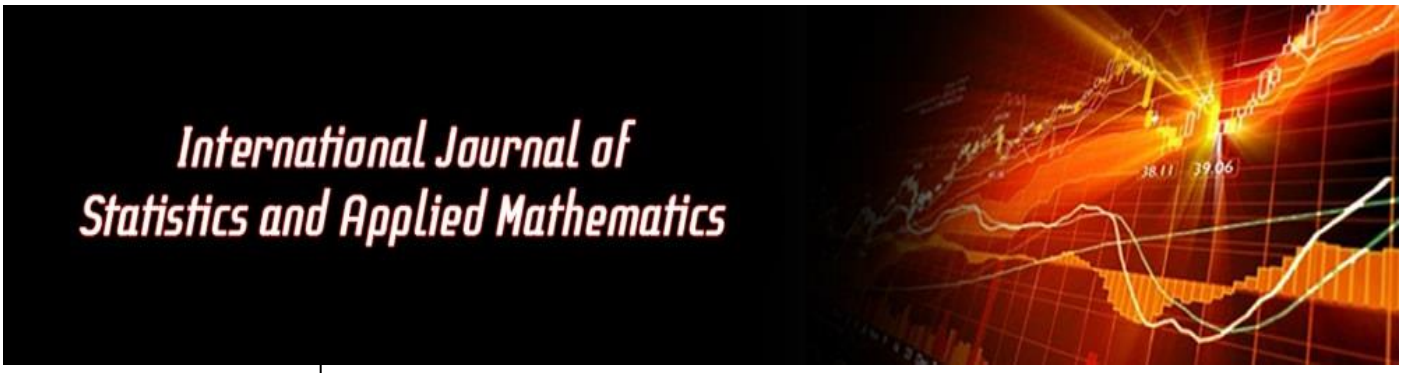
International Journal of Statistics and Applied Mathematics 2023; SP-8(3): 568-573



ISSN: 2456-1452
Maths 2023; SP-8(3): 568-573

https://www.mathsjournal.com
Received: 02-05-2023
Accepted: 07-06-2023

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Genetic studies for yield and yellow vein mosaic virus resistance in okra (*Abelmoschus esculentus* L. moench)

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Abstract
The present investigation was carried out in okra consisting of 11 diverse genotypes (8 lines & 3 testers) and their 24 F1 hybrids. Phenotypic and genotypic correlation indicated positive association of average fruit length with average fruit weight while negative association between days taken to first flower with number of fruits per plant. The maximum positive direct effect on yield was due to number of fruits per plant followed by average fruit weight. The F_1 hybrid VRO-6 × Parbhani Kranti exhibits highest negative heterobeltiosis for days taken to 1st flowering while D-1-87-5 × Pusa A-4 and Arka Abhay × Parbhani Kranti are earliest heterobeltiotic hybrids for days taken to 1st harvest. The hybrid Arka Abhay × Pusa A-4 represents highest heterobeltiosis for average fruit length, number of fruits/ plant and average yield. Among all parents, only Akra Abhay exhibits better GCA effect. The highest SCA effect for average yield observed in VRO-6 × Arka Anamika, while VRO-6 × Pusa A-4 for per cent infestation of YVMV. The cross Arka Abhay × Pusa A-4 incurred the highest net returns/ ha and B: C ratio (3.21) followed by that of D-1-87-5 × Parbhani Kranti and the parent Hisar Unnat gave the higher net returns/ ha with B: C ratio of 2.02 among the parents. These elite hybrids may be tested for yield and other quality traits under different agro-climatic conditions for commercial exploitation of hybrid vigour.

Keywords: Okra, correlation, path analysis, heterosis, combining ability, YVMV, B: C ratio

