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Screening of okra genotypes across environments for resistance against shoot and fruit borer, yellow vein mosaic virus and enation leaf curl virus under natural field conditions

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Abstract
Cultivation of okra in India is seriously affected by Okra Shoot and Fruit Borer, YVMV and also ELCV. Hence, constant research is in progress to identify stable resistance sources against these pest and diseases. Screening of available genetic resources and incorporating the resistant genotypes in the crop improvement programme serves as a potential method in breeding resistant varieties/hybrids. Therefore, in the present study sowing of 36 genotypes of okra comprising 8 lines, 3 testers, their 24 hybrids and one commercial check GJOH-4 was carried out under three different environments to evaluate against OFSB infestation, infection of YVMV and ELCV under natural condition at Regional Horticultural Research Station, NAU, Navsari. None of the hybrids gave immune/resistant reaction for okra shoot and fruit borer, YVMV and ELCV in all environments. Hence, parents and hybrids showing moderately resistant or tolerance reaction can be used in further breeding programmes to develop varieties/hybrids resistant or tolerant to shoot and fruit borer, YVMV, ELCV along with good agronomic traits.

Keywords: ELCV, okra shoot and fruit borer, resistance, tolerance, YVMV

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) belongs to family Malvaceae and it has a prominent position in vegetables due to its wide adaptability, wide popularity, year round export potential and high nutritive value. It is grown extensively in tropical, subtropical and warm temperate regions for its green tender fruits. The chromosome number (2n) of okra varies from 56 to 199 (Siemonsma, 1982) [1]. Okra is a polyploid with most common observed chromosome number of 2n = 8x = 130 (Choudhury and Choomsai, 1970 and Shalaby, 1972) [3, 2] and it is an often cross pollinated crop and occurrence of out crossing to an extent of 4 to 19% with the maximum of 42.2% is noticed with the insect assisted pollination (Kumar, 2006) [4]. Being popular in the ethnic markets, India stands first in okra production with an area accounting for about 72% of the total area under okra at global level. Although, India is one of the largest producers and consumers of okra in the world, the average productivity of okra is very low and almost stagnant over the last few decades. The successful cultivation of okra is often hampered by an array of nearly 72 insect pests, of which shoot and fruit borer, *Earias vitella;* whitefly, *Bemisia tabaci*; aphid, *Aphis gossypii* and leafhopper, *Amrasca biguttula biguttula* are important (Dikshit *et al.*, 2001) [5]. Yellow Vein Mosaic Virus (YVMV) is a devastating viral disease transmitted through white fly (*Bemisia tabaci*) in okra (Ali *et al.*, 2000, Ghanem 2003, Fajinmi and Fajinmi 2010) [6, 8, 7]. YVMV belongs to the genus Begomovirus, family Geminiviridae. This viral disease causes colossal losses in the crop by affecting the quality and yield of the fruits.

In India, the occurrence of YVMV disease was first reported by Kulkarni (1924) in Bombay province. It has been reported that when plants infected at 20, 35 and 50 days after germination the losses seen upto an extent of 98, 83 and 49 per cent, respectively (Sastry and Singh, 1974) [10]. The host range is limited to Malvaceae family and the vector of YVMV is the female whitefly. The disease is characterized by a homogenous knotted, yellow veins and yellowish or creamy color of green leaf, stunted plant growth and bear very few deformed small fruits (Ali *et al.*, 2005) [11]. The identification of stable resistance sources is a continuous process to fight with this devastating menace.

Among the pests, Shoot and Fruit Borer (*Earias vittella*) is the most serious pest which causes direct damage to tender shoots and fruits. It is reported that about 69% losses occurred in marketable yield due to attack of this insect pest (Rawat and Sahu, 1973) [12]. The larvae damage to the crop in two ways. Firstly larvae bore into growing shoots and move down by making tunnels inside. As a result, the shoots droop downward or dry up (Atwal and Singh, 1990) [13]. Secondly, the larvae enter the fruits by making holes, rendering them unfit for human consumption.

