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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

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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 40 genotypes of okra comprising 7 lines, 4 testers, their 28 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 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) 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. It is a powerhouse of variable nutrients which has captured a prominent position among vegetables and commonly known as *bhindi* or lady's finger in India. It is a member of Malvaceae family having somatic chromosome number of $2n=130$. 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. Okra cultivation in India is seriously hampered mainly due to Yellow Vein Mosaic Virus (YVMV) and Okra Shoot and Fruit Borer. The loss in marketable yield has been estimated at 50-94 per cent, depending upon the stage of crop growth at which the infection occurs. 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) ^[1]. 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) ^[2]. Secondly, the larvae enter the fruits by making holes, rendering them unfit for human consumption.

Yellow vein mosaic virus (YVMV) is the most serious disease of okra in India causing considerable losses in yield and reducing quality of fruits. It was first reported by Kulkarni (1924) ^[3] in the then Bombay presidency. 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) ^[4]. The identification of stable resistance sources is a continuous process to fight with this devastating menace.

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) ^[5].

ELCV was first reported from Indian Institute of Horticultural Research, Hesarghatta, Bengaluru (Karnataka) by Singh and Dutta (1986) [6]. ELCV disease causes yield loss between 80 per cent and 90 per cent (Singh, 1996) [7] 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) [8]. 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) [9]. 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, 40 genotypes of okra comprising 7 lines, 4 testers, their 28 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-2019 by crossing 11 diverse parents (7 lines and 4 testers) using L × T mating design. The evaluation programme was carried out under three consecutive environments *viz.*, sowing in January 2nd week-2021 (E₁), February 2nd week-2021 (E₂) and March 2nd week-2021 (E₃) during summer 2021 (evaluation). The experiment was conducted in Randomized Complete Block Design (RBD) with three replications which included 40 genotypes comprising of 7 lines (NOL-18-1, NOL-18-2, NOL-18-3, NOL-18-4, NOL-18-5, NOL-18-6, NOL-18-7), 4 testers (GAO-5, GO-6, Arka Anamika, Arka Abhay), their resultant 28 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:

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

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:

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

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.

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

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

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

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 3.33 (NOL-18-6) to 16.67 per cent (NOL-18-4) in E₁, 13.33 (NOL-18-3 and NOL-18-5) to 23.33 per cent (NOL-18-1 and NOL-18-4) in E₂, 16.67 (NOL-18-5) to 30.00 per cent (NOL-18-7, GO-6, Arka Anamika and Arka Abhay) in E₃ and among hybrids, it varied between 3.33 (NOL-18-4 × Arka Abhay and NOL-18-5 × GAO-5) to 23.33 per cent (NOL-18-3 × GO-6 and NOL-18-7 × GO-6) in E₁, 13.33 (NOL-18-2 × GAO-5) to 30.00 per cent (NOL-18-7 × Arka Abhay) in E₂, 10.00 (NOL-18-4 × Arka Anamika) to 33.33 per cent (NOL-18-3 × Arka Abhay) in E₃.

Among the parents, intensity of fruit borer incidence ranged between 9.20 (Arka Abhay) to 16.93 per cent (NOL-18-2) in E₁, 10.13 (Arka Abhay) to 20.78 per cent (NOL-18-3) in E₂, 12.93 (Arka Abhay) to 20.80 per cent (NOL-18-3) in E₃ and among hybrids, it varied between 6.27 (NOL-18-5 × GAO-5) to 21.47 per cent (NOL-18-1 × GO-6) in E₁, 9.57 (NOL-18-5 × GAO-5) to 22.53 per cent (NOL-18-7 × GO-6) in E₂, 9.07 (NOL-18-5 × GAO-5) to 22.96 per cent (NOL-18-3 × GO-6) in E₃.