Introduction
Okra is an important vegetable crop in the tropical and subtropical region of the world belongs to the family Malvaceae. It's grown throughout the tropical and subtropical part of world. It is widely grown all over India both in summer and rainy season. It is extensively grown in all parts of the country withan area of 0.514 million ha with total production of 6.126million tonnes and a productivity of 11.9 metric tonnes/ha (Anonymous 2018) [3]. Hence, an attempt has been made to study the 'line × tester' analysis (Kempthorne, 1957) [9], to know the heterobeltiosis (heterosis over better parent), relative heterosis (heterosis over mid parent) and economic heterosis (heterosis over check variety) for interested traits in okra (Singh *et al.*, 2009) [14]. Heterosis is a special genetic mechanism wherein the distant genotypes are brought together in a specific pattern to express their ability to make a dramatic shift in the magnitude of a particular trait. The genetical studies revealed that yield and its components is most assessing in nature and magnitude of gene effect is important for increasing the yield potential. Exploitation of heterosis and hybrid vigour has been reported for increase in yield and other yield related traits. Okra has suffered major cultivation problem in India due to lack of yielding varieties along with hybrids with resistance to one of the most severe problem i.e. yellow vein mosaic virus (YVMV). Various approaches being used to overcome this problem one of them considered as heterosis breeding for exploitation of heterosis breeding. Moreover, okra which is categorized under often-cross-pollinated group showed easy emasculation and high number of seed production in single pollination. It should be kept in mind that due to high chromosome number and polygenic control of major economic traits, 100% homozygosity in the parents is difficult to achieve (Dhankar and Mishra, 2006) [6]. In okra insufficient work has been done in estimating the heterosis effects in different environments. Therefore, the present investigation has been undertaken to estimation of the heterosis over better parents in different seasons for fruit yield and related traits in okra.

Materials and Methods

The present investigation was carried out in line × tester mating design in okra consisting of 11 diverse genotypes (8 lines & 3 testers) and their 24 F1 hybrids was evaluated in a complete randomized block design (CRBD) with three replications at the research farm of the Department of Horticulture (Vegetable & Floriculture), Bihar Agricultural College, Sabour, Bhagalpur (Bihar). The parental materials comprised of 8 lines *viz.*, D-1-87-5, Nirmal-303, Hisar Unnat, Arka Abhay, Indam- 9821, Ankur-40, Varsha Uphar, VRO-6 and 3 testers i.e., Pusa-A-4, Arka Anamika and Parbhani Kranti (Table 1).

Table 1: Genotypes of okra employed in the investigation.

Sl. No.	Genotypes	Specific traits	Source
1.	D-1-87-5	High yielding, long poded, early variety.	IARI, New Delhi
2.	Nirmal 303	Long poded, high yielding variety.	Nirmal Seeds Pvt. Ltd., Pachora, Maharashtra
3.	Hisar Unnat	Light green pods, early, high yielding and resistant to YVMV.	CCSHAU, Hisar, Hariyana
4.	Indam- 9821	Light green and long poded, high yielding variety.	Indo American Hybrid Seeds (India) Pvt. Ltd., Bangalore, Karnataka
5.	Ankur-40	Smooth pods with attractive green colour, high yielding variety.	Ankur Seeds Pvt. Ltd., Nagpur, Maharashtra
6.	*VRO-6	Resistant to YVMV, high yielding and better for Kharif season.	IIVR, Varanasi, Uttar Pradesh
7.	Varsha Uphar	Early harvesting, pods are medium in size and dark green colour.	CCSHAU, Hisar, Hariyana
8.	Arka Abhay	Wider adaptable variety and resistant to YVMV.	IIHR, Bangalore, Karnataka
9.	Arka Anamika	Moderately resistant to YVMV, high yielding variety.	IIHR, Banglore, Karnataka
10.	Pusa A-4	Resistant to YVMV, high yielding and good for fresh fruit export.	IARI, New Delhi
11.	Parbhani Kranti	YVMV resistant variety.	MPKV, Rahuri, Maharashtra

*Standard check variety – VRO-6

The recommended agronomic practices were adopted for raising a good okra crop. Observations were recorded on 10 economically important traits *viz.*, Plant height (m), number of branches/ plant, days to 1st flowering, days to 1st harvest, average fruit length (cm) average fruit weight (g), number of fruits/ plant, number of seeds per pod, average yield (q/ ha) and per cent infestation of YVMV. The soil of the plot was sandy loam in texture having good fertility properly leveled and well drained. The pH of the soil under study was 6.8 (Table 2).

Table 2: Soil test results of experimental plot.

