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RESEARCH ARTICLE

Evaluation of advanced breeding lines for yield and yield related components and resistance to okra yellow vein mosaic virus (OYVMV) disease in okra

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SUMMARY

Sixty four entries consisting of fifty seven inbred lines and seven checks (four hybrids and three commercial varieties) were evaluated for yield and yield related components and screened for reaction to okra yellow vein mosaic virus in three replications of Partial balanced lattice design (triple lattice) under unprotected conditions during summer 2011. High genotypic and phenotypic co-efficients of variation were noticed for disease incidence followed by number of primary branches per plant and fruit yield per hectare indicating maximum variability among the different genotypes. High estimates of heritability coupled with high genetic advance obtained for fruit yield per plant indicating presence of additive gene effects which indicated the effectiveness of selection for these traits. Presence of high heritability coupled with low genetic advance for average fruit weight, plant height and fruit diameter revealed that straight selection has limited scope for further improving these traits. The results exhibited that four lines were highly resistant to yellow vein mosaic virus, ten lines showed moderate resistant, 26 lines tolerant, 10 lines moderate susceptible, 6 susceptible and one highly susceptible. The highest yield per hectare was found in the DBh-25 (21.98 t/ha) followed by DBh-33 (19.9 t/ha) and DBh-7 (19.54 t/ha).

Key Words : Resistance, Tolerant, Okra yellow vein mosaic virus, Genetic advance, Heritability

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Okra [*Abelmoschus esculentus* (L.) Moench], originated in tropical Africa, is an important vegetable throughout the tropical and subtropical regions of the world. It is one of important vegetable crops in india and called lady's finger in England, gumbo in the United States of America, guino-gombo in Spanish, guibeiro in Portuguese and bhendi in India. Viruses pose serious constraints to its production. Yellow vein mosaic virus (YVMV) transmitted by white fly (*Bemisia tabaci* Gen.) is the most serious disease of okra. Infection of 100 per cent plants in a field is very usual and yield losses range from 50 to 94 per cent depending on the stage of crop growth at which infection occurs (Sastry and Singh, 1974). The disease can not be controlled properly by chemical means. Uprooting of infected plants is not practical and economical because of heavy infection rate in the field. The only practical solution of this problem is to develop tolerant varieties. Therefore, an extensive search for tolerance in cultivated okra was started by screening available germplasm. Studies were also undertaken to transfer genes for tolerance to YVM from related wild species to susceptible cultivated varieties (Jambhale and Nerkar, 1985).

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MATERIAL AND METHODS

Sixty four entries consisting of fifty seven inbred lines

and seven checks (four hybrids and three commercial varieties) were evaluated for yield and yield related components and screened for reaction to okra yellow vein mosaic virus in three replications of Partial balanced lattice design (triple lattice) under unprotected conditions during summer 2011. Row-to-row and plant-to-plant distances were maintained at 60 cm and 30 cm, respectively. Cultural practices were carried out as required to raise a good crop.

Observations were recorded on five competitive plants excluding border plants in each replication for days to 50 per cent flowering, plant height, number of branches, inter-nodal length, fruit length, fruit diameter, number of fruits per plant, fruit weight, fruit yield per plant and fruit yield per hectare and were used to calculate the mean values for each genotype/ replication. The mean values obtained were used for analysis of variance and to estimate genotypic and phenotypic co-efficient of variation and genetic advance as per cent of mean. The phenotypic and genotypic co-efficients of variation were estimated as per formula suggested by Burton and DeVane (1953). Heritability in broad sense and genetic advance were calculated by using formula given by Hanson *et al.* (1956) and Johnson *et al.* (1955).The number of plants showing okra yellow vein mosaic disease from 10 randomly chosen plants was counted. Counting was done early in the morning between 7 and 10 am. The disease on each test entry was assessed according to Prakasha *et al.* (2010), following disease rating scale by Ali *et al.* (2005a, b) presented in Table A.

Table A : Disease rating scale of OYVMV (Ali *et al.*, 2005a,b)

Rating scale	Type	Severity range (%)
0	Immune	0
1	Highly resistant	1-10
2	Moderate resistant	11-25
3	Tolerant	26-50
4	Moderate susceptible	51-60
5	Susceptible	61-70
6	Highly susceptible	71-100

Disease incidence of yellow vein mosaic virus was recorded 60 days after planting. The fruits were picked regularly and weighed separately for each plot. The data obtained with respect to disease incidence of yellow vein mosaic virus was recorded and yield components subjected to statistical analysis.

