	-1	0	+1	+1	+1	+1	+1	-1	9	6	H	L x H
14	KO1603 x KO1604	-1	0	0	+1	-1	-1	0	-1	+1	0	0	-1	+1	+1	0	+1	+1	-1	+1	-1	7	7	A	L x L
15	KO1603 x KO1605	+1	+1	+1	+1	-1	-1	-1	-1	-1	0	0	+1	+1	+1	+1	+1	+1	-1	0	0	10	6	H	L x H
16	KO1603 x KO1606	0	+1	0	+1	+1	+1	+1	+1	+1	0	0	+1	+1	+1	+1	+1	+1	+1	+1	-1	15	1	H	L x H
17	KO1603 x KO1607	-1	-1	-1	-1	-1	-1	-1	-1	-1	+1	+1	+1	+1	+1	+1	+1	+1	-1	+1	+1	10	10	A	L x L

Table 26 contd.....

Sl. No.	Crosses	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total		Status of	
																						+ve	-ve	CH	PG
18	KO1603 x KO1608	+1	+1	+1	-1	+1	-1	-1	+1	-1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	15	5	H	L x H
19	KO1604 x KO1605	0	0	-1	+1	-1	-1	-1	-1	-1	0	-1	+1	+1	-1	-1	-1	-1	-1	+1	-1	4	13	L	L x H
20	KO1604 x KO1606	+1	+1	+1	-1	+1	-1	-1	-1	-1	+1	0	-1	0	+1	+1	+1	+1	+1	-1	-1	10	8	H	L x H
21	KO1604 x KO1607	0	0	0	+1	-1	-1	-1	0	+1	+1	+1	+1	+1	-1	0	-1	-1	-1	-1	-1	6	9	L	L x L
22	KO1604 x KO1608	0	+1	+1	+1	+1	+1	-1	+1	+1	-1	0	0	+1	0	+1	+1	+1	+1	+1	-1	13	3	H	L x H
23	KO1605 x KO1606	0	+1	+1	+1	+1	+1	-1	+1	+1	0	0	-1	+1	-1	+1	+1	+1	+1	+1	-1	13	4	H	H x H
24	KO1605 x KO1607	0	0	0	+1	-1	-1	-1	-1	-1	+1	+1	-1	-1	+1	0	+1	+1	+1	+1	-1	8	8	A	H x L
25	KO1605 x KO1608	0	+1	0	+1	+1	+1	-1	+1	+1	+1	0	-1	+1	-1	+1	+1	+1	+1	+1	0	13	3	H	H x H
26	KO1606 x KO1607	0	+1	0	-1	+1	+1	-1	+1	-1	-1	0	+1	+1	+1	+1	+1	+1	+1	0	-1	11	5	H	H x L
27	KO1606 x KO1608	+1	+1	+1	-1	-1	-1	-1	+1	-1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	-1	14	6	H	H x H
28	KO1607 x KO1608	0	+1	0	+1	+1	+1	-1	+1	+1	0	0	+1	+1	-1	+1	+1	+1	+1	+1	-1	13	3	H	L x H

1. Plant height at 45 DAS
2. Plant height at 60 DAS
3. Plant height at 90 DAS
4. Number of leaves at 45 DAS
5. Number of leaves at 60 DAS
6. Number of leaves at 90 DAS
7. Internodal length
8. Number of branches per plant
9. Number of nodes on main stem
10. Days to first flowering
11. Days to 50 per cent flowering
12. Fruit length
13. Fruit diameter
14. Average fruit weight
15. Number of fruits per plant
16. Total yield per plant
17. Yield per plot
18. Yield per hectare
19. Number of ridges on fruit surface
20. Number of seeds per fruit

0 – Non-significant heterosis
+1 – Heterosis in desirable direction
-1 – Heterosis in undesirable direction
H – Highly heterotic
L – Low heterotic
A – Average heterotic
DAS – Days after sowing
CH – Crosses for heterosis
PG – Parents for gca

plant height at 45 DAS (Lyngdoh *et al*., 2013 and Khatik *et al*., 2012), number of seeds per fruit (Laxman *et al*., 2013), days to first flowering (Wakode *et al*., 2016 and Bhatt *et al*., 2015), internodal length (Paul *et al*., 2017, Kumar and Reddy, 2016a and Medagam *et al*., 2012) and average fruit weight (Bhatt *et al*., 2015, Nagesh *et al*., 2014 and Laxman *et al*., 2013). Hence, these characters can be improved through recurrent selection schemes. Non-additive component of genetic variance was slightly higher than additive components for yield per hectare (Reddy *et al*., 2013a), number of branches per plant (Jonah *et al.*, 2015), total yield per plant (Reddy *et al*., 2013a) and number of fruits per plant (Jonah *et al.*, 2015) Hence, direct selection or recurrent selection schemes can be employed for improvement of these traits. For getting higher heterosis with non additive components for yield new set of lines can be explored by which F_1 hybrids can be commercially exploited.