Sl. No	Content	Result	
1.	pH	7.95	Slightly Basic
2.	E.C. (Desi/m)	0.117	Normal
3.	Organic Carbon (%)	0.42	Low
4.	Available P_2O_5 (kg/ha)	41.04	Medium
5.	Potash (kg/ha)	91.12	Low

The heterosis of F_1's over the better parent (BPH) and mid parent (MPH) was calculated by using the formula:

$$\text{Per cent heterosis over better parent (BPH)} = \frac{F_1 - BP}{BP} \times 100$$

$$\text{Per cent heterosis over mid parent (MPH)} = \frac{F_1 - MP}{MP} \times 100$$

$$\text{Per cent heterosis over standard parent (SPH)} = \frac{F_1 - SP}{SP} \times 100$$

Where, F_1 = Mean value of F_1s, BP= Mean of better parent, MP= mean of mid parent value and SP= mean of standard parent value.

Analysis of combining ability was carried out as recommended by Kempthorne, 1957 [9]. The genetic parameters, such as phenotypic, genotypic, and environmental coefficients of variation (GCV, PCV and ECV), heritability in broad sense (h^2b), genetic advance and correlation coefficients for each character were estimated as suggested by Tsegaye *et al.* 2007 [16].

Scoring of YVMV disease incidence was scored on 0 – 4 scale (Table 1) at the 15 days intervals (30 day, 45 day, 60 day and 75 days) after sowing and PDI and CI value was calculated by the procedure coined by Banerjee and Kaloo, 1987 [4].

$$\text{PDI (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of plants observed}} \times 100$$

$$CI = RV \times PDI$$

Where,
RV = Response value
PDI = per cent disease infection.

Table 3: Scale for classifying disease reaction in okra to YVMV disease.

Symptoms	Severity grade	Response value	Coefficient of infection	Reaction
Symptoms absent	0	0	0 – 4	HR
Very mild symptoms up to 25% leaves	1	0.25	4.1 – 9	R
Appearance of disease between 26-50% leaves	2	0.50	9.1 – 19	MR
Symptom between 51-75% leaves	3	0.75	19.1 – 39	MS
Severe disease infection at 75% leaves	4	1.00	39.1 – 69	S
Above 75% leaves	>4	>1.00	69.1 – 100	HS

Note, R = Resistant, S = Susceptible, H R = Highly resistant, H S = Highly susceptible,
M R = Moderately resistant, M S = Moderately susceptible.

Table 4: Analysis of Variance (ANOVA) for Line × Tester analysis and its combining ability for ten quantitative traits in okra.

Sources	d. f	Plant height (m)	Number of branches per plant	Days taken to first flower	Days taken to first harvest	Average fruit length (cm)	Average Fruit weight (g)	Number of fruits/plant	Number of seeds per pod	Average Yield (q/ha)	Per cent infestation of YVMV
Replication	2	0.089	0.619	11.063	9.867	1.048	10.016	1.416	133.039	276.459	656.363
Treatment	34	0.070**	1.056**	12.904**	5.633	2.540**	4.392**	42.395**	93.467**	1844.807**	39.906
Parent	10	0.092**	0.543**	11.496**	1.685	3.704**	10.462**	21.908**	72.745*	415.354**	39.250
F_1	23	0.064**	1.324**	14.059**	3.753**	1.324**	1.861	50.388**	106.211**	2171.681**	38.967
Parent Vs F_1	1	0.002	0.031	0.387	88.356**	18.864**	1.824	63.416**	7.568	8621.247**	0.0587
Error	68	0.024	0.176	3.542	1.602	0.526	1.310	6.914	31.707	118.728	37.352

*,** Significant at 5% and 1%, respectively.

Table 5; Mean, range, genotypic and phenotypic coefficient of variation heritability and genetic advance in okra.

Sl No.	Characters	Mean	Range			Coefficient of variation		h^2b (%)	GA as% of Mean
			Line	Tester	Crosses	GCV	PCV		
1	Plan height (m)	1.01	0.85-1.31	0.85-1.03	0.78-1.32	12.33	19.70	39.18	15.90
2	Number of branches/ plant	4.56	3.63-5.20	4.43-4.90	3.63-5.77	11.86	15.00	62.47	19.31
3	Days taken to 1st flowering	40.02	36.99-42.34	41.17-42.46	34.82-44.33	4.41	6.45	46.84	6.22
4	Days taken to 1st Harvest	46.52	46.33-48.67	47.33-48.67	44.67-49.33	2.49	3.69	45.62	3.47
5	Average fruit length (cm)	15.36	13.06-17.64	14.34-15.13	14.63-17.14	7.46	11.25	43.95	10.18
6	Average fruit weight (g)	13.59	11.49-14.24	11.03-18.21	11.46-15.71	5.33	7.12	56.09	8.23
7	Number of fruits/ plant	17.91	13.62-20.29	13.72-21.24	9.29-24.92	7.31	11.65	39.37	9.45
8	Number of seeds per pod	62.08	57.66-68.11	53.88-65.89	49.33-73.44	19.20	24.17	63.11	31.42
9	Average yield (q/ha)	106.51	78.50-112.04	80.58-83.53	59.03-156.36	22.52	24.74	82.89	42.24
10	Percent infestation of YVMV	25.28	20.26-31.45	23.18-29.20	16.56-32.93	1.70	24.24	49.00	25.00

Table 6: Phenotypic and genotypic correlation coefficient in okra.

