# Screening for okra enation leaf curl disease resistance in wild okra (Abelmoschus moschatus ssp. moschatus) germplasm of India

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#### **ABSTRACT**

Okra enation leaf curl disease (OELCuD) caused by *Okra enation leaf curl virus* (OELCuV) is a whitefly (*Bemisia tabaci*) transmitted viral disease of okra which deteriorates vegetable quality and reduces yield. The OELCuV was confirmed based on the amplicon of 1.3 Kb of beta satellite (DNA-β) molecule of the virus. Field screening of wild okra (*Abelmoschus moschatus* ssp. *moschatus*) accessions was carried out for OELCuD resistance during *kharif* 2017–19 at experimental Farm of ICAR-National Bureau of Plant Genetic Resources, Pusa, New Delhi. Out of 76 wild okra accessions tested, 10 accessions, viz. EC360586, EC360794, EC360830, EC360900, EC359730, EC359836, EC359870, EC360351, EC361111 and EC361171 showed resistant (R) reaction in *kharif* 2017, whereas in *kharif* 2019, only four accessions, viz. EC360794, EC360586, EC360830 and EC361171 exhibited R reaction and remaining six accessions were moderately resistant (MR). In the first year, average percent disease index (PDI) was 14.15 and overall PDI ranged from 3.70 to 52.86. The range of PDI was 4.53–56.40 during the second year with an average PDI value 18.04. Apart from PDI determination, whitefly population was also monitored in both the years mainly showed moderate preference. The prominent four accessions of okra, *viz.* EC360794, EC360586, EC360830 and EC361171 could be utilized in resistance breeding programmes against OELCuV.

**Keywords**: *Abelmoschus moschatus* ssp. *moschatus*, DNA-β, Field screening, OELCuV, OELCuD, Whitefly

Okra (Abelmoschus esculentus) is one of the important vegetable crops in India (Naveed et al. 2009). Okra capsule has high foreign exchange value of about 60% export potential from India (Singh et al. 2014). Production and productivity of okra is declined in India due to continuous utilization of low yielding cultivars and severe infestation of insect-pests and diseases, in particular viral diseases. Unfortunately, okra is susceptible to several viral pathogens, viz. Okra yellow vein mosaic virus (OYVMV) and Okra enation leaf curl virus (OELCuV) that resulted in severe quality deterioration and yield reduction. Among all viral diseases in okra, OELCuV is an emerging begomovirus (Singh 1996). The virus belongs to geminiviridae family, genome comprised circular single-stranded (ss) DNA molecule and whiteflies assist its transmission in natural conditions (Lazarowitz and Shepherd 1992). Generally, monopartite begomoviruses associated with a class of

ssDNA satellites molecule is named as beta satellites (DNA- $\beta$ ). Recombination is a main factor for evolution of begomoviruses (Seal et al. 2006) and the evidence claimed that recombination played a part in OELCuV origin. Conspicuous symptom of okra enation leaf curl disease (OELCuD) is leaf cupping, vein-thickening, twisting of petioles, stunted plant growth and eventually poor crop yield noticed with non-preference to customer (Sanwal et al. 2014). So far, very less okra accessions were claimed to have resistance against OELCuV (Singh et al. 2007). Wild relatives are indispensable source of resistance as they harbour genes for resistance and observed to be free from OELCuV (Singh et al. 2009). Recent studies revealed wild okra (A. moschatus ssp. moschatus) having immune response to OELCuD in India (Pasupathi et al. 2019). Hence there is a need to evaluate more number of accessions of A. moschatus ssp. moschatus in order to find out new sources of resistance which can be utilized by the breeders in resistance breeding programmes.

## MATERIALS AND METHODS

Screening of wild okra germplasm: A total of 76 accessions of wild okra along with four checks, viz. Arka Anamika (resistant check), VRO-6 (resistant check), Pusa Sawani (susceptible check) and Parbhani Kranti (susceptible

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check) (Table 1) were sown in the New Area Farm of ICAR-National Bureau of Plant Genetic Resources, Pusa campus in Augmented Block Design (ABD) during *kharif* 2017 and 2019 with one row of each accession maintaining plant-to-plant spacing 30 cm  $\times$  30 cm and row-to-row spacing of 75 cm  $\times$  75 cm.

Percent disease index (PDI) was calculated on 10 plants of each accession. Observations were recorded thrice at an interval of 25 days during vegetative growth phase. Cupping of leaves and petiole bending in plant were recorded as the characteristic symptom of OELCuD. The scale 0-4 as suggested by Cao *et al.* (2009) was used for calculation of percent disease index (PDI) with slight modification.