Out of the 40 genotypes, none of the genotypes were free from shoot and fruit borer incidence. Among parents, NOL-18-2, GO-6 and Arka Abhay for shoot borer, NOL-18-4, Arka Anamika and Arka Abhay for fruit borer were found to perform better. Among 28 hybrids, 13 in E₁ and one each in E₂ and E₃ exhibited highly resistant reaction against shoot borer, three in E₁ and one each in E₂ and E₃ 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) [10], Haider *et al.* (2015) [11], Biswas *et al.* (2016) [12], Dave and Pandya (2017) [13], Mouli and Tayde (2017) [14], Jalgaonkar *et al.* (2018) [15],

Kumar and Tayde (2018a) ^[16], Subbireddy *et al.* (2018) ^[17], Raghuwanshi *et al.* (2019) ^[18] and Patel *et al.* (2021) ^[19].

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 6.67 (NOL-18-2) to 23.33 per cent (NOL-18-1, NOL-18-3, NOL-18-6) in E₁, 13.33 (NOL-18-4, GO-6, Arka Abhay) to 33.33 per cent (NOL-18-2) in E₂, 20.00 (NOL-18-3, NOL-18-6, Arka Anamika) to 30.00 per cent (NOL-18-7, Arka Abhay) in E₃. Among hybrids, it ranged from 3.33 (NOL-18-2 × GO-6, NOL-18-2 × Arka Anamika, NOL-18-6 × GAO-5, NOL-18-6 × GO-6) to 23.33 per cent (NOL-18-2 × Arka Abhay, NOL-18-3 × Arka Anamika, NOL-18-4 × GO-6, NOL-18-4 × Arka Anamika, NOL-18-6 × Arka Abhay) in E₁, 10.00 (NOL-18-6 × GAO-5) to 33.33 per cent (NOL-18-4 × Arka Abhay) in E₂, 16.67 (NOL-18-2 × GAO-5, NOL-18-5 × GO-6) to 36.67 per cent (NOL-18-3 × Arka Anamika) in E₃.

Among the parents, ELCV intensity varied between 0.00 (NOL-18-2, NOL-18-3, NOL-18-5) to 13.33 per cent (NOL-18-6) in E₁, 3.33 (NOL-18-6 and Arka Abhay) to 30.00 per cent (NOL-18-5) in E₂, 16.67 (NOL-18-4) to 30.00 per cent (GAO-5) in E₃ and among hybrids, it ranged from 0.00 (NOL-18-2 × GO-6, NOL-18-3 × GAO-5, NOL-18-4 × GO-6, NOL-18-5 × Arka Anamika, NOL-18-5 × Arka Abhay, NOL-18-6 × Arka Anamika, NOL-18-7 × Arka Anamika) to 13.33 per cent (NOL-18-1 × GAO-5, NOL-18-1 × GO-6, NOL-18-1 × Arka Anamika, NOL-18-2 × Arka Anamika, NOL-18-5 ×

GAO-5 and NOL-18-6 × Arka Abhay) in E₁, 0.00 (NOL-18-2 × Arka Abhay) to 26.67 per cent (NOL-18-5 × Arka Abhay) in E₂, 10.00 (NOL-18-1 × GO-6, NOL-18-3 × GAO-5, NOL-18-4 × GAO-5) to 33.33 per cent (NOL-18-5 × Arka Anamika) in E₃.

Out of the 40 genotypes, none of the genotypes were free from YVMV and ELCV. Among parents, NOL-18-4, NOL-18-6 and GAO-5 for YVMV and NOL-18-2, NOL-18-3 and Arka Anamika for ELCV was found to perform better. Among 28 hybrids, 25 in E₁ and 15 in E₂ and four in E₃ registered highly tolerant reaction against YVMV and 22 in E₁ and 24 in E₂ and 22 in E₃ 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) ^[20], Devi *et al.* (2018) ^[21], Kumar and Tayde (2018b) ^[22], Manjua *et al.* (2018) ^[23], Das *et al.* (2020) ^[24] and Joshi *et al.* (2020) ^[25]. Also, many hybrids showed lesser damage in per cent against ELCV. Lesser incidence of ELCV was also observed in okra by Yadav *et al.* (2018) ^[26], Devi *et al.* (2018) ^[21] and Patel *et al.* (2021) ^[19].