Characters		Plant height	Days taken to first flower	Average fruit length	Average fruit weight	Number of fruits/plant	Average yield
Plant height (m)	G	1.0000	-0.2436	0.5525**	0.1017	0.2186	0.2533
	P	1.0000	-0.2079	0.3267	-0.0150	0.1299	0.1522
Days taken to 1st flowering	G		1.0000	-0.0369	-0.1898	-0.5032**	-0.5889**
	P		1.0000	-0.1201	-0.139	-0.3852*	-0.4909**
Average fruit length (cm)	G			1.0000	0.4470	0.2217	0.3556*
	P			1.0000	0.1553	0.1596	0.2784
Average fruit weight(g)	G				1.0000	0.0878	0.4102*
	P				1.0000	0.0272	0.2782
Number of fruits/ plant	G					1.0000	0.9144**
	P					1.0000	0.7841**

G = Genotypic correlation coefficient,
P = Phenotypic correlation coefficient
*,** Significant at 5% and 1%, respectively.

Table 7: Genotypic direct and indirect effects in okra.

Traits	Plant height (m)	Days taken to 1st flower	Days taken to 1st harvest	Average fruit weight (g)	Number of fruits/ plant	Yield (q/ ha)
Plant height (m)	**-0.0079**	0.0292	0.0223	0.0303	0.1794	0.2533
Days taken to1st flowering	0.0019	**-0.1198**	-0.0015	-0.0566	-0.4130	-0.5889
Average fruit length (cm)	-0.0044	0.0044	**0.0403**	0.1333	0.1819	0.3556
Average Fruit Weight (g)	-0.0008	0.0227	0.0180	**0.2981**	0.0721	0.4102
Number of Fruit/ Plant	-0.0017	-0.0265	0.0957	0.0262	**0.8208**	0.9144

*Bold lines indicate direct effects, R^2 =0.9557, Residual effect = 0.2104

Table 8: Best three heterotic F_1s and GCA and SCA effects for ten characters in okra.

Characters	Hybrids (F_1)	MP (%)	BP (%)	SP (%)	Parents	GCA	Hybrids (F_1)	SCA
Plan height (m)	V-6 × A.An.	54.90*	54.30**	28.25*	VRO-6	0.1851	A-40 × P.K.	0.2422 **
	V-6 × P-4	46.04	34.25*	10.71	Nirmal -303	0.0751	H.U. × A.An.	0.1464
	H.U. × A.An.	21.09	21.09	0.65	Parbhani Kranti	0.0486	V.U × A.An.	0.1381
Number of branches / plant	H.U. × A.An.	24.90*	22.56**	11.64	Arka Abhay	0.4875	A- 40 × P-4	1.0722 **
	A-40 × A.An.	22.14*	20.30**	9.59	Arka Anamika	0.1542	N-303 × P-4	0.9097 **
	N-303 × A.An.	15.44*	12.95	7.53	Pusa-A-4	0.1208	I - 9821 × P-4	0.8167 **
Days taken to 1st flowering	V-6 × P.K.	-11.79*	-17.03**	-17.03**	VRO-6	-2.4240	H.U. × P.K	-3.6225**
	A.Ab. × P-4	-13.20*	-13.38**	-15.03**	Hisar Unnat	-1.6618	A.Ab. × P-4	-2.7764*
	H.U. × P-4	-5.32	-8.98*	-10.72**	Pusa-A-4	-0.9831	H.U. × P-4	-2.2236*
Days taken to 1st Harvest	D-1 × P-4	-7.27**	-8.22**	-8.22**	Hisar Unnat	-0.6806	D-1 × P-4	-1.7347*
	A.Ab. × P.K	-6.94**	-8.22**	-8.22**	Pusa-A-4	-0.5694	V-6 × A.An.	-1.1597
	A.Ab. × P-4	-5.96**	-6.29**	-8.22**	Arka Abhay	-0.3472	A.Ab. × P.K.	-0.9375
Average fruit length (cm)	A.Ab. × P-4	18.07*	16.97**	19.53**	Nirmal -303	0.8107	H.U. × A.An.	0.9053 *