Currently, productivity of cultivated okra is gradually decreasing in the tropics due to infection by the begomovirus, enation leaf curl virus (ELCV) which have other hosts also grown in the regions (Venkataravanappa *et al*., 2015) [14] ELCV was first reported from Indian Institute of Horticultural Research, Hesarghatta, Bengaluru (Karnataka) by Singh and Dutta (1986) [15]. ELCV disease causes yield loss between 80 per cent and 90 per cent (Singh, 1996) [16] and is widely emerging as an important threat to production and there is a need to evolve resistance against the causal virus (Yadav *et al*., 2018). The important symptoms of this disease are curling of leaves in adaxial direction and mild or bold enations on the under surface of the leaves which become thick and deformed. The other characteristic symptoms are twisting of the main stem, lateral branches and leaf petiole. In case of heavy infection, the plant growth is retarded. Fruits from infected plants are small and deformed and unfit for marketing.

Frequent pickings, high operational cost and residues of pesticides entering food chain are the limiting factors for chemical control of this disease. Use of synthetic pesticides for managing pests and diseases is the immediate and most practiced method by the farmers but, okra being a vegetable with shorter harvesting intervals, poses residual hazards to the consumers. Therefore, emphasis is now been shifted in favour of host plant resistance, particularly insect and disease resistant/tolerant varieties are more economical and environmentally safe (Sanford and John, 1994) [17]. Hence, development of high yielding and tolerant/resistant varieties is the major necessity. Interspecific and intervarietal hybridization followed by selection have been adopted to develop high yielding and resistant varieties. However, frequent breakdown of resistance of most of the resistant varieties is a matter of concern and this needs continuous attention of the breeders.

The information on previous disease and insect screening results over the years may assist us in understanding the status and development of disease or insects over the years and also different methods employed in screening the genotypes. Screening genetic biodiversity of okra for identification of resistant genotypes and employing them in the crop improvement programme is an important step of disease resistance breeding. Therefore, there is an urgent need to develop okra hybrids which show resistance/ tolerance against these biotic stresses. Thus, in the present study, 36 genotypes of okra comprising 8 lines, 3 testers, their 24 hybrids and one commercial check GJOH-4 was carried out under three different environments to evaluate against OFSB infestation, infection of YVMV and ELCV under natural condition.

Materials and Methods

The experimental material was developed at Regional Horticultural Research Station, NAU, Navsari during Kharif 2020 by crossing 11 diverse parents (8 lines and 3 testers) using L × T mating design. The evaluation programme was carried out under three consecutive environments *viz*., sowing in 1st March, 2021 (E_1), 15th March, 2021 (E_2) and 1st April, 2021 (E_3) during summer 2021 (evaluation). The experiment was conducted in Randomized Block Design (RBD) with three replications which included 36 genotypes comprising of 8 lines (AOL-10-22, AOL-12-59, JOL-13-05, JOL-9-05, NOL-18-10, NOL-17-6, NOL-19-1, NOL-19-3); 3 testers (Arka Anamika, Arka Abhay, Kashi Kranti); their resultant 24 hybrids and one standard check 'GJOH-4'.

For shoot borer, the number of plants infected from the total plant in each genotype were counted and expressed in percentage after 45 days of sowing by using the following formula:

$$\text{Shoot borer infestation}(\%) = \frac{\text{Number of plants infected by shoot borer}}{\text{Total number of plants observed}} \times 100$$

For fruit borer, total number of fruits infected with borer from randomly selected plants in each genotype was counted in each picking and expressed in percentage by using the following formula:

$$\text{Fruit borer infestation}(\%) = \frac{\text{Number of pods infected by fruit borer}}{\text{Total number of pods observed}} \times 100$$

For YVMV, it was calculated on the basis of number of plants infected with YVMV from total number of plants in parents, hybrids and standard check and percentage of incidence was calculated.