RESULTS AND DISCUSSION

The analysis of variance carried out for the fruit yield and its component characters is presented in Table 1. Variance due to genotypes was found highly significant for days to 50 per cent flowering, plant height, number of branches, inter-nodal length, fruit length, fruit diameter, number of fruits per plant, fruit weight, fruit yield per plant, fruit yield per hectare and disease incidence to yellow vein mosaic virus which indicated that the genotypes differ significantly for all the traits.

High range was observed for the traits *viz*., days to 50% flowering (43 to 52 days), plant height (60 to 121.7 cm), number of branches (3 to 6), inter-nodal length (5 to 8.8 cm), average fruit weight (17.7 to 28 g), fruit diameter (1.85 to 2.26 cm), fruit length (14.5 to 18.6 cm) and number of fruit per plant (20 to 43). Since the variation for number of branches per plant, fruit yield per plant, fruit yield per hectare, plant height and number of fruits per plant is found to be quite high which might be responsible for the wide range in yield potential of different genotypes. Wide range of variability observed for all characters studied. Thaker *et al.* (1981) and Vijay and Manohar (1990) reported wide range of variability for average fruit weight and number of fruits per plant in okra. The mean for fruit yield per plant and fruit yield per hectare varied from 182 g to 399.3g and from 10.02 T/ha to 21.98T/ ha, respectively. A lot of variability for fruit yield per plant and fruit yield per hectare indicates a great scope for selection of desirable types (Table 2).

The range of mean values could present a rough estimate about the variation of magnitude of divergence present among different genotypes. However, the estimates of genotypic and

Table 1 : Analysis of variance (ANOVA) for evaluation and screening of advanced breeding lines for okra yellow vein mosaic virus (OYVMV) disease of inbred lines in okra

Sources of variation	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Inter nodal length (cm)	Fruit length (cm)	Fruit diameter (cm)	Number of fruits per plant	Average fruit weight (g)	Fruit yield per plant (g)	Fruit yield per hectare (T/ha)	Disease Incidence (%)
Replications	3.583	242.599	10.744	0.843	0.430	0.080	12.036	4.519	198.146	10.975	549.296
Treatment (unadjusted)	11.934	628.574	1.931	1.306	2.026	0.210	79.91	14.083	7424.824	22.597	1552.723
Treatment (adjusted)	11.466**	564.814**	1.775**	1.071**	1.963**	0.21**	81.173**	14.064**	7410.153**	23.364**	1472.802**
Blocks within Reps (adj.)	4.300	404.662	1.079	1.398	0.632	0.017	127.052	1.253	395.761	19.781	1160.837
Intrablock error	1.059	55.145	0.333	0.292	0.212	0.013	31.249	0.867	240.959	6.286	311.855

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

Table 2 : Estimates of heritability, genetic advance and co-efficients of variation for important traits

Characters	Mean	Range	Genotypic variance (GV)	Phenotypic variance (PV)	Genotypic coefficient of variation (GCV %)	Phenotypic coefficient of variation (PCV %)	Heritability (h^2)	Genetic advance (GA)	Genetic advance over mean (GAM) %
Days to 50% flowering	46.82	43.0-52.0	3.57	5.06	4.04	4.80	0.71	3.27	6.99
Plant height (cm)	97.20	60.0-121.7	165.68	275.96	13.24	17.09	0.60	20.55	21.14
Number of branches per plant	4.15	3.0-6.0	0.60	1.13	18.64	25.63	0.53	1.16	27.93
Inter nodal length (cm)	6.76	5.0-8.8	0.32	0.76	8.35	12.90	0.42	0.75	11.13
Fruit length (cm)	15.89	14.5-18.6	0.56	0.82	4.70	5.70	0.68	1.27	7.99
Fruit diameter (cm)	2.04	1.85-2.26	0.07	0.08	4.21	4.50	0.87	0.52	8.11
Number of fruits per plant	31.67	20.0-43.0	13.68	59.56	11.68	24.37	0.23	3.65	11.53
Average fruit weight (g)	23.22	17.7-28.0	5.06	5.72	9.69	10.30	0.89	4.36	18.79
Fruit yield per plant (g)	271.85	18.0-399.3	2386.02	2652.78	17.97	18.95	0.90	95.43	35.10
Fruit yield per hectare (T/ha)	14.94	10.02-21.98	5.03	13.36	15.00	24.46	0.38	2.83	18.95
Disease incidence (%)	61.57	0.00-85.09	385.35	811.07	31.88	46.25	0.48	27.87	45.27