	A.Ab. × P.K.	12.70*	12.85**	12.85**	Hisar Unnat	0.2651	V.U. × P.K.	0.8036
	A-40 × P.K.	12.29*	12.12**	12.46**	Varsha Uphar.	0.1751	A-40 × P.K.	0.7956
Average fruit weight (g)	V.U. × P.K.	22.39*	19.92*	24.96**	Nirmal -303	0.6844	I - 9821 × P-4	1.2200
	D-1 × P.K.	20.13*	10.9	31.04**	Arka Abhay	0.6278	D-1 × P.K.	1.1197
	H.U. × P-4	14.62*	10.52	36.20**	VRO-6	0.3589	H.U. × A.An.	0.6719
Number of fruits/plant	A.Ab. × P-4	71.39*	65.51**	17.33	Arka Abhay	4.1369	H.U. × P-4	5.1608 **
	N-303 × P-4	51.00*	48.76**	8.68	Nirmal -303	1.9714	V-6 × A.An.	4.9747 **
	N-303 × A.An.	56.00*	46.98**	7.38	Pusa-A-4	1.7235	A- 40 × P-4	3.8967 *
Number of seeds per pod	V-6 × A.An.	25.54*	21.50**	11.46	I -9821	5.2465	A.Ab. × P.K.	9.0258 **
	H.U. × P-4	22.91*	18.89*	4.05	VRO-6	3.8010	A-40 × A.An.	7.3744 *
	I- 9821 × P-4	14.89*	17.01*	5.57	Ankur-40	2.2088	D-1 × P.K.	5.8575
Average Yield (q/ha)	A.Ab. × P-4	93.00*	87.18**	94.12**	Arka Abhay	26.6579*	V-6 × A.An.	41.0658 **
	D-1 × P.K.	88.65*	86.78**	86.78**	VRO-6	12.2401	H.U. × P-4	27.9386 **
	H.U. × P-4	49.05*	30.09**	80.95**	Pusa-A-4	9.1710	D-1 × P.K.	26.2042 **
Percent infestation of YVMV	A.Ab. × A.An.	-29.37	-33.23	-28.03	Arka Abhay	-4.8620	V-6 × P-4	-3.7773
	A-40 × P.K.	-5.77	-11.62	-11.62	Ankur-40	-1.6878	A.Ab. × P-4	-3.5786
	D-1 × P-4	-20.1	-27.52	-8.52	D-1 -87-5	-0.9046	I-9821 × P-4	-3.2105

Where, D-1 = D-1 -87-5, N-303 = Nirmal -303, H.U. = Hisar Unnat, I - 9821 = INDAM -9821, A-40 = Ankur-40, V- 6 = VRO – 6, V.U. = Varsha Uphar, A.Ab.
= Arka Abhay, P-4 = Pusa A-4, A.An. = Arka Anamika, P.K. = Parbhani Kranti.
*,** Significant at 5% and 1%, respectively.