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

For ELCV, number of plants affected in each plot were counted and expressed in percentage by using the following formula:

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

Results and Discussion

The results obtained by screening of 40 genotypes on the basis of per cent pest infestation under field condition for shoot borer and fruit borer incidence is mentioned in Table 4 and 5, respectively. Among the parents, intensity of shoot borer incidence ranged between 13.33 (NOL-18-1, NOL-18-4 and Kashi Kranti) to 23.33 per cent (NOL-18-3 and NOL-18-5) in E_1, 10.00 (NOL-18-3) to 23.33 per cent (Kashi Kranti) in E_2, 20.00 (NOL-18-3, NOL-18-4, NOL-19-3 and Kashi Kranti) to 30.00 per cent (NOL-18-5) in E_3 and among hybrids, it varied between 10.00 (NOL-17-6 × Arka Anamika) to 26.67 per cent (NOL-19-3 × Kashi Kranti, NOL-19-3 × Arka Anamika and NOL-17-6 × Kashi Kranti in E_1, 13.33 (JOL-9-05 × Kashi Kranti) to 26.67 per cent (NOL-19-3 × Arka Anamika) in E_2, 10.00 (AOL-12-59 × Arka Anamika and NOL-19-3 × Arka Anamika) to 30.00 per cent (AOL-10-22 × Arka Abhay,) in E_3.

Among the parents, intensity of fruit borer incidence ranged between 7.05 (Arka Abhay) to 10.52 per cent (NOL-18-7) in E_1, 4.35 (NOL-18-5) to 11.53 per cent (NOL-18-7) in E_2, 1.87 (Kashi Kranti) to 6.52 per cent (NOL-18-3) in E_3 and among hybrids, it varied between 2.96 (NOL-18-10 × Kashi Kranti to 21.47 per cent (NOL-18-1 × GO-6) in E_1, 9.57 (NOL-18-5 × GAO-5) to 16.54 per cent (NOL-19-3 × Kashi Kranti) in E_2, 1.75 (NOL-17-6 × Arka Anamika) to 14.53 per cent (NOL-19-3 × Arka Abhay, JOL-13-05 × Arka Abhay and JOL-9-05 × Arka Anamika) in E_3.

Out of the 36 genotypes, none of the genotypes were free from shoot and fruit borer incidence. Among parents, NOL-18-3, NOL-19-3 and Arka Abhay for shoot borer when NOL-18-1, Arka Anamika and Kashi Kranti for fruit borer were found to perform better. Among 24 hybrids, one each in E_1 (NOL-17-6 × Arka Anamika) and E_3 (AOL-12-59 × Arka Anamika) exhibited highly resistant reaction against shoot borer, 14 in E_1, seven in E_2 and 22 in E_3 exhibited highly resistant reaction against fruit borer. However, many hybrids showed lesser damage (in per cent) against okra shoot and fruit borer. Lesser incidence of okra shoot and fruit borer was also observed in okra by Afzal *et al.*(2015) [18], Dave and Pandya (2017) [19], Mouli and Tayde (2017) [20], Jalgaonkar *et al.* (2018) [21], Kumar and Tayde (2018b) [22], Subbireddy *et al.* (2018) [23], Raghuwanshi *et al.* (2019) [24], Vekariya (2019) [34], Patel (2020) and Jayanth (2021) [26].

The results obtained by screening of 40 genotypes on the basis of per cent disease incidence under field condition for YVMV and ELCV is mentioned in Table 6 and 7, respectively. Among the parents, YVMV intensity varied between 13.33 (NOL-18-7, NOL-19-3 and Arka Abhay) to 30.00 per cent (NOL-18-5 and NOL-18-6) in E_1, 10.00 (NOL-18-3 and Arka Abhay) to 26.67 per cent (NOL-18-7) in E_2, 10.00 (NOL-18-3, NOL-18-4 and Arka Abhay) to 30.00 per cent (NOL-18-6) in E_3. Among hybrids, it ranged from 3.33 (NOL-19-1 × Kashi Kranti) to 36.67 per cent (AOL-10-22 × Kashi Kranti) in E_1, 10.00 (JOL-9-05 × Arka Anamika and NOL-19-3 × Kashi Kranti) to 36.67 per cent (NOL-17-6 × Kashi Kranti) in E_2, 10.00 (JOL-13-05 × Arka Abhay, JOL-13-05 × Kashi Kranti, NOL-19-1 × Kashi Kranti and NOL-19-3 × Kashi Kranti) to 33.33 per cent (AOL-10-22 × Arka Anamika) in E_3.