Future line of work

The cross KO1603 x KO1606 was selected as superior hybrid for yield per hectare since this cross exhibited significant standard heterosis and significant sca effects in desirable direction for yield per hectare. This cross can be further assessed for its yield stability to confirm its potentiality and also its adaptability to different agro-climatic conditions before exploiting it on commercial scale.

The crosses KO1606 x KO1608 and KO1602 x KO1608 were the superior cross combinations selected for yield per hectare since these crosses exhibited significant standard heterosis in desirable direction but the sca effects for yield per hectare was non-significant. Additive gene action influenced the yield traits therefore the direct selection could be more effective and better homogenous lines could be isolated from the segregating population. As the hybrid KO1606 x KO1608 is the highest yielder and also had fewer ridges on fruits and fairly tolerant to pest and diseases, it can be commercially exploited till the superior lines are isolated from segregating generations using this hybrid.

The parents KO1606 and KO1608 are the good general combiners for yield per hectare and can be used in identifying superior new heterotic combinations. The parents KO1605, KO1606 and KO1608 are also good general combiners for most of the characters and can be subjected to recurrent selection for improving the combining ability for exploitation of heterosis.

For the development of highly heterotic crosses from the existing genetic stock, generally the parental combinations of high x low or low x high and low x low combining ability would be rewarding.

Plant height at 45, 60 and 90 DAS, number of leaves at 45, 60 and 90 DAS, internodal length, number of nodes on the main stem, days to first flowering, days to 50 per cent flowering, fruit length, fruit diameter, average fruit weight, number of ridges on fruit surface and number of seeds per fruit are predominantly controlled by non-additive gene action and hence heterosis breeding and recurrent selection can be employed for improvement. Non additive component of genetic variance was slightly higher than additive component for number of branches per plant, numbers of fruits per plant, total yield per plant and yield per hectare and these characters can be improved through direct selection or recurrent selection schemes.

6. SUMMARY AND CONCLUSION

The field experiment was undertaken to study the “Diallel analysis in okra” with the objective to assess the magnitude and direction of heterosis and to identify good combiners for growth, earliness, yield and quality parameters. The experimental material comprised of eight parents and its 28 cross combinations produced through half-diallel fashion and two commercial checks. All the crosses were evaluated along with the parents and the commercial checks in randomised block design with two replications at Vegetable Science unit, Kittur Rani Channamma College of Horticulture, Arabhavi, Belagavi (Karnataka). Various growth, earliness, yield and quality parameters recorded were subjected to diallel analysis. Variance due to genotypes and crosses was highly significant for all the growth, earliness, yield and quality parameters. Variance due to the parents was significant for all the characters studied except for fruit diameter and average fruit weight. Variance due to parents vs crosses was significant for plant height at 45 and 60 DAS, number of leaves at 45, 60 and 90 DAS, internodal length at 60 DAS, number of nodes on main stem, fruit length, average fruit weight, number of fruits per plant and number of ridges on fruit surface.

Magnitude of heterosis over the commercial checks (Arka Anamika and MHY-10) was high in the desirable direction for number of branches per plant (88.89 and 58.33 %), total yield per plant (59.33 and 20.35 %), yield per plot (59.06 and 20.25 %), yield per hectare (58.98 and 20.21 %), number of nodes on the main stem (38.58 and 25.04 %), number of fruits per plant (37.93 and 17.35 %), number of leaves at 60 DAS (35.43 and 16.15 %), plant height at 60 DAS (32.76 and 24.21 %) and number of leaves at 45 DAS (32.47 and 9.31 %). Magnitude of standard heterosis in the desirable direction over the commercial checks Arka Anamika and MHY-10 was medium to low for number of leaves at 90 DAS (28.23 and 20.14 %), average fruit weight (24.82 and 14.50 %), plant height at 90 DAS (22.09 and 18.11 %), plant height at 45 DAS (21.72 and 18.31 %), fruit diameter (17.82 and 8.34 %), internodal length at 60 DAS (-17.01 and -24.10 %), days to 50 per cent flowering (-14.42 and -10.10 %), number of seeds per fruit (10.75 and 40.09 %), days to first flowering (-8.43 and -5.00 %), fruit length (8.37 and 6.79 %) and number of ridges on fruit surface (-5.66 and -1.96 %).