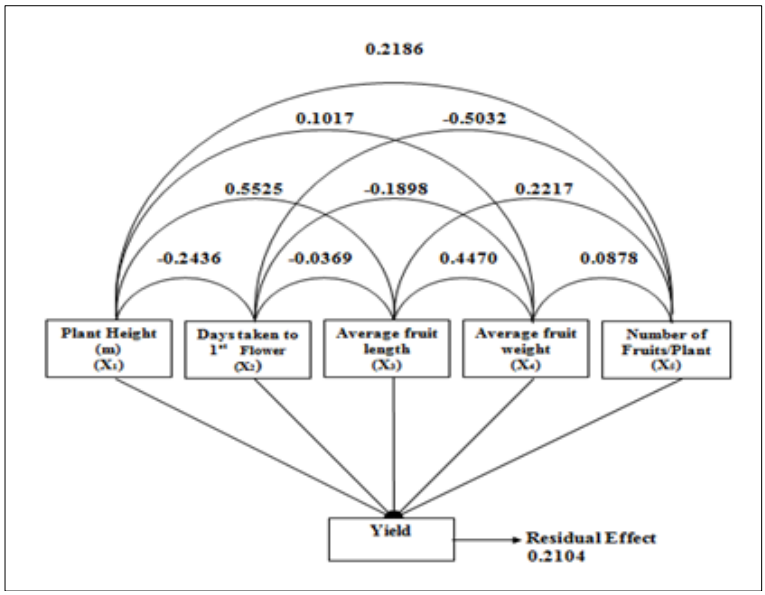
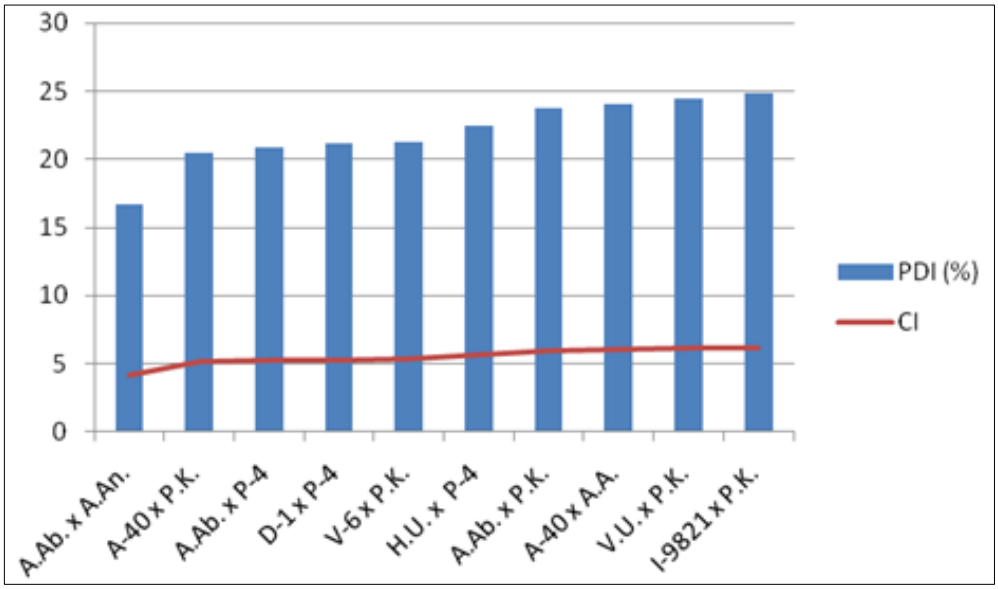


Fig 1: Path diagram showing direct and indirect effects on yield contributing traits in okra**.**



Where, D-1 = D-1 -87-5, N-303 = Nirmal -303, H.U. = Hisar Unnat, I - 9821 = INDAM -9821, A-40 = Ankur-40, V- 6 = VRO – 6, V.U. = Varsha Uphar, A.Ab. = Arka Abhay, P-4 = Pusa A-4, A.An. = Arka Anamika, P.K. = Parbhani Kranti.

Fig 2: Best ten resistant F_1 hybrids of okra.

Results and discussion

The analysis of variance of the experiment indicated significant difference among the treatments for all the characters except per cent infestation of YVMV (Table 4). Parent vs. crosses were highly significant for the characters like days taken to first harvest, average fruit length (cm) number of fruits/ plant and average yield (q/ha).

The highest genotypic coefficient of variation (Table 5) was noticed for average yield (22.52) followed by number of fruits/ plant (19.20) and plant height (12.33). The maximum phenotypic coefficient of variation was observed for average fruit yield (24.74) followed by percent infestation of YVMV (24.24) and number of fruits/ plant (24.17). The highest broad sense heritability (h^2b) was obtained for average yield (82.89%) followed by number of fruits/ plant (63.11%) and number of branches/ plant (62.47%). The genetic advance expressed as percentage of mean was the highest for average yield (42.24%) followed by number of fruits/ plant (31.42%) and number of branches per plant (19.31%). Existence of high variability for yield per plant in okra was also reported by Adiger *et al*., 2013 [1].

In general, genotypic correlations were higher than phenotypic correlations (Table 6). Phenotypic and genotypic correlations of average yield (q/ha) with number of fruits/ plant (G=0.914, P=0.784) were significantly positive, whereas, it was negatively correlated with days taken to 1st flowering (G=-0.588, P=-0.491). Phenotypic and genotypic correlation indicated significant negative association for days taken to first flower with number of fruits per plant (G=-0.503, P=-0.385) and average yield (G=-0.588, P=-0.490). Similar pattern of correlation was also reported by Dhankar and Dhankar 2002 [5].