Among the parents, ELCV intensity varied between 10.00 (Arka Abhay) to 20.00 per cent (NOL-18-3 and NOL-18-6) in E_1, 3.33 (NOL-19-3) to 20.00 per cent (NOL-18-2 and Kashi Kranti) in E_2, 6.67 (Arka Anamika and Kashi Kranti) to 30.00 per cent (NOL-18L7 and Arka Abhay) in E_3 whenever in hybrids, it ranged from 3.33 (JOL-13-05 × Arka Anamika, NOL-17-6 × Arka Anamika) to 23.33 per cent (NOL-19-3 × Arka Anamika) in E_1, 3.33 (AOL-10-22 × Kashi Kranti, JOL-9-05 × Kashi Kranti, NOL-18-10 × Arka Anamika and NOL-19-1 × Arka Abhay) to 23.33 per cent (AOL-10-22 × Arka Anamika and AOL-10-22 × Arka Abhay) in E_2, 3.33 (AOL-10-22 × Arka Abhay, AOL-10-22 × Kashi Kranti, NOL-17-6 × Arka Anamika and NOL-18-10 × Kashi Kranti) to 30.00 per cent (NOL-19-3 × Arka Anamika) in E_3.

Out of the 36 genotypes, none of the genotypes were free from YVMV and ELCV. Among parents, NOL-18-3, NOL-18-4 and Arka Abhay for YVMV and NOL-18-1, NOL-19-3 and Arka Anamika for ELCV (Highly tolerant) were found to perform better. Among 24 hybrids, six in E_1 (JOL-9-05 × Arka Abhay, JOL-9-05 × Kashi Kranti, NOL-18-10 × Arka Abhay, NOL-19-1 × Arka Abhay, NOL-19-1 × Arka Abhay, NOL-19-1 × Kashi Kranti, NOL-19-3 × Kashi Kranti) and two in E_2 JOL-9-05 × Arka Anamika, NOL-19-3 × Kashi Kranti) and four (JOL-13-05 × Arka Abhay, JOL-13-05 × Kashi Kranti, NOL-19-1 × Kashi Kranti, NOL-19-3 × Kashi Kranti) in E_3 registered highly tolerant reaction against YVMV and 23 in E_1 (except NOL-19-3 × Arka Anamika), 22 in both E_2 (except AOL-10-22 × Arka Anamika, AOL-10-22 × Arka Abhay and E_3 (except NOL-19-3 × Arka Anamika, AOL-10-22 × Arka Anamika) showed highly tolerant reaction against ELCV. In the present investigation, many hybrids showed lesser damage in per cent against YVMV. Lesser incidence of YVMV was also observed in okra by Kumar and Reddy (2015) [27], Patel (2015) [30], More (2015) [31], Kumar and Tayde (2018a) [32], Rynjah *et al.* (2018) [33], Vekariya (2019) [34], Das *et al.* (2020) [35] and Joshi *et al.* (2020) [36]. Also, many hybrids showed lesser damage in per cent against ELCV. Lesser incidence of ELCV was also observed in okra by Patel (2015) [30], More (2015) [31], Vekariya (2019) [34], Jamil *et al.* (2020) [38], Joshi *et al.* (2020) [36], Nagendra (2020) [37] and Jayanth (2021) [26].

Table 1: Scale for shoot and fruit borer resistance (Rai and Satpathy, 1998) [39].

Grade	Fruit infestation	Category
1	0	Immune (I)
2	0.1- 10	Highly resistant (HR)
3	10.1-20	Fairly resistant (FR)
4	20.1-30	Tolerant (T)
5	30.1-40	Susceptible (S)
6	40.1 and above	Highly susceptible (HS)

Table 2: Scale for yellow vein mosaic virus resistance (Ali *et al.*, 2005) [11].