Among 28 crosses, four crosses over better parent, two crosses over the best parent and 22 crosses over the commercial check Arka Anamika and seven crosses over the commercial check MHY-10 showed significantly positive heterosis for total yield per hectare. Maximum standard heterosis (Arka Anamika and MHY-10) for yield per hectare was observed in the cross KO1606 x KO1608 (58.98 and 20.21 %) followed by KO1602 x KO1608 (51.48 and 14.53 %), KO1603 x KO1606 (49.78 and 13.25 %), KO1606 x KO1607 (45.84 and 10.27 %) and KO1601 x KO1605 (41.62 and 7.08 %).

The cross KO1606 x KO1608 was the best hybrid selected for yield per hectare and its estimated yield was 14.51 tonnes per hectare. It also exhibited significant standard heterosis over the commercial checks Arka Anamika and MHY-10 in the desirable direction for plant height at 45 and 90 DAS, fruit diameter, number of fruits per plant, total yield per plant, yield per plot and yield per hectare. This hybrid was found to be moderately free from yellow vein mosaic virus symptom, fruit borer and sucking pests (leaf hopper and white fly) attack and also free from fusarium wilt incidence.

The cross KO1602 x KO1608 was the second best hybrid selected for yield per hectare and its estimated yield was 13.83 tonnes per hectare. It also exhibited significant standard heterosis (Arka Anamika and MHY-10) in the desirable direction for number of branches per plant, days to first flowering, days to 50 per cent flowering, number of fruits per plant, total yield per plant, yield per plot and yield per hectare. This hybrid was found to be moderately free from yellow vein mosaic virus symptom and sucking pests (leaf hopper and white fly) attack and also free from fusarium wilt incidence.

The third best hybrid was KO1603 x KO1606 and its estimated yield was 13.67 tonnes per hectare. It also exhibited significant standard heterosis (Arka Anamika and MHY-10) in the desirable direction for number of leaves at 45, 60 and 90 DAS, internodal length, number of branches per plant, number of nodes on main the stem, average fruit weight, number of fruits per plant, total yield per plant, yield per plot and yield per hectare. This hybrid was found to be moderately free from yellow vein mosaic virus symptom and fruit borer attack and had low incidence of sucking pests (leaf hopper and white fly) and also free from fusarium wilt incidence.

The parents KO1606 and KO1608 were identified as the good general combiners for total yield per plant, yield per plot and yield per hectare. Similarly, the parent KO1608 for plant height at 45 and 60 DAS, KO1608 and KO1606 for plant height at 90 DAS, KO1608, KO1605, KO1604 and KO1606 for number of leaves on 45 DAS, KO1608, KO1602 and KO1604 for number of leaves on 60 DAS, KO1608, KO1606 and KO1602 for number of leaves on 90 DAS, KO1604 and KO1605 for internodal length, KO1608 and KO1602 for number of branches per plant, KO1604, KO1608 and KO1605 for number of nodes on the main stem, KO1602 and KO1608 for days to first flowering and days to 50 per cent flowering, KO1603 for fruit length, KO1608 for fruit diameter, KO1606 and KO1603 for average fruit weight, KO1608, KO1602 and KO1606 for number of fruits per plant, KO1608, KO1607 and KO1605 for number of ridges per fruit and KO1603 and KO1605 for number of seeds per fruit were identified as good general combiners in order of merit.