Number of plants infected in each entry was monitored and PDI was computed with the following formula:

Sum of all ratings

Percent Disease Index = Highest grade  $\times$  Total number of  $\times$  100 plants examined

Computation of whitefly population during kharif: Populations of *B. tabaci* were recorded on three leaves/ plant each from lower, middle and upper canopy of plants. Observations were made thrice at 25 days interval during vegetative phase from three randomly identified symptomatic plants of each wild okra accession. Further, mean and critical difference (CD) values were calculated to know the whitefly preferences to wild accessions and were graded into four groups, viz. negligible, moderate, high and very high preference (Manoharan *et al.* 1982).

DNA isolation and PCR amplification: Total nucleic acid extracted from promising and symptomatic plant/leaf tissues collected from field using cetyl trimethyl ammonium bromide method (Doyle and Doyle 1990) with slight modification in the isopropanol step. OELCuV Complete Beta Satellite molecule was amplified using universal primer pair (Beta01F/Beta02R) (Briddon et al. 2002). The PCR reactions were carried out in a DNA Engine (Peltier thermal cycler) machine. Agarose gel (1%) was used for amplified PCR product electrophoresis (1 h at 80 volts) and visualised on a gel documentation system (SYNGENE-Gi

Box). Sequencing and Blast analysis of desired size of 1.3 Kb amplified products corresponding to the OELCuV of okra leaf were obtained.

Statistical analysis: The data of PDI were subjected to Augmented Block Design (ABD) statistical analysis using SPAD software to compute standard error and critical difference.

#### RESULTS AND DISCUSSION

Disease reaction and response of germplasm: Wild okra (A. moschatus ssp. moschatus) genotypes showed varied OELCuD symptoms (Fig 1). Majority (>70%) of wild okra accessions exhibited typical top leaves curled symptom during consecutive two years of field screening. During the first year of field screening, minimum, maximum and average PDI values were 3.70, 52.86 and 14.14, respectively, while during the second year, minimum, maximum and average PDI values were 4.53, 56.40 and 18.04, respectively, which clearly indicated that disease progress was higher during the second year.

Out of 76 accessions, promising 10 lines namely, EC360586, EC360794, EC360830, EC360900, EC359730, EC359836, EC359870, EC360351, EC361171 and EC361111 clearly exhibited resistant (R) reaction in first year of screening whereas, only four lines, viz. EC360794, EC360586, EC360830 and EC361171 remained resistant during the second year of field screening (Table 1). Surprisingly, six resistant lines, viz. EC360900, EC359730, EC359836, EC359870, EC360351 and EC361111 of the first year exhibited moderately resistant (MR) reaction during the second year (Table 1). Finally, four lines, viz. EC360794, EC360586, EC360830 and EC361171 exhibited R reaction in both years of field screening (Fig 2).

Response to whitefly (Bemisia tabaci): During kharif 2017, the mean population of whiteflies per leaf was 0.522 and the range value for whitefly per leaf was 0.146 to 0.916, whereas during kharif 2019, the mean population of whiteflies per leaf was 0.457 within the range value 0.110 to 0.880. During both the seasons, genotypes were grouped based on whitefly population into either moderate

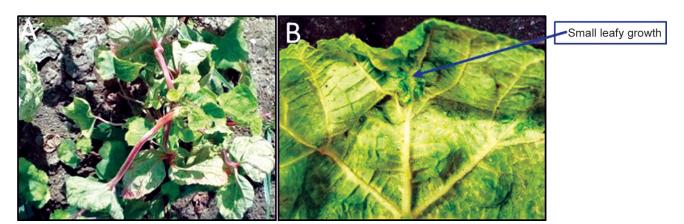


Fig 1 Typical okra enation leaf curl disease symptom on okra susceptible check (Pusa Sawani). A, Initial symptom exhibits twisting of branches; B, Advanced symptom showing small leafy structures development on abaxial surface of the affected leaf.