Table 3 : Performance of top 10 lines for fruit yield per hectare and their disease incidence and type of reaction in okra

Lines	Fruit yield per hectare	Disease incidence (%)	Type of reaction
DBh-25	21.98	84.26	HS
DBh-33	19.9	62.65	S
DBh-7	19.54	52.95	MS
DBh-10	19.06	39.38	T
Arka Abhay	19.02	56.21	MS
DBh-13	18.83	57.94	MS
Line1	18.68	21.14	MR
DBh-30	18.49	1.45	HR
DBh-9	18.22	65.91	S
DBh-12	18.14	44.84	T

phenotypic co-efficients are of greater use in determining the content of variability present within the material. The range of genotypic co-efficient of variation was 4.04% (days to 50 % flowering) to 31.88 % (disease incidence). Phenotypic co-efficient of variation (PCV) was highest for disease incidence (46.25%) and lowest for fruit diameter (4.5%). Moderate values of GCV and PCV were observed for number of branches per plant, fruit yield per plant, fruit yield per hectare, plant height and number of fruits per plant. Low values of GCV and PCV were recorded for days to 50 % flowering, inter-nodal length, fruit length, fruit diameter and average fruit weight. High genotypic and phenotypic co-efficients of variation was noticed for disease incidence indicating maximum variability among the genotypes selected for evaluation and thus this trait provides better chance of selection of desirable genotypes.

Heritability values were generally high for fruit yield per plant, average fruit weight and fruit diameter, low heritability for fruit yield per hectare and number of fruits per plant and moderate heritability for remaining characters studied. Highest heritability suggests that selection would be successful for these traits. The highest value of genetic advance as per cent of mean was obtained for disease incidence, fruit yield per plant, number of branches per plant and plant height. Low values for genetic advance as per cent of mean were observed for days to 50% flowering, fruit length and fruit diameter. The knowledge of the heritability along with genetic advance aids in drawing valuable conclusions for selection of breeding methods to be employed for further improvement of the traits. A broad sense heritability estimate provides information on relative magnitude of genetic and environmental variation in genotypes. High estimates of heritability coupled with high genetic advance observed for fruit yield per plant indicating presence of additive gene effects which further indicates the effectiveness of selection for these traits. Vashistha *et al.* (1982) also observed high heritability coupled with high genetic advance for fruit yield per plant and number of fruits per plant. Presence of high heritability coupled with low genetic advance for average fruit weight, plant height and fruit diameter may be attributed to the action of nonadditive gene effects including dominance and epistasis. Hence, straight selection has limited scope for improving these traits (Table 3).

Range of the disease incidence to yellow vein mosaic virus from 0% to 85.09% and grouped in to seven groups. Four lines *viz*., DBh-30 (1.45%), DBh-39 (8.25%), DBh-37 (9.96%) and DBh-47 (10.43%) showed highly resistant to yellow vein mosaic virus, ten lines showed moderate resistant, 26 lines were tolerant, 10 lines were moderate susceptible, 6 were susceptible and one was highly susceptible. None of the lines was immune. Commercial varieties like Arka Anamika (85.09%) and Arka abhay (56.21%) recorded highly susceptible and susceptible reactions. Batra and Singh (2000) screened eight okra varieties against OYVMV and found Okra No.6, LORM-1, VRO-3 and P-7 were free from disease whereas VRO-4 showed mild reaction. Ali *et al.* (2005b) reported Safal, Subz Pari and Surkh Bhindi varieties against OYVMV in a field trial (3.36-24.40%). Moreover, OYVMV resistance among different okra cultivars has also been

Table 4 : Mean performance of fifty seven inbred lines, four hybrids and three commercial varieties with respect to fruit yield and its attributing characters in okra