The crosses KO1601 x KO1605 and KO1603 x KO1606 were identified as the good specific combiners for total yield per plant, yield per plot and yield per hectare. Similarly, the crosses KO1603 x KO1605 followed by KO1601 x KO1602 for plant height at 45 DAS, KO1604 x KO1606 followed by KO1602 x KO1604 for plant height at 60 DAS, KO1601 x KO1603 followed by KO1604 x KO1608 for plant height at 90 DAS, KO1603 x KO1606 followed by KO1601 x KO1604 for number of leaves at 45 DAS, internodal length and number of nodes on the main stem, KO1603 x KO1606 followed by KO1604 x KO1608 for number of leaves at 60 DAS, KO1603 x KO1606 followed by KO1605 x KO1606 for number of leaves at 90 DAS, KO1601 x KO1608 followed by KO1606 x KO1607 for number of branches per plant, KO1603 x KO1607 followed by KO1604 x KO1607 for days to first flowering, KO1601 x KO1602 followed by KO1602 x KO1605 for days to 50 per cent flowering, KO1606 x KO1607 followed by KO1604 x KO1605 for fruit length, KO1602 x KO1605 followed by KO1601 x KO1607 for fruit diameter, KO1601 x KO1605 followed by KO1604 x KO1606 for average fruit weight, KO1601 x KO1604 followed by KO1603 x KO1606 for number of fruits per plant, KO1601 x KO1602 followed by KO1601 x KO1607 for number of ridges on fruit surface and KO1601 x KO1606 followed by KO1603 x KO1607 for number of seeds per fruit were identified as good specific combiners.

Comprehensive assessment of parents by considering gca effects of 20 characters studied has resulted into identification of parents *viz*., KO1605, KO1606 and KO608 as good combiners for most of the characters. Assessment of crosses by considering standard heterosis values of 20 characters revealed that, out of 28 crosses, 15 crosses were highly heterotic, five were average heterotic and eight were low heterotic. Among the 15 highly heterotic crosses, ten crosses involved high x low or low x high, three crosses involved high x high parental combinations and two crosses involved low x low parental combinations (over all gca status).

Studies on combining ability variance revealed that the plant height at 45, 60 and 90 DAS, number of leaves at 45, 60 and 90 DAS, internodal length, number of nodes on the main stem, days to first flowering, days to 50 per cent flowering, fruit length, fruit diameter, average fruit weight, number of ridges on fruit surface and number of seeds per fruit are predominantly controlled by non-additive gene action and hence heterosis breeding and recurrent selection can be employed for improvement. Non additive component of genetic variance was slightly higher than additive component for number of branches per plant, numbers of fruits per plant, total yield per plant and yield per hectare and these characters can be improved through direct selection or recurrent selection schemes.

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**- Originals not seen*

Appendix I. Meteorological data recorded during the period of experimentation (2016) at Agricultural Research Station, Arabhavi

Month	Temperature ^{0}C		RH%	Rainfall (mm)	No. of Rainy days	Evaporation (mm/month)
	Maximum	Minimum				
January	31.50	10.40	88.90	0.00	00	3.60
February	35.90	14.50	91.70	0.00	00	4.10
March	37.30	16.30	84.30	0.00	00	5.60
April	40.30	19.70	77.00	12.30	01	7.10
May	40.20	19.10	81.90	19.60	01	7.00
June	32.50	21.40	84.80	66.90	07	3.80
July	30.00	21.40	90.60	126.30	11	2.10
August	30.80	19.10	86.27	29.60	09	1.55
September	32.20	17.70	83.34	41.10	04	1.45
October	31.60	18.20	89.10	7.80	01	4.30
November	31.20	13.30	85.90	0.00	00	4.00
December	30.10	10.50	90.00	0.00	00	5.30