Table 1 Percent disease index and reaction of okra enation leaf curl disease in germplasm accessions of wild okra

Table 1 (Continued)

Accession/ cultivar	Re	action again	nst OELCuI	)	Accession/ cultivar	Reaction against OELCuD			
	Kharif 2		Kharif 2019		Cuttival	Kharif 2017		Kharif 2019	
						PDI	Reaction	PDI	Reaction
EC360900	PDI 3.70 (11.09) <sup>a</sup>	Reaction R	15.13	Reaction MR	EC361148	12.86 (21.01) <sup>bcd</sup>	MR	14.46 (22.35) <sup>b</sup>	MR
EC360794	4.16 (11.77) <sup>a</sup>	R	(22.89) <sup>b</sup> 4.53	R	EC360665	12.96 (21.1) <sup>bcd</sup>	MR	14.50 (22.38) <sup>b</sup>	MR
EC360351	4.70 (12.52) <sup>a</sup>	R	(12.29) <sup>a</sup> 14.86	MR	EC361231	12.96 (21.1) <sup>bcd</sup>	MR	14.06 (22.02) <sup>b</sup>	MR
EC361111	4.83 (12.7) <sup>a</sup>	R	(22.67) b	MR	EC359906	13.00 (21.13) <sup>bcd</sup>	MR	54.33 (47.48) <sup>de</sup>	HS
EC359836	5.20 (13.18) <sup>a</sup>	R	(22.27) b	MR	EC360855	13.43 (21.5) <sup>bcd</sup>	MR	14.76 (22.59) <sup>b</sup>	MR
EC360830	5.30 (13.31) <sup>a</sup>	R	(22.65) b 6.46	R	EC361022	13.46 (21.52) <sup>bcd</sup>	MR	55.60 (48.22) <sup>e</sup>	HS
EC360586	5.40 (13.44) <sup>a</sup>	R	(14.72) <sup>a</sup> 6.46	R	EC360735	13.50 (21.56) <sup>bcd</sup>	MR	13.90 (21.89) <sup>b</sup>	MR
EC359870	5.43 (13.48) <sup>a</sup>	R	(14.72) <sup>a</sup> 14.50	MR	EC361007	13.50 (21.56) <sup>bcd</sup>	MR	14.23 (22.16) <sup>b</sup>	MR
EC361171	5.46 (13.51) <sup>a</sup>	R	(22.38) b 5.46	R	EC361129	13.63 (21.67) <sup>bcd</sup>	MR	14.56 (22.43) <sup>b</sup>	MR
EC359730	5.96 (14.13) <sup>a</sup>	R	(13.51) a 15.43	MR	EC360672	13.66 (21.69) <sup>bcd</sup>	MR	13.40 (21.47) <sup>b</sup>	MR
EC360820	11.70 (20) <sup>b</sup>	MR	$(23.13)^{b}$ $13.60$	MR	EC361131	13.70 (21.72) <sup>bcd</sup>	MR	14.76 (22.59) <sup>b</sup>	MR
EC360736	12.03	MR	$(21.64)^{b}$ $13.40$	MR	EC361200	13.86 (21.86) <sup>bcd</sup>	MR	14.76 (22.59) <sup>b</sup>	MR
EC360554	$(20.29)^{b}$ 12.10	MR	$(21.47)^{b}$ 47.53	HS	EC360911	13.90 (21.89) <sup>bcd</sup>	MR	13.26 (21.35) <sup>b</sup>	MR
EC360337	$(20.36)^{bc}$ 12.10	MR	$(43.58)^{d}$ $13.90$	MR	EC359653	14.13 (22.08) <sup>bcd</sup>	MR	14.80 (22.63) <sup>b</sup>	MR
EC360095	(20.36) <sup>bc</sup> 12.26	MR	(21.89) b 14.86	MR	EC360787	14.16 (22.1) <sup>bcd</sup>	MR	13.03 (21.16) <sup>b</sup>	MR
EC316073	(20.5) <sup>bcd</sup> 12.30	MR	(22.67) <sup>b</sup> 15.16	MR	EC361019	14.16 (22.1) <sup>bcd</sup>	MR	15.73 (23.37) <sup>b</sup>	MR
EC360819	(20.53) <sup>bcd</sup> 12.36	MR	(22.91) b 14.70	MR	EC359709	14.23 (22.16) <sup>bcd</sup>	MR	16.40 (23.89) <sup>b</sup>	MR
EC360484	(20.58) <sup>bcd</sup> 12.53	MR	(22.54) b 13.23	MR	EC361020	14.26 (22.19) <sup>bcd</sup>	MR	15.33 (23.05) <sup>b</sup>	MR
EC361137	(20.73) <sup>bcd</sup> 12.73 (20.9) <sup>bcd</sup>	MR	(21.33) <sup>b</sup> 14.83	MR	IC141055	14.36 (22.27) <sup>bcd</sup>	MR	12.96 (21.1) <sup>b</sup>	MR
EC361006	12.80	MR	(22.65) b 16.03	MR	EC360675	14.43 (22.33) <sup>bcd</sup>	MR	13.16 (21.27) <sup>b</sup>	MR
EC360927	(20.96) <sup>bcd</sup> 12.86 (21.01) <sup>bcd</sup>	MR	(23.6) b 13.40 (21.47) b	MR	EC329394	14.50 (22.38) <sup>bcd</sup>	MR	14.46 (22.35) <sup>b</sup>	MR