Lines/ hybrids/ popular varieties	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Inter-nodal length (cm)	Fruit length (cm)	Fruit diameter (cm)	Number of fruits per plant	Average fruit weight (g)	Fruit yield per plant	Fruit yield per hectare (T/ha)	Disease incidence (%)	Type of reaction
DBh-1	46.00	62.00	4.00	7.60	16.20	2.26	38.00	24.00	339.3	18.68	21.14	MR
DBh-2	44.00	81.70	5.00	8.00	14.90	2.13	38.00	22.70	297	17.70	38.64	T
DBh-3	47.00	71.00	4.00	8.00	15.00	2.17	31.00	25.30	258.3	14.77	51.18	MS
DBh-4	47.00	82.30	5.00	7.70	15.80	2.10	30.00	24.90	266.3	13.80	39.23	T
DBh-5	50.00	88.70	5.00	6.90	15.50	2.10	36.00	25.20	319	17.55	48.84	T
DBh-6	47.00	72.70	4.00	6.70	15.80	2.04	32.00	24.40	249.3	14.00	36.14	T
DBh-7	46.00	87.70	5.00	7.50	16.20	2.07	39.00	24.70	359.3	19.54	52.95	MS
DBh-8	46.00	94.00	5.00	8.80	15.80	2.04	30.00	21.90	213.7	11.76	41.62	T
DBh-9	46.00	65.70	5.00	7.10	17.30	2.01	39.00	22.90	348.3	18.22	65.91	S
DBh-10	47.00	84.30	6.00	7.50	17.10	2.01	38.00	24.90	361.3	19.06	39.38	T
DBh-11	49.00	60.00	3.00	6.20	18.50	2.04	35.00	24.90	324.7	17.86	51.38	MS
DBh-12	46.00	95.00	5.00	6.40	16.10	2.07	35.00	24.90	343	18.14	44.84	T
DBh-13	45.00	80.70	5.00	6.10	16.50	2.04	37.00	24.90	346.7	18.83	57.94	MS
DBh-14	48.00	110.00	5.00	7.10	15.10	2.01	33.00	23.80	294	16.21	49.9	T
DBh-15	45.00	87.70	5.00	7.10	15.80	1.97	32.00	19.60	237.7	13.00	33.7	T
DBh-16	47.00	98.50	5.00	7.40	15.30	1.85	42.00	17.70	258.3	15.19	66.29	S
DBh-17	47.00	103.00	6.00	6.40	16.20	1.91	37.00	22.40	310	17.05	66.41	S
DBh-18	48.00	103.00	5.00	6.30	14.90	1.88	27.00	19.30	228.3	12.50	57.08	MS
DBh-19	50.00	98.00	5.00	7.80	16.10	2.01	32.00	21.50	252.3	14.08	55.68	MS
DBh-20	52.00	113.70	5.00	7.40	15.20	1.94	39.00	19.50	291	15.55	60.4	MS
DBh-21	49.00	110.00	6.00	7.00	15.80	1.94	35.00	21.00	277.3	14.96	50.72	MS
DBh-22	48.00	106.70	6.00	6.90	15.90	1.91	31.00	21.00	257.7	13.41	52.96	MS
DBh-23	46.00	108.70	4.00	7.60	15.60	1.94	33.00	21.00	260.7	14.21	23.34	MR
DBh-24	47.00	111.70	4.00	7.40	15.20	1.97	31.00	20.80	248	13.32	32.04	T
DBh-25	52.00	88.30	4.00	7.70	14.90	2.20	43.00	25.10	399.3	21.98	84.26	HS
DBh-26	48.00	106.00	4.00	6.70	15.80	1.94	24.00	20.60	193	10.02	34.5	T
DBh-27	46.00	109.00	4.00	6.30	16.00	2.07	37.00	21.90	299	16.57	47.79	T
DBh-28	46.00	109.70	4.00	6.40	16.00	2.13	35.00	21.40	276.3	15.16	26.66	T
DBh-29	45.00	110.00	3.00	6.50	15.50	2.10	27.00	23.70	244.7	12.85	49.8	T
DBh-30	46.00	76.70	3.00	6.10	15.10	2.07	38.00	23.50	327.3	18.49	1.45	HR
DBh-31	48.00	110.70	4.00	6.60	15.30	2.04	34.00	24.70	308.3	17.59	27.8	T
DBh-32	46.00	98.00	4.00	6.40	15.70	2.01	26.00	21.80	215	11.83	22.7	MR
DBh-33	46.00	94.00	4.00	7.00	16.40	2.17	35.00	27.50	346.3	19.90	62.65	S
DBh-34	47.00	75.00	5.00	6.10	17.00	2.20	20.00	27.50	215	11.39	67.98	S
DBh-35	46.00	91.20	4.00	6.00	15.90	2.17	25.00	28.00	267.7	14.19	19.24	MR
DBh-36	46.00	100.00	3.00	6.70	15.40	2.13	28.00	23.90	249.3	13.74	26.65	T
DBh-37	48.00	110.30	3.00	6.30	15.90	2.13	27.00	24.40	243.3	13.73	9.96	HR
DBh-38	47.00	110.70	3.00	7.80	15.70	2.07	31.00	23.00	269.3	14.40	32.45	T
DBh-39	45.00	97.30	3.00	6.50	15.00	2.01	27.00	22.10	216.3	11.94	8.25	HR
DBh-40	46.00	112.70	3.00	6.40	15.30	1.97	27.00	22.60	233	12.85	30.29	T
DBh-41	45.00	100.30	4.00	6.70	15.60	1.94	25.00	20.50	182	10.33	29.36	T
DBh-42	47.00	93.00	4.00	6.80	15.60	1.94	34.00	20.80	262.7	14.70	36.49	T
DBh-43	46.00	114.30	4.00	6.70	16.70	2.13	26.00	25.90	251	13.89	14.75	MR
DBh-44	47.00	101.00	5.00	7.20	15.60	2.04	33.00	23.60	286.7	15.78	62.6	S