Appendix II. Fruit colour, pubescence and tenderness in okra genotypes

Sl. No.	Genotypes	Fruit colour	Fruit pubescence	Fruit tenderness
Parents				
1	KO1601	Light Green	Smooth	Moderately Fibrous
2	KO1602	Green	Smooth	Moderately Fibrous
3	KO1603	Light Green	Rough	Tender
4	KO1604	Dark Green	Rough	Moderately Fibrous
5	KO1605	Light Green	Smooth	Moderately Fibrous
6	KO1606	Dark Green	Smooth	Tender
7	KO1607	Dark Green	Rough	Moderately Fibrous
8	KO1608	Green	Smooth	Moderately Fibrous
Crosses				
9	KO1601 x KO1602	Light Green	Smooth	Moderately Fibrous
10	KO1601 x KO1603	Green	Smooth	Moderately Fibrous
11	KO1601 x KO1604	Light Green	Smooth	Moderately Fibrous
12	KO1601 x KO1605	Dark Green	Smooth	Moderately Fibrous
13	KO1601 x KO1606	Green	Smooth	Moderately Fibrous
14	KO1601 x KO1607	Green	Rough	Moderately Fibrous
15	KO1601 x KO1608	Green	Smooth	Moderately Fibrous
16	KO1602 x KO1603	Dark Green	Rough	Moderately Fibrous
17	KO1602 x KO1604	Light Green	Smooth	Moderately Fibrous
18	KO1602 x KO1605	Dark Green	Rough	Moderately Fibrous
19	KO1602 x KO1606	Dark Green	Smooth	Moderately Fibrous
20	KO1602 x KO1607	Light Green	Smooth	Moderately Fibrous
21	KO1602 x KO1608	Green	Smooth	Moderately Fibrous
22	KO1603 x KO1604	Green	Rough	Moderately Fibrous
23	KO1603 x KO1605	Dark Green	Rough	Moderately Fibrous
24	KO1603 x KO1606	Light Green	Rough	Moderately Fibrous
25	KO1603 x KO1607	Dark Green	Smooth	Moderately Fibrous
26	KO1603 x KO1608	Light Green	Rough	Moderately Fibrous
27	KO1604 x KO1605	Green	Smooth	Tender
28	KO1604 x KO1606	Green	Smooth	Moderately Fibrous
29	KO1604 x KO1607	Green	Smooth	Moderately Fibrous
30	KO1604 x KO1608	Dark Green	Rough	Moderately Fibrous
31	KO1605 x KO1606	Dark Green	Rough	Tender
32	KO1605 x KO1607	Dark Green	Rough	Tender
33	KO1605 x KO1608	Green	Smooth	Moderately Fibrous
34	KO1606 x KO1607	Dark Green	Rough	Moderately Fibrous
35	KO1606 x KO1608	Green	Rough	Moderately Fibrous
36	KO1607 x KO1608	Light Green	Rough	Moderately Fibrous
Commercial checks				
37	Arka Anamika	Light Green	Rough	Moderately Fibrous
38	Mahyco-10	Dark Green	Smooth	Moderately Fibrous

DIALLEL ANALYSIS IN OKRA [*Abelmoschus esculentus* (L.) Moench]

SHWETHA A. **2017** **Dr. RAVINDRA MULGE**
Major Advisor

ABSTRACT

The investigation on diallel analysis in okra was carried out during the year 2016-17 at Vegetable Science unit, Kittur Rani Channamma College of Horticulture, Arabhavi. The experimental material comprised of eight parents and 28 cross combinations produced through half-diallel fashion and two commercial checks (Arka Anamika and MHY-10). All the crosses were evaluated along with the parents and the commercial checks in randomised block design with two replications. Magnitude of heterosis over the commercial check (MHY-10) was high in the desirable direction for number of branches per plant (58.33 %), number of seeds per fruit (40.09 %), number of nodes on the main stem (25.04 %), plant height at 60 DAS (24.21 %), internodal length at 60 DAS (-24.10 %), total yield per plant (20.35 %), yield per plot (20.25 %), yield per hectare (20.21 %) and number of leaves at 90 DAS (20.14 %). Magnitude of standard heterosis in the desirable direction over the commercial check (MHY-10) was medium to low for plant height at 45 DAS (18.31 %), plant height at 90 DAS (18.11 %), number of fruits per plant (17.35 %), number of leaves at 60 DAS (16.15 %), average fruit weight (14.50 %), days to 50 per cent flowering (-10.10 %), number of leaves at 45 DAS (9.31 %), fruit diameter (8.34 %), fruit length (6.79 %), days to first flowering (-5.00 %) and number of ridges on fruit surface (-1.96 %). Maximum standard (MHY-10) heterosis for yield per hectare was observed in the cross KO1606 x KO1608 (20.21 %) followed by KO1602 x KO1608 (14.53 %) and KO1603 x KO1606 (13.25 %).

The crosses KO1601 x KO1605 and KO1603 x KO1606 were identified as the good specific combiners for yield per hectare and the parents KO1606 and KO1608 were identified as the good general combiners for yield and yield attributing traits. Studies on combining ability variance revealed that non-additive gene action was predominant for number of nodes on the main stem, plant height at 90 DAS, average fruit weight, internodal length, days to first flowering, number of seeds per fruit and fruit length. Non additive component of genetic variance was slightly higher than additive component for total yield per plant and yield per hectare.