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Table 1 (Continued)

Table 1 (Concluded)

Accession/ cultivar	Re	eaction agai	nst OELCuI	)	Accession/	Reaction against OELCuD				
	Kharif 2017		Kharif 2019		cultivar	Kharif 2017		Kharif 2019		
	PDI	Reaction	PDI	Reaction		PDI	Reaction	PDI	Reaction	
EC316077	14.56 (22.43) <sup>bcd</sup>	MR	47.50 (43.57) <sup>d</sup>	HS	EC360953	15.60 (23.26) <sup>bcd</sup>	MR	16.40 (23.89) <sup>b</sup>	MR	
EC361018	14.63 (22.49) <sup>bcd</sup>	MR	14.40 (22.3) <sup>b</sup>	MR	EC361003	15.83 (23.44) <sup>bcd</sup>	MR	17.13 (24.45) <sup>b</sup>	MR	
EC359828	14.66 (22.51) <sup>bcd</sup>	MR	15.70 (23.34) <sup>b</sup>	MR	EC359715	16.13 (23.68) <sup>bcd</sup>	MR	15.96 (23.55) <sup>b</sup>	MR	
EC361170	14.66 (22.51) <sup>bcd</sup>	MR	15.26 (22.99) <sup>b</sup>	MR	EC361138	16.13 (23.68) <sup>bcd</sup>	MR	14.53 (22.41) <sup>b</sup>	MR	
EC361044	14.70 (22.54) <sup>bcd</sup>	MR	15.36 (23.07) <sup>b</sup>	MR	EC360915	16.16 (23.7) <sup>bcd</sup>	MR	15.76 (23.39) <sup>b</sup>	MR	
EC329408	14.73 (22.57) <sup>bcd</sup>	MR	56.40 (48.68) <sup>e</sup>	HS	EC361132	16.23 (23.76) <sup>bcd</sup>	MR	16.20 (23.73) <sup>b</sup>	MR	
EC359878	14.80 (22.63) <sup>bcd</sup>	MR	15.06 (22.83) b	MR	EC360900-A	16.26 (23.78) <sup>bcd</sup>	MR	15.50 (23.18) <sup>b</sup>	MR	
EC361261	14.83 (22.65) <sup>bcd</sup>	MR	14.56 (22.43) b	MR	EC361264	16.43 (23.91) <sup>bcd</sup>	MR	15.56 (23.23) <sup>b</sup>	MR	
EC360245	14.86 (22.67) <sup>bcd</sup>	MR	14.76 (22.59) b	MR	EC361178	16.46 (23.94) <sup>bcd</sup>	MR	13.90 (21.89) <sup>b</sup>	MR	
EC360331	14.90 (22.71) <sup>bcd</sup>	MR	56.16 (48.54) e	HS	EC361067	16.50 (23.97) <sup>bcd</sup>	MR	15.46 (23.15) <sup>b</sup>	MR	
EC360826	14.96 (22.75) <sup>bcd</sup>	MR	14.63 (22.49) <sup>b</sup>	MR	EC360964	16.90 (24.27) <sup>cd</sup>	MR	14.66 (22.51) <sup>b</sup>	MR	
EC360853	15.00 (22.79) <sup>bcd</sup>	MR	14.93	MR	EC359787	17.03 (24.37) <sup>d</sup>	MR	15.03 (22.81) <sup>b</sup>	MR	
EC360332	15.00	MR	(22.73) b	MR	EC360629	51.50 (45.86) <sup>e</sup>	HS	53.13 (46.79) <sup>de</sup>	HS	
EC360828	(22.79) <sup>bcd</sup> 15.36	MR	(23.15) b 13.56	MR	EC360945	52.86 (46.64) <sup>e</sup>	HS	33.36 (35.28) <sup>c</sup>	MS	
IC140985	(23.07) <sup>bcd</sup> 15.40	MR	(21.61) <sup>b</sup> 16.36	MR	Parbhani Kranti (Check)	61.46 (51.62) <sup>f</sup>	HS	60.56 (51.09) <sup>f</sup>	HS	
EC360193	(23.11) <sup>bcd</sup> 15.43	MR	(23.86) <sup>b</sup> 15.46	MR	Arka Anamika (Check)	61.50 (51.65) <sup>f</sup>	HS	62.26 (52.1) <sup>f</sup>	HS	
EC360410	(23.13) <sup>bcd</sup> 15.46	MR	(23.15) <sup>b</sup> 15.56	MR	Pusa Sawani (Check)	62.46 (52.22) <sup>f</sup>	HS	61.43 (51.6) <sup>f</sup>	HS	
	(23.15) <sup>bcd</sup>		(23.23) <sup>b</sup>		VRO-6 (Check)	62.86 (52.45) <sup>f</sup>	HS	64.20 (53.24) <sup>f</sup>	HS	
EC361014	15.50 (23.18) <sup>bcd</sup>	MR	13.70 (21.72) <sup>b</sup>	MR	SEd	1.6	2	1.7	71	
EC361082	15.50 (23.18) <sup>bcd</sup>	MR	13.60 (21.64) <sup>b</sup>	MR	CD (5%)	3.97		4.19		
EC361284	15.56 (23.23) <sup>bcd</sup>	MR	15.23 (22.97) b	MR	The values significantly dif MR: Moderately	ferent at 5% Resistant, N	level of signs: Modera	gnificance. F tely Suscepti	R: Resistant ible and HS	

MR: Moderately Resistant, MS: Moderately Susceptible and HS: Highly Susceptible. Values inside parentheses are transformed for corresponding mean value.

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Table 2 Preference of germplasm accessions of wild okra by the insect vector (Bemisia tabaci) of okra enation leaf curl

Table 2 (Continued)

insect vector (Bemisia tabaci) of okra enation leaf curl virus					Accession/	Preference of okra genotypes by whiteflies				
Accession/ cultivar	Preferenc	ce of okra ge	notypes by v	whiteflies	cultivar	Kharif 2017		Kharif 2019		
		f 2017	Kharij			Average	Preference	Average whiteflies/ leaf	Preference	
	Average whiteflies/	Preference	Average whiteflies/	Preference		whiteflies/ leaf				
	leaf		leaf		EC361170	0.440 (0.97) <sup>a</sup>	Moderate	0.586 (1.04) <sup>abc</sup>	Moderate	
EC360900	0.146 (0.8) <sup>a</sup>	Moderate	0.183 (0.83) <sup>a</sup>	Moderate	EC361200	0.440 (0.97) <sup>a</sup>	Moderate	0.403 (0.95) <sup>a</sup>	Moderate	
EC359836	0.146 (0.8) <sup>a</sup>	Moderate	0.146 (0.8) <sup>a</sup>	Moderate	EC360629	0.476 (0.99) <sup>a</sup>	Moderate	0.440 (0.97) <sup>a</sup>	Moderate	
EC360351	0.146 (0.8) <sup>a</sup>	Moderate	0.256 (0.87) <sup>a</sup>	Moderate	EC360900-A	0.476 (0.99) <sup>a</sup>	Moderate	0.550 (1.02) <sup>ab</sup>	Moderate	
EC361111	0.146 (0.8) <sup>a</sup>	Moderate	0.183 (0.83) <sup>a</sup>	Moderate	EC316073	0.476 (0.99) <sup>a</sup>	Moderate	0.586 (1.04) <sup>abc</sup>	Moderate	
EC360794	0.183 (0.83) <sup>a</sup>	Moderate	0.183 (0.83) <sup>a</sup>	Moderate	EC360945	0.476 (0.99) <sup>a</sup>	Moderate	0.440 (0.97) <sup>a</sup>	Moderate	
EC360830	0.183 (0.83) <sup>a</sup>	Moderate	0.146 (0.8) <sup>a</sup>	Moderate	EC361019	0.476 (0.99) <sup>a</sup>	Moderate	0.440 (0.97) <sup>a</sup>	Moderate	
EC359870	0.183 (0.83) <sup>a</sup>	Moderate	0.220 (0.85) <sup>a</sup>	Moderate	EC361067	0.476 (0.99) <sup>a</sup>	Moderate	0.403 (0.95) <sup>a</sup>	Moderate	
EC361171	0.183 (0.83) <sup>a</sup>	Moderate	0.110 (0.78) <sup>a</sup>	Moderate	EC361131	0.476 (0.99) <sup>a</sup>	Moderate	0.403 (0.95) <sup>a</sup>	Moderate	
EC360586	0.220 (0.85) <sup>a</sup>	Moderate	0.146 (0.8) <sup>a</sup>	Moderate	EC361261	0.476 (0.99) <sup>a</sup>	Moderate	0.476 (0.99) <sup>a</sup>	Moderate	
EC359730	0.220 (0.85) <sup>a</sup>	Moderate	0.220 (0.85) <sup>a</sup>	Moderate	EC360665	0.513 (1.01) <sup>a</sup>	Moderate	0.513 (1.01) <sup>a</sup>	Moderate	
EC360820	0.403 (0.95) <sup>a</sup>	Moderate	0.403 (0.95) <sup>a</sup>	Moderate	EC360672	0.513 (1.01) <sup>a</sup>	Moderate	0.513 (1.01) <sup>a</sup>	Moderate	
EC360828	0.440 (0.97) <sup>a</sup>	Moderate	0.440 (0.97) <sup>a</sup>	Moderate	EC360911	0.513 (1.01) <sup>a</sup>	Moderate	0.513 (1.01) <sup>a</sup>	Moderate	
EC359715	0.440 (0.97) <sup>a</sup>	Moderate	0.476 (0.99) <sup>a</sup>	Moderate	EC359709	0.513 (1.01) <sup>a</sup>	Moderate	0.513 (1.01) a	Moderate	
EC360410	0.440 (0.97) <sup>a</sup>	Moderate	0.440 (0.97) <sup>a</sup>	Moderate	EC360337	0.513 (1.01) <sup>a</sup>	Moderate	0.550 (1.02) ab	Moderate	
EC361006	0.440 (0.97) <sup>a</sup>	Moderate	0.440 (0.97) <sup>a</sup>	Moderate	EC361284	0.513 (1.01) <sup>a</sup>	Moderate	0.403 (0.95) <sup>a</sup>	Moderate	
EC361018	0.440 (0.97) <sup>a</sup>	Moderate	0.550 (1.02) <sup>ab</sup>	Moderate	EC360554	0.550 (1.02) <sup>a</sup>	Moderate	0.513 (1.01) <sup>a</sup>	Moderate	
EC361129	0.440 (0.97) <sup>a</sup>	Moderate	0.550 (1.02) <sup>ab</sup>	Moderate	EC360675	0.550 (1.02) a	Moderate	0.476 (0.99) <sup>a</sup>	Moderate	
EC361137	0.440 (0.97) <sup>a</sup>	Moderate	0.403 (0.95) <sup>a</sup>	Moderate	EC360826	0.550 (1.02) <sup>a</sup>	Moderate	0.513 (1.01) a	Moderate	
EC361138	0.440 (0.97) <sup>a</sup>	Moderate	0.440 (0.97) <sup>a</sup>	Moderate	EC360245	0.550 (1.02) a	Moderate	0.550 (1.02) ab	Moderate	
EC361148	0.440 (0.97) <sup>a</sup>	Moderate	0.476 (0.99) <sup>a</sup>	Moderate	EC360915	0.550 (1.02) a	Moderate	0.476 (0.99) <sup>a</sup>	Moderate	

Table 2 (Continued)

Table 2 (Concluded)

Accession/	Preference	ce of okra ge	notypes by v	vhiteflies	Accession/	Preference of okra genotypes by whiteflies				
cultivar	Kharif 2017		Kharif 2019		cultivar	Kharif 2017		Kharif 2019		
	Average whiteflies/ leaf	Preference	Average whiteflies/ leaf	Preference		Average whiteflies/ leaf	Preference	Average whiteflies/ leaf	Preference	
EC361014	0.550 (1.02) <sup>a</sup>	Moderate	0.513 (1.01) <sup>a</sup>	Moderate	EC359878	0.660 (1.08) <sup>ab</sup>	High	0.550 (1.02) <sup>ab</sup>	Moderate	
EC361022	0.550 (1.02) <sup>a</sup>	Moderate	0.513 (1.01) <sup>a</sup>	Moderate	EC359906	0.660 (1.08) <sup>ab</sup>	High	0.880 (1.17) <sup>abcd</sup>	High	
EC361132	0.550 (1.02) <sup>a</sup>	Moderate	0.440 (0.97) <sup>a</sup>	Moderate	EC360331	0.660 (1.08) <sup>ab</sup>	High	0.440 (0.97) <sup>a</sup>	Moderate	
EC360787	0