To study the cause and effects of relationship the whole system of variables was represented in the form of path coefficient. The maximum positive direct effect on yield (Table 7 & Fig. 1) was due to number of fruits per plant (0.820) followed by average fruit weight (0.298) and average fruit length (0.040) while, other variable had negative direct effects. The maximum negative direct effect on yield was due to days to first flowering (-0.119) and plant height (-0.008). The maximum positive indirect effect for yield was due to average fruit length with number of fruits per pant (0.182) followed by plant height with number of fruits per plant (0.179). The maximum negative indirect effect on yield was due to days taken to 1st flowering with number of fruits per plant (-0.413). Similar trend were also found by Hazra and Basu 2000 [7] and Reddy *et al*. 2013 [12].

The cross VRO-6 × Arka Anamika exhibited highest positive heterobeltiosis (Table 8) for plant height (54.30%) and number of seeds/ pod (25.54%) however, Hisar Unnat × Arka Anamika (22.56%) represent highest positive heterobeltiosis for number of branches/ plant. The F_1 hybrid VRO-6 × Parbhani Kranti (-17.03%) exhibit highest negative heterobeltiosis for days taken to 1st flowering while, D-1-87-5 × Pusa A-4 and Arka Abhay × Parbhani Kranti is earliest better parent heterotic hybrids for days taken to 1st harvest (-8.22%). The hybrid Arka Abhay × Pusa A-4 represents highest heterobeltiosis for average fruit length (16.97%), number of fruits/ plant (65.51%) and average yield (87.18%) moreover; Varsa Uphar × Parbhani Kranti (19.92%) retained highest heterobeltiosis for average fruit weight. The hybrid Arka Abhay × Arka Anamika represent highest negative better and standard parent heterosis (-33.23%, -29.37%, respectively) that showed resistant response against this most severe viral disease of okra. Significant negative heterosis for this character in okra has been reported earlier by Adiger *et al*. 2013 [1], Kumar *et al*. 2013 [11]. Evidently manifestation of heterosis for yield and yield components may be due to non-additive gene effects in the parents. However, present study revealed manifestation and considerable amount of heterosis for yield per plant in okra and indicates large scope for heterosis breeding for further improvement in yield.

Considering the GCA effect of different characters (Table 8) it was found non-significant for all the genotypes except Akra Abhay for average yield (q/ ha). The results of SCA effect indicated that the crosses Ankur-40 × Parbhani Kranti (0.24) for plant height (m), Ankur-40 × Pusa A-4 (1.07m) for number of branches/ plant, Hisar Unnat × Pusa A-4 (-3.62) for days taken to 1st flowering, D-1-87-5 × Pusa A-4 (-1.73) for days taken to 1st harvest, Hisar Unnat × Arka Anamika (0.90) for average fruit length (cm), Indam- 9821 × Pusa A-4 (1.22) for average fruit weight (g), Hisar Unnat × Pusa A-4 (5.16) for number of fruits/ plant, Arka Abhay × Parbhani Kranti (9.02) number of seeds/ pod, VRO-6 × Arka Anamika (41.06) for average yield (q/ha) and VRO-6 × Pusa A-4 (-3.77) for per cent infestation of YVMV exhibited high value of SCA effect. The SCA effect of all the characters showed significant value except average fruit weight and per cent infestation of YVMV. This is in accordance with Khatik *et al.*, 2012 [10], Indu Rani and Veeraragavathatham, 2013 Kumar *et al*. 2013 [11]. These high SCA effects could therefore be useful to predict or identify heterotic responsive hybrids in okra.

The incidence to YVMV indicates (Fig. 2) that out of 24 F1 hybrids only ten hybrids have resistance response against YVMV in which Arka Abhay × Arka Anamika (PDI = 16.65%, CI = 4.16) followed by Ankur-40 × Parbhani Kranti (PDI = 20.45%, CI = 5.11) and Arka Abhay × Pusa A-4 (PDI = 20.91%, CI = 5.23) are most resistant hybrids. The resistant response of these hybrids is due to the presence of resistant gene from their parents. Similar findings were reported by Reddy *et al.*, 2012 [13] and Ali *et al*., 2012 [2].