Sr. No.	Rating Scale	Severity Range (%)
1	Immune	0
2	Highly resistant	1 - 10
3	Moderately resistant	11 - 25
4	Tolerant	26 - 50
5	Moderately susceptible	51 - 60
6	Susceptible	61 - 70
7	Highly susceptible	71 - 100

Table 3: Disease rating scale of ELCV disease (Nazeer *et al*., 2014) [40]

Disease Index (%)	Severity Grade	Symptoms	Remarks
0	0	No symptoms	Resistant
1-20	1	Thickening of only secondary and tertiary veins	Highly tolerant
21-30	2	Thickening of only secondary and primary (midrib) veins	Tolerant
31-50	3	Vein thickening, leaf curling or enation or both	Susceptible
>50	4	Stunting along with vein thickening, leaf curling or enation	Highly susceptible

Table 4: Field evaluation of 36 genotypes of okra for shoot borer infestation and reaction in individual environment

Sr. No.	Genotypes	Shoot borer infestation (%)			Shoot borer reaction		
		E_1	E_2	E_3	E_1	E_2	E_3
Parents							
Females (Lines)							
1	NOL-18-1	23.33	16.67	23.33	T	FR	T
2	NOL-18-2	16.67	20.00	23.33	FR	FR	T
3	NOL-18-3	13.33	10.00	20.00	FR	HR	FR
4	NOL-18-4	23.33	20.00	20.00	T	FR	FR
5	NOL-18-5	13.33	20.00	30.00	FR	FR	T
6	NOL-18-6	16.67	16.67	23.33	FR	FR	T
7	NOL-18-7	16.67	20.00	26.67	FR	FR	T
8	NOL-19-3	20.00	20.00	20.00	FR	FR	FR
Males (Testers)							
9	Arka Anamika	20.00	20.00	26.67	FR	FR	T
10	Arka Abhay	16.67	16.67	16.67	FR	FR	FR
11	Kashi Kranti	13.33	23.33	20.00	FR	T	FR
Hybrids							
12	AOL-10-22 × Arka Anamika	23.33	20.00	23.33	T	FR	T
13	AOL-10-22 × Arka Abhay	16.67	16.67	30.00	FR	FR	T
14	AOL-10-22 × Kashi Kranti	23.33	20.00	26.67	T	FR	T
15	AOL-12-59 × Arka Anamika	16.67	16.67	10.00	FR	FR	HR
16	AOL-12-59 × Arka Abhay	13.33	16.67	20.00	FR	FR	FR
17	AOL-12-59 × Kashi Kranti	20.00	16.67	23.33	FR	FR	T
18	JOL-13-05 × Arka Anamika	16.67	20.00	20.00	FR	FR	FR
19	JOL-13-05 × Arka Abhay	16.67	20.00	30.00	FR	FR	T
20	JOL-13-05 × Kashi Kranti	23.33	20.00	20.00	T	FR	FR
21	JOL-9-05 × Arka Anamika	16.67	20.00	30.00	FR	FR	T
22	JOL-9-05 × Arka Abhay	20.00	20.00	20.00	FR	FR	FR
23	JOL-9-05 × Kashi Kranti	20.00	13.33	26.67	FR	FR	T
24	NOL-18-10 × Arka Anamika	20.00	20.00	23.33	FR	FR	T
25	NOL-18-10 × Arka Abhay	16.67	23.33	26.67	FR	T	T
26	NOL-18-10 × Kashi Kranti	13.33	16.67	20.00	FR	FR	FR
27	NOL-17-6 × Arka Anamika	10.00	20.00	20.00	HR	FR	FR
28	NOL-17-6 × Arka Abhay	16.67	23.33	16.67	FR	T	FR
29	NOL-17-6 × Kashi Kranti	26.67	20.00	26.67	FR	FR	T
30	NOL-19-1 × Arka Anamika	20.00	23.33	26.67	FR	T	T
31	NOL-19-1 × Arka Abhay	23.33	23.33	20.00	T	T	FR
32	NOL-19-1 × Kashi Kranti	20.00	16.67	26.67	FR	FR	T
33	NOL-19-3 × Arka Anamika	26.67	26.67	16.67	T	T	FR
34	NOL-19-3 × Arka Abhay	16.67	23.33	20.00	FR	T	FR
35	NOL-19-3 × Kashi Kranti	26.67	23.33	26.67	T	T	T
36.	GJOH-4 (Standard check)	16.67	13.33	16.67	FR	FR	FR

HR: Highly resistant, FR: Fairly resistant, T: Tolerant

Table 5: Field evaluation of 36 genotypes of okra for fruit borer infestation and reaction in individual environment

Sr. No.	Genotypes	Fruit borer infestation (%)			Fruit borer reaction		
		E_1	E_2	E_3	E_1	E_2	E_3
Parents							
Females (lines)							
1	NOL-18-1	10.18	9.95	3.18	FR	HR	HR
2	NOL-18-2	7.72	8.47	4.50	HR	HR	HR
3	NOL-18-3	9.31	10.57	6.52	HR	FR	HR
4	NOL-18-4	8.91	7.21	5.04	HR	HR	HR
5	NOL-18-5	8.79	4.35	3.45	HR	HR	HR
6	NOL-18-6	10.28	9.31	3.88	FR	HR	HR
7	NOL-18-7	10.52	11.53	5.07	FR	FR	HR

8	NOL-19-3	8.47	10.36	4.26	HR	FR	HR
Males (testers)							
9	Arka Anamika	7.19	6.37	2.76	HR	HR	HR
10	Arka Abhay	7.05	11.21	5.77	HR	FR	HR
11	Kashi Kranti	8.05	10.35	1.87	HR	FR	HR
Hybrids							
12	AOL-10-22 × Arka Anamika	10.39	14.69	5.22	FR	FR	HR
13	AOL-10-22 × Arka Abhay	10.80	14.06	3.09	FR	FR	HR
14	AOL-10-22 × Kashi Kranti	8.91	11.40	5.57	HR	FR	HR
15	AOL-12-59 × Arka Anamika	4.89	7.27	3.81	HR	HR	HR
16	AOL-12-59 × Arka Abhay	12.68	12.29	4.40	FR	FR	HR
17	AOL-12-59 × Kashi Kranti	4.38	7.71	2.94	HR	HR	HR
18	JOL-13-05 × Arka Anamika	7.53	9.66	1.99	HR	HR	HR
19	JOL-13-05 × Arka Abhay	13.22	22.29	11.01	FR	T	FR
20	JOL-13-05 × Kashi Kranti	13.92	13.84	5.42	FR	FR	HR
21	JOL-9-05 × Arka Anamika	9.50	17.03	5.33	HR	FR	HR
22	JOL-9-05 × Arka Abhay	10.67	17.94	3.68	FR	FR	HR
23	JOL-9-05 × Kashi Kranti	5.19	11.25	8.67	HR	FR	HR
24	NOL-18-10 × Arka Anamika	4.65	5.79	3.66	HR	HR	HR
25	NOL-18-10 × Arka Abhay	8.05	9.20	6.73	HR	HR	HR
26	NOL-18-10 × Kashi Kranti	2.96	3.93	2.32	HR	HR	HR
27	NOL-17-6 × Arka Anamika	3.15	6.68	1.75	HR	HR	HR
28	NOL-17-6 × Arka Abhay	4.77	11.87	8.10	HR	FR	HR
29	NOL-17-6 × Kashi Kranti	8.77	12.26	9.08	HR	FR	HR
30	NOL-19-1 × Arka Anamika	9.91	11.48	3.32	HR	FR	HR
31	NOL-19-1 × Arka Abhay	8.73	10.24	6.73	HR	FR	HR
32	NOL-19-1 × Kashi Kranti	14.00	11.53	2.09	FR	FR	HR
33	NOL-19-3 × Arka Anamika	15.05	19.98	5.94	FR	FR	HR
34	NOL-19-3 × Arka Abhay	15.26	18.01	14.53	FR	FR	FR
35	NOL-19-3 × Kashi Kranti	16.54	18.36	8.02	FR	FR	HR
36.	GJOH-4 (Standard check)	8.64	12.41	3.61	HR	FR	HR

HR: Highly resistant, FR: Fairly resistant, T: Tolerant

Table 6: Field evaluation of 36 genotypes of okra for YVMV disease incidence and reaction in individual environment

Sr. No.	Genotypes	YVMV infection			Disease reaction		
		E_1	E_2	E_3	E_1	E_2	E_3
Parents							
Females (lines)							
1	NOL-18-1	20.00	23.33	23.33	MR	MR	MR
2	NOL-18-2	23.33	20.00	16.67	MR	MR	MR
3	NOL-18-3	20.00	10.00	10.00	MR	HR	HR
4	NOL-18-4	16.67	16.67	10.00	MR	MR	HR
5	NOL-18-5	30.00	16.67	16.67	T	MR	MR
6	NOL-18-6	30.00	20.00	30.00	T	MR	T
7	NOL-18-7	13.33	26.67	26.67	MR	T	T
8	NOL-19-3	13.33	23.33	13.33	MR	MR	MR
Males (testers)							
9	Arka Anamika	26.67	16.67	16.67	MR	MR	MR
10	Arka Abhay	13.33	10.00	10.00	MR	HR	HR
11	Kashi Kranti	23.33	23.33	16.67	MR	MR	MR
Hybrids							
12	AOL-10-22 × Arka Anamika	30.00	33.33	33.33	T	T	T
13	AOL-10-22 × Arka Abhay	26.67	23.33	23.33	T	MR	MR
14	AOL-10-22 × Kashi Kranti	36.67	20.00	26.67	T	MR	T
15	AOL-12-59 × Arka Anamika	26.67	26.67	36.67	T	T	T
16	AOL-12-59 × Arka Abhay	13.33	20.00	26.67	MR	MR	T
17	AOL-12-59 × Kashi Kranti	13.33	13.33	20.00	MR	MR	MR
18	JOL-13-05 × Arka Anamika	16.67	23.33	20.00	MR	MR	MR
19	JOL-13-05 × Arka Abhay	13.33	20.00	10.00	MR	MR	HR
20	JOL-13-05 × Kashi Kranti	33.33	13.33	10.00	T	MR	HR
21	JOL-9-05 × Arka Anamika	16.67	10.00	16.67	MR	HR	MR
22	JOL-9-05 × Arka Abhay	6.67	26.67	23.33	HR	T	MR
23	JOL-9-05 × Kashi Kranti	10.00	20.00	20.00	HR	MR	MR
24	NOL-18-10 × Arka Anamika	13.33	23.33	16.67	MR	MR	MR
25	NOL-18-10 × Arka Abhay	16.67	50.00	30.00	HR	T	T
26	NOL-18-10 × Kashi Kranti	10.00	13.33	13.33	MR	MR	MR

27	NOL-17-6 × Arka Anamika	13.33	23.33	16.67	MR	MR	MR
28	NOL-17-6 × Arka Abhay	13.33	20.00	13.33	MR	MR	MR
29	NOL-17-6 × Kashi Kranti	13.33	36.67	30.00	MR	T	T
30	NOL-19-1 × Arka Anamika	13.33	23.33	20.00	MR	MR	MR
31	NOL-19-1 × Arka Abhay	6.67	16.67	16.67	HR	MR	MR
32	NOL-19-1 × Kashi Kranti	3.33	16.67	10.00	HR	MR	HR
33	NOL-19-3 × Arka Anamika	23.33	33.33	30.00	MR	T	T
34	NOL-19-3 × Arka Abhay	23.33	20.00	20.00	MR	MR	MR
35	NOL-19-3 × Kashi Kranti	26.67	10.00	10.00	HR	HR	HR
36.	GJOH-4 (Standard check)	20.00	26.67	20.00	MR	HR	MR

HT: Highly tolerant, MR: Moderately tolerant, T: Tolerant

Table 7: Field evaluation of 36 genotypes of okra for ELCV disease incidence and reaction in individual environment

Sr. No.	Genotypes	ELCV infection			Disease reaction		
		E_1	E_2	E_3	E_1	E_2	E_3
Parents							
Females (lines)							
1	NOL-18-1	13.33	10.00	20.00	HT	HT	HT
2	NOL-18-2	23.33	20.00	23.33	T	HT	T
3	NOL-18-3	20.00	13.33	13.33	HT	HT	HT
4	NOL-18-4	16.67	13.33	10.00	HT	HT	HT
5	NOL-18-5	13.33	20.00	16.67	HT	HT	HT
6	NOL-18-6	20.00	16.67	10.00	HT	HT	HT
7	NOL-18-7	13.33	6.67	30.00	HT	HT	T
8	NOL-19-3	13.33	3.33	13.33	HT	HT	HT
Males (testers)							
9	Arka Anamika	20.00	13.33	6.67	HT	HT	HT
10	Arka Abhay	10.00	16.67	30.00	HT	HT	T
11	Kashi Kranti	23.33	20.00	6.67	T	HT	HT
Hybrids							
12	AOL-10-22 × Arka Anamika	13.33	23.33	26.67	HT	T	T
13	AOL-10-22 × Arka Abhay	13.33	23.33	3.33	HT	T	HT
14	AOL-10-22 × Kashi Kranti	6.67	3.33	3.33	HT	HT	HT
15	AOL-12-59 × Arka Anamika	20.00	10.00	16.67	HT	HT	HT
16	AOL-12-59 × Arka Abhay	10.00	10.00	10.00	HT	HT	HT
17	AOL-12-59 × Kashi Kranti	6.67	6.67	6.67	HT	HT	HT
18	JOL-13-05 × Arka Anamika	3.33	16.67	20.00	HT	HT	HT
19	JOL-13-05 × Arka Abhay	16.67	6.67	13.33	HT	HT	HT
20	JOL-13-05 × Kashi Kranti	6.67	13.33	16.67	HT	HT	HT
21	JOL-9-05 × Arka Anamika	13.33	10.00	13.33	HT	HT	HT
22	JOL-9-05 × Arka Abhay	13.33	10.00	13.33	HT	HT	HT
23	JOL-9-05 × Kashi Kranti	13.33	3.33	6.67	HT	HT	HT
24	NOL-18-10 × Arka Anamika	10.00	3.33	10.00	HT	HT	HT
25	NOL-18-10 × Arka Abhay	13.33	16.67	10.00	HT	HT	HT
26	NOL-18-10 × Kashi Kranti	10.00	16.67	3.33	HT	HT	HT
27	NOL-17-6 × Arka Anamika	3.33	10.00	3.33	HT	HT	HT
28	NOL-17-6 × Arka Abhay	13.33	16.67	16.67	HT	HT	HT
29	NOL-17-6 × Kashi Kranti	10.00	10.00	6.67	HT	HT	HT
30	NOL-19-1 × Arka Anamika	10.00	6.67	6.67	HT	HT	HT
31	NOL-19-1 × Arka Abhay	6.67	3.33	13.33	HT	HT	HT
32	NOL-19-1 × Kashi Kranti	6.67	6.67	13.33	HT	HT	HT
33	NOL-19-3 × Arka Anamika	23.33	13.33	30.00	T	HT	T
34	NOL-19-3 × Arka Abhay	20.00	20.00	20.00	HT	HT	HT
35	NOL-19-3 × Kashi Kranti	16.67	13.33	13.33	HT	HT	HT
36.	GJOH-4 (Standard check)	20.00	13.33	16.67	HT	HT	HT

HT: Highly tolerant T: Tolerant

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