¨ÉqÉÁ¬Ä (C¨ÉïªÀÄ¸ÀÄï J¸ïÀ¯ÉÉl ¸ï (°.) ªÀÄAZï) AiÀÄ° qÉ°Ã¯ï «±ÉèµÀuÉAiÀÄCzsÀåAiÀÄ£À

±ÉÆvÀJ. **2017** **qÁ‡ gÀAzÀÆ ªÀÄ®UÉ ¥ÁæzsÁåÀR ¸ÀAºÉÆÃgÀ**

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¨AqPÁ¬ÄAiÄ° qÉC°Ã¯ï «±ÃµuAiÄ CzsÀAiÄ£ª£Ä 2016-17 g° vgPÁj «eÁ£ «¨ÁU, QvÆg gÁt Z£Äª vÆÃlUÁjP ªÄºÁ«zÁå®AiÄ, Cg¨Á«AiÄ° PÉUÆ¼¯Á¬ÄvÄ. JAlÄ ¥ææÃzU¼° Czð qÉC°Ã¯ï «±ÃµuAiÄ «zÁ£ª£Ä G¥AiÆÃV¹PÆAqÄ 28 ¸APgt v½U¼£Ä C©ªÉ¢¥r¹ eÆvU ¸ÁzÁgt (CPÁð C£Á«ÄPÁ) ºÁUÆ ¥æÆ°v ¸APgt (ªÄ»-10) v½U¼£Ä G¥AiÆÃV¹ qÉC°Ã¯ï «±Ãµu ªÄÄSÁAvg Dgï.©.r. «£Á¸z° ªiË®ªiÁ¥£ ªiÁq¯Á¬ÄvÄ. MlÄ gA¨U¼ ¸ASå ¥æe VqP (58.33%), ©ÃdU¼ ¸ASå ¥æe ºtU (40.09%), ªÄÄRå PÁAqz ªÄÃ°£ UtÄU¼ ¸ASå (25.04%), Vqz Gzæ 60£Ã ¢£zAzÄ (24.21%), UtÄU¼ £qÄ«£ Gz (-24.10%), E¼Äªj ¥æe VqP (20.35%), E¼Äªj ¥æe ºPÃjU (20.25%) ªÄvÄ J¯U¼ ¸ASå 90£Ã ¢£zAzÄ (20.14%) F UÄtU½U ¸AQgtv ¥æiÁtªÀ ¥æÆ°v v½VAv (ªÄ»-10) ±ÃPqÁªÁgÄ ¥ÆgP ¢Q£° C¢PªÁV PAqÄ§A¢z. PªÇ1606 x PªÇ1608 (20.21%) vz£Avg PªÇ1602 x PªÇ 1608 (14.53%) ªivÄ PªÇ1603 x PªÇ1606 (13.25%) F ¸APgt v½U¼Ä ¥æÆ°v v½VAv (ªÄ»-10) ±ÃPqÁªÁgÄ ºZÄ ¸AQgtvAiÄ£Ä E¼Äªj ¥æe ºPÃjU vÆÃjzªÀ.

¸APgt v½U¼ ¥ÉQ PªÇ1601 x PªÇ1605 ªivÄ PªÇ1603 x PªÇ1606 U¼£Ä E¼Äªj ¥æe ºPÃjU GvªÄ ¤¢ðµ ¸AAiÆÃdPU¼AzÄ ºÁUÆ ¥ææÃzU¼ÁzAvº PªÇ1606 ªivÄ PªÇ1608 U¼£Ä E¼Äªj ªÄvÄ E¼ÄªjU ¸A§¢v UÄtU½U GvªÄ ¸ÁªiÁ£å ¸AAiÆÃdPU¼AzÄ UÄgÄw¸¯ÁVz. C¸AR°v ªA±ªÁ»AiÄ QæéÄAiÄÄ ªÄÄRå PÁAqz ªÄÃ°£ UtÄU¼ ¸ASå, Vqz Gz, ¸gÁ¸j PÁ¬ÄAiÄ vÆP, UtÄU¼ £qÄ«£ Gz, ªÆz® ºÆª£Ä ©q®Ä vUzÄPÆAq ¢£U¼Ä, ©ÃdU¼ ¸ASå ¥æe ºtU ªivÄ PÁ¬ÄAiÄ Gz F UÄtU½U ¥§®ªÁVz. ¥æe Vqz E¼Äªj ºÁUÆ ¥æe ºPÃj£ MlÄ E¼ÄªjU C¸AR°v ªA±ªÁ»AiÄ QæéÄAiÄÄ ¥ÆgP ¢Q£° PAqÄ§A¢gÄvz.