Table 4 contd...

Contd.... Table 4

DBh-45	46.00	100.30	3.00	6.90	15.10	1.97	28.00	21.40	221.3	12.21	18.29	MR
DBh-46	47.00	121.70	4.00	6.70	15.00	2.01	32.00	23.30	280	15.49	29.65	T
DBh-47	47.00	119.00	4.00	6.50	16.10	2.10	25.00	24.20	230.3	12.56	10.43	HR
DBh-48	48.00	108.30	4.00	6.90	16.20	2.13	25.00	26.80	248.7	13.70	44.19	T
DBh-49	52.00	103.00	4.00	7.10	16.30	2.07	26.00	25.00	244	13.43	29.54	T
DBh-50	49.00	101.70	4.00	6.70	16.70	1.94	30.00	22.80	263	13.89	41.43	T
DBh-51	46.00	115.00	4.00	6.50	14.50	2.04	29.00	21.00	228	12.26	19.94	MR
DBh-52	48.00	105.70	3.00	5.40	15.90	2.04	27.00	21.80	220	12.12	19.26	MR
DBh-53	49.00	119.70	4.00	6.90	16.00	2.04	26.00	21.80	203.7	11.45	36.81	T
DBh-54	48.00	105.00	4.00	6.00	15.50	2.04	34.00	22.60	286.7	15.76	15.95	MR
DBh-55	48.00	106.00	3.00	5.90	16.10	2.07	27.00	24.00	233.7	13.07	14.72	MR
DBh-56	52.00	99.30	4.00	6.30	16.30	2.04	25.00	23.80	217	11.96	55.78	MS
DBh-57	47.00	88.70	3.00	6.30	15.60	1.97	30.00	21.70	243.7	13.41	34.41	T
Syngenta 152	43.00	102.70	4.00	6.10	15.60	2.17	25.00	24.70	230.3	12.71	15.49	MR
Mahyco No. 55	43.00	78.30	3.00	6.40	14.50	1.97	34.00	23.20	293.3	16.20	0	I
JKOH-7315	43.00	85.30	3.00	5.00	17.10	2.13	32.00	27.00	326	17.92	0	I
Mahyco No. 64	43.00	95.00	4.00	6.90	16.20	2.04	24.00	22.00	195.7	10.78	0	I
Drwad local	45.00	92.70	4.00	6.10	17.70	1.97	42.00	23.90	374	20.58	61.82	S
Arka Abhay	45.00	98.30	4.00	6.30	18.60	2.07	37.00	26.60	345.3	19.02	56.21	MS
Arka Anamika	45.00	84.30	4.00	6.80	17.00	2.13	32.00	25.40	286.7	15.84	85.09	HS

I = immune, HR = highly resistant, MR = moderate resistant, T= tolerant, MS = moderate susceptible, S = susceptible, HS = highly susceptible

reported by other researchers such as Arora *et al.* (1992) who evaluated 157 advanced germplasm and 7 cultivars/hybrids of okra for two years and observed that Punjab Padmini and EMS-8 were free from the OYVMV. Sharma *et al.* (1993) also reported that Punjab Padmini and Punjab-7 varieties of okra were high yielding and resistant to OYVMV. Four lines *viz*., DBh-30 (1.45%), DBh-39 (8.25%), DBh-37 (9.96%) and DBh-47 (10.43%) showed highly resistant to yellow vein mosaic virus (Table 5). The highest yield per hectare was found in the DBh-25 (21.98 t/ha) followed by DBh-33 (19.9 t/ha) and DBh-7 (19.54 t/ha) (Table 4).

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