However, none of the hybrids gave immune/resistant reaction for 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.

Table 1: Scale for shoot and fruit borer resistance (Rai and Satpathy, 1998) ^[27]

Grade	Rating Scale	Severity Range (%)
1	0%	Immune (I)
2	0.1%-10%	Highly resistant (HR)
3	10.1%-20%	Fairly resistance (FR)
4	20.1%-30%	Tolerant (T)
5	30.1%-40%	Susceptible (S)
6	40.1% and above	Highly susceptible (HS)

Table 2: Disease rating scale of YVMV resistance (Ali *et al.*, 2005) ^[4]

Disease index	Rating Scale	Severity Range (%)
0	Immune	0%
1	Highly resistant	1%-10%
2	Moderately resistance	11%-25%
3	Tolerant	26%-50%
4	Moderately susceptible	51%-60%
5	Susceptible	61%-70%

Table 3: Disease rating scale of ELCV disease (Nazeer *et al.*, 2014) ^[28]

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 secondary and primary (mid-rib) veins	Tolerant
31-50	3	Veins thickening, leaf curling or Enation on both	Susceptible
>50	4	Stunting along with vein thickening, leaf curling or enation	Highly Susceptible

Table 4: Field evaluation of 40 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	13.33	23.33	26.67	FR	T	T
2	NOL-18-2	6.67	16.67	20.00	HR	FR	FR
3	NOL-18-3	13.33	13.33	20.00	FR	FR	FR
4	NOL-18-4	16.67	23.33	20.00	FR	T	FR
5	NOL-18-5	10.00	13.33	16.67	HR	FR	FR

6	NOL-18-6	3.33	16.67	26.67	HR	FR	T
7.	NOL-18-7	13.33	16.67	30.00	FR	FR	T
	Males (Testers)						
8	GAO-5	16.67	20.00	20.00	FR	FR	FR
9	GO-6	6.67	20.00	30.00	HR	FR	T
10	Arka Anamika	16.67	16.67	30.00	FR	FR	T
11	Arka Abhay	10.00	13.33	30.00	HR	FR	T
	Hybrids						
12	NOL-18-1 × GAO-5	13.33	23.33	23.33	FR	T	FR
13	NOL-18-1 × GO-6	13.33	16.67	16.67	FR	FR	FR
14	NOL-18-1 × Arka Anamika	16.67	23.33	26.67	FR	T	FR
15	NOL-18-1 × Arka Abhay	20.00	26.67	30.00	FR	T	T
16	NOL-18-2 × GAO-5	16.67	13.33	23.33	FR	FR	FR
17	NOL-18-2 × GO-6	13.33	20.00	30.00	FR	FR	T
18	NOL-18-2 × Arka Anamika	6.67	16.67	23.33	HR	FR	FR
19	NOL-18-2 × Arka Abhay	16.67	16.67	26.67	FR	FR	T
20	NOL-18-3 × GAO-5	13.33	23.33	16.67	FR	T	FR
21	NOL-18-3 × GO-6	23.33	16.67	23.33	T	FR	T
22	NOL-18-3 × Arka Anamika	10.00	20.00	16.67	HR	FR	FR
23	NOL-18-3 × Arka Abhay	10.00	20.00	33.33	HR	FR	S
24	NOL-18-4 × GAO-5	13.33	20.00	20.00	FR	FR	FR
25	NOL-18-4 × GO-6	20.00	16.67	33.33	FR	FR	S
26	NOL-18-4 × Arka Anamika	10.00	16.67	10.00	HR	HR	HR
27	NOL-18-4 × Arka Abhay	3.33	23.33	23.33	HR	T	T
28	NOL-18-5 × GAO-5	3.33	16.67	20.00	HR	FR	FR
29	NOL-18-5 × GO-6	10.00	26.67	23.33	HR	T	T
30	NOL-18-5 × Arka Anamika	6.67	20.00	23.33	HR	FR	T
31	NOL-18-5 × Arka Abhay	16.67	23.33	30.00	FR	T	T
32	NOL-18-6 × GAO-5	16.67	20.00	20.00	FR	FR	FR
33	NOL-18-6 × GO-6	10.00	26.67	26.67	HR	T	T
34	NOL-18-6 × Arka Anamika	6.67	16.67	20.00	HR	FR	FR
35	NOL-18-6 × Arka Abhay	20.00	26.67	16.67	FR	T	FR
36.	NOL-18-7 × GAO-5	10.00	20.00	26.67	HR	FR	T
37.	NOL-18-7 × GO-6	23.33	23.33	20.00	T	T	FR
38.	NOL-18-7 × Arka Anamika	10.00	16.67	13.33	HR	FR	FR
39.	NOL-18-7 × Arka Abhay	20.00	30.00	23.33	FR	T	T
40.	GJOH-4 (Standard check)	10.00	16.67	16.67	HR	FR	FR

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

Table 5: Field evaluation of 40 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	15.27	11.90	15.00	FR	FR	FR
2	NOL-18-2	16.93	17.70	17.43	FR	FR	FR
3	NOL-18-3	13.00	20.78	20.80	FR	T	T
4	NOL-18-4	9.37	15.33	16.53	HR	FR	FR
5	NOL-18-5	12.37	16.23	20.53	FR	FR	T
6	NOL-18-6	13.47	11.27	15.60	FR	FR	FR
7.	NOL-18-7	9.90	17.17	20.13	HR	FR	T
	Males (Testers)						
8	GAO-5	12.27	12.40	15.27	FR	FR	FR
9	GO-6	12.20	17.80	20.47	FR	FR	T
10	Arka Anamika	9.83	14.53	17.30	HR	FR	FR
11	Arka Abhay	9.20	10.13	12.93	HR	FR	FR
	Hybrids						
12	NOL-18-1 × GAO-5	11.67	14.83	19.50	FR	FR	FR
13	NOL-18-1 × GO-6	21.47	22.33	22.30	T	T	T
14	NOL-18-1 × Arka Anamika	12.60	19.23	19.90	FR	FR	FR
15	NOL-18-1 × Arka Abhay	11.17	18.83	16.43	FR	FR	FR
16	NOL-18-2 × GAO-5	16.83	12.80	11.47	FR	FR	FR
17	NOL-18-2 × GO-6	13.67	15.17	18.47	FR	FR	FR
18	NOL-18-2 × Arka Anamika	11.87	15.87	12.13	FR	FR	FR
19	NOL-18-2 × Arka Abhay	11.73	20.57	16.60	FR	T	FR
20	NOL-18-3 × GAO-5	13.70	20.13	18.30	FR	T	FR
21	NOL-18-3 × GO-6	15.43	20.97	22.96	FR	T	T
22	NOL-18-3 × Arka Anamika	14.07	17.27	20.82	FR	FR	T

23	NOL-18-3 × Arka Abhay	9.57	13.53	9.93	HR	FR	HR
24	NOL-18-4 × GAO-5	10.60	10.43	11.43	FR	FR	FR
25	NOL-18-4 × GO-6	11.37	19.60	19.50	FR	FR	FR
26	NOL-18-4 × Arka Anamika	17.60	14.90	19.80	FR	FR	FR
27	NOL-18-4 × Arka Abhay	9.47	10.87	12.73	HR	FR	FR
28	NOL-18-5 × GAO-5	6.27	9.57	9.07	HR	HR	T
29	NOL-18-5 × GO-6	10.70	11.77	15.80	FR	FR	FR
30	NOL-18-5 × Arka Anamika	20.47	15.43	16.90	T	FR	FR
31	NOL-18-5 × Arka Abhay	13.60	16.93	19.57	FR	FR	FR
32	NOL-18-6 × GAO-5	13.53	15.20	17.13	FR	FR	FR
33	NOL-18-6 × GO-6	12.27	13.07	19.43	FR	FR	FR
34	NOL-18-6 × Arka Anamika	9.33	12.73	14.63	T	FR	FR
35	NOL-18-6 × Arka Abhay	11.90	17.10	20.47	FR	FR	T
36	NOL-18-7 × GAO-5	10.03	13.10	15.50	FR	FR	FR
37	NOL-18-7 × GO-6	13.30	22.53	22.20	FR	T	T
38	NOL-18-7 × Arka Anamika	9.67	12.30	11.87	T	FR	FR
39	NOL-18-7 × Arka Abhay	8.53	13.83	14.50	T	FR	FR
40	GJOH-4 (Standard check)	10.10	14.90	15.17	FR	FR	FR

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

Table 6: Field evaluation of 40 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	23.33	23.33	26.67	T	T	T
2	NOL-18-2	6.67	33.33	26.67	HT	S	T
3	NOL-18-3	23.33	30.00	20.00	T	T	HT
4	NOL-18-4	16.67	13.33	26.67	HT	HT	T
5	NOL-18-5	16.67	26.67	23.33	HT	T	T
6	NOL-18-6	23.33	16.67	20.00	T	HT	HT
7	NOL-18-7	13.33	30.00	30.00	HT	T	T
	Males (Testers)						
8	GAO-5	13.33	16.67	20.00	HT	HT	HT
9	GO-6	16.67	13.33	23.33	HT	HT	T
10	Arka Anamika	23.33	20.00	26.67	T	HT	T
11	Arka Abhay	16.67	13.33	30.00	HT	HT	T
	Hybrids						
12	NOL-18-1 × GAO-5	13.33	26.67	26.67	HT	T	T
13	NOL-18-1 × GO-6	16.67	13.33	23.33	HT	HT	T
14	NOL-18-1 × Arka Anamika	20.00	30.00	33.33	HT	T	S
15	NOL-18-1 × Arka Abhay	10.00	13.33	30.00	HT	HT	T
16	NOL-18-2 × GAO-5	16.67	26.67	16.67	HT	T	HT
17	NOL-18-2 × GO-6	3.33	23.33	23.33	HT	T	T
18	NOL-18-2 × Arka Anamika	3.33	16.67	26.67	HT	HT	T
19	NOL-18-2 × Arka Abhay	23.33	23.33	26.67	T	T	T
20	NOL-18-3 × GAO-5	20.00	16.67	23.33	HT	HT	T
21	NOL-18-3 × GO-6	13.33	20.00	30.00	HT	HT	T
22	NOL-18-3 × Arka Anamika	23.33	26.67	36.67	T	T	S
23	NOL-18-3 × Arka Abhay	20.00	26.67	23.33	HT	T	T
24	NOL-18-4 × GAO-5	10.00	20.00	26.67	HT	HT	T
25	NOL-18-4 × GO-6	23.33	23.33	30.00	T	T	T
26	NOL-18-4 × Arka Anamika	23.33	20.00	23.33	T	T	T
27	NOL-18-4 × Arka Abhay	10.00	33.33	26.67	HT	S	T
28	NOL-18-5 × GAO-5	6.67	16.67	23.33	HT	HT	T
29	NOL-18-5 × GO-6	13.33	26.67	16.67	HT	T	HT
30	NOL-18-5 × Arka Anamika	16.67	23.33	23.33	HT	T	T
31	NOL-18-5 × Arka Abhay	16.67	20.00	20.00	HT	HT	HT
32	NOL-18-6 × GAO-5	3.33	10.00	23.33	HT	HT	T
33	NOL-18-6 × GO-6	3.33	13.33	20.00	HT	HT	HT
34	NOL-18-6 × Arka Anamika	16.67	10.00	23.33	HT	HT	T
35	NOL-18-6 × Arka Abhay	23.33	20.00	26.67	T	HT	T
36	NOL-18-7 × GAO-5	16.67	16.67	30.00	HT	HT	T
37	NOL-18-7 × GO-6	13.33	30.00	26.67	HT	T	T
38	NOL-18-7 × Arka Anamika	10.00	20.00	26.67	HT	HT	T
39	NOL-18-7 × Arka Abhay	13.33	26.67	23.33	HT	T	T
40	GJOH-4 (Standard check)	16.67	20.00	30.00	HT	HT	T

HT: Highly tolerant, T: Tolerant, S: Susceptible

Table 7: Field evaluation of 40 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	6.67	20.00	26.67	HT	HT	T
2	NOL-18-2	0.00	13.33	23.33	R	HT	T
3	NOL-18-3	0.00	20.00	26.67	R	HT	T
4	NOL-18-4	6.67	10.00	16.67	HT	HT	HT
5	NOL-18-5	0.00	30.00	26.67	R	T	T
6	NOL-18-6	13.33	3.33	23.33	HT	HT	T
7	NOL-18-7	10.00	13.33	23.33	HT	HT	T
	Males (Testers)						
8	GAO-5	6.67	20.00	30.00	HT	HT	T
9	GO-6	6.67	20.00	26.67	HT	HT	T
10	Arka Anamika	10.00	13.33	20.00	HT	HT	HT
11	Arka Abhay	3.33	3.33	23.33	HT	HT	T
	Hybrids						
12	NOL-18-1 × GAO-5	13.33	16.67	26.67	HT	HT	T
13	NOL-18-1 × GO-6	13.33	3.33	10.00	HT	HT	HT
14	NOL-18-1 × Arka Anamika	13.33	23.33	23.33	HT	T	T
15	NOL-18-1 × Arka Abhay	10.00	16.67	16.67	HT	HT	HT
16	NOL-18-2 × GAO-5	13.33	13.33	26.67	HT	HT	T
17	NOL-18-2 × GO-6	0.00	3.33	13.33	R	HT	HT
18	NOL-18-2 × Arka Anamika	13.33	6.67	23.33	HT	HT	T
19	NOL-18-2 × Arka Abhay	6.67	0.00	13.33	HT	HT	HT
20	NOL-18-3 × GAO-5	0.00	3.33	10.00	R	HT	HT
21	NOL-18-3 × GO-6	10.00	20.00	20.00	HT	HT	HT
22	NOL-18-3 × Arka Anamika	3.33	13.33	30.00	HT	HT	T
23	NOL-18-3 × Arka Abhay	3.33	23.33	20.00	HT	T	HT
24	NOL-18-4 × GAO-5	10.00	6.67	10.00	HT	HT	HT
25	NOL-18-4 × GO-6	0.00	10.00	20.00	R	HT	HT
26	NOL-18-4 × Arka Anamika	3.33	10.00	20.00	HT	HT	HT
27	NOL-18-4 × Arka Abhay	6.67	16.67	16.67	HT	HT	HT
28	NOL-18-5 × GAO-5	13.33	6.67	16.67	HT	HT	HT
29	NOL-18-5 × GO-6	6.67	3.33	13.33	HT	HT	HT
30	NOL-18-5 × Arka Anamika	0.00	23.33	33.33	R	T	S
31	NOL-18-5 × Arka Abhay	0.00	26.67	23.33	R	T	T
32	NOL-18-6 × GAO-5	10.00	13.33	16.67	HT	HT	HT
33	NOL-18-6 × GO-6	6.67	20.00	20.00	HT	HT	HT
34	NOL-18-6 × Arka Anamika	0.00	3.33	13.33	R	HT	HT
35	NOL-18-6 × Arka Abhay	13.33	3.33	20.00	HT	HT	HT
36	NOL-18-7 × GAO-5	3.33	23.33	20.00	HT	T	HT
37	NOL-18-7 × GO-6	6.67	3.33	13.33	HT	HT	HT
38	NOL-18-7 × Arka Anamika	0.00	16.67	26.67	R	HT	T
39	NOL-18-7 × Arka Abhay	10.00	16.67	23.33	HT	HT	T
40	GJOH-4 (Standard check)	3.33	3.33	20.00	HT	HT	HT

R: Resistant, HT: Highly tolerant, T: Tolerant, S: Susceptible

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