Conclusion

The maximum net return and B: C ratio was obtained due to heterosis among various heterotic combinations. The cross Arka Abhay × Pusa A-4 incurred the highest net returns i.e. Rs.143113.00/ ha and B: C ratio (3.21) followed by that of D-1-87-5 × Parbhani Kranti (Rs. 136013.00/ ha, B: C ratio 3.05) and the parent Hisar Unnat gave the highest net return of Rs. 89929.00/ ha with B: C ratio of 2.02 among the parents.

In the present study based on per se performance, heterosis and SCA effects, the hybrids Arka Abhay × Pusa A-4, VRO-6 × Arka Anamika and VRO-6 × Pusa A-4 were found superior hybrids for yield and yield attributing traits. The three short listed hybrids may be tested for yield and other quality traits under different agro-climatic conditions for commercial exploitation of hybrid vigour.

Acknowledgements

Authors express their gratitude to Department of Horticulture (Vegetable & Floriculture), Bihar Agricultural University, Sabour for providing research facility and okra genotypes.

References

1. Adiger S, Shanthkumar G, Gangashetti PI and Salimath PM. Heterosis for fruit yield and its component traits in double cross derived inbred lines of okra [*Abelmoschus*

esculentus (L.) Moench]. Ind. J of Genet. 2013;73(1): 116-19.
2. Ali MI, Khan MA, Rashid A, Ehetisham-ul-haq M, Javed MT and Sajid M. Epidemiology of okra yellow vein mosaic virus (OYVMV) and Its Management through Tracer, Mycotal and Imidacloprid. Amr. J of Plant Sci. 2012;3:1741-45.
3. Anonymous. Indian Horticulture Database. National Horticulture Board, Ministry of Agriculture, Government of India; 2018; p.4-5.
4. Banerjee MK and Kalloo G. Sources and inheritance of resistance to leaf curl virus in *Lycopersicon spp*. Theor. and Appl. Genet. 1987;73:707-10.
5. Dhankar BS and Dhankar SK.Genetic variability, correlation and path analysis in okra (*Abelmoschus esculentus* (L.) Moench). Veg. Sci. 2002;29(1):63-8.
6. Dhankar BS and Mishra JP. Objectives of okra breeding (In) Hybrid Vegetable Development, IBDC, New Delhi; c2006; p.203.
7. Hazra P and Basu D. Genetic variability, correlation and path analysis in okra. Annals of Agril. Res. 2002;21(3):452-53.
8. Indu Rani C and Veeraragavathatham D. Heterosis for yield and yield components in okra. Ind. J of Hort. 2013;70(2):290-92.
9. Kempthorne O. An introduction to genetical statistics. Jhon weley and sons (Eds.), New York, 1957; pp 458-70.
10. Khatik, K.R., Chaudhary, R. and Khatik, C.L. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. Annals of Hort. 2012;5(2):213-18.
11. Kumar A, Baranwal DK, Aparna J, Srivastava K. Combining Ability and Heterosis for yield and its contributing characters in okra (*Abelmoschus esculantus* (L.) Moench). Madras Agril. J 2013;100(1-3):30-35.
12. Reddy MT, Babu KH, Ganesh M, Reddy KC, Begum H, Reddy RSK and Babu JD. Correlation and path coefficient analysis of quantitative characters in okra (*Abelmoschus esculentus* (L.) Moench). Songklanakarin J of Sci. and Tech. 2013;35(3):243-50.
13. Reddy MT, Haribabu K, Ganesh M, Reddy KC, Begum H, Reddy RSK and Babu JD. Genetic analysis for yield and its components in okra (*Abelmoschus esculentus* (L.) Moench). Songklanakarin J of Sci. and Tech. 2012;34(2):133-41.
14. Singh B, Kumar D, Singh KV and Chaudhary V. Heterobeltiosis and inbreeding depression in okra [*Abelmoschus esculentus* (L.) Moench]. Adv. in Plant Sci. 2009;22(1):273-5.
15. Solankey SS, Singh AK and Singh RK. heterosis of okra resistance sources for okra yellow vein mosaic virus in okra., Indian J of agricultural sciences. 2013;86(11):1460-5.
16. Tsegaye E, Dechassa N and Sastry D. Genetic variability for yield and other agronomic traits in sweet potato. J of Agron. 2007;6(1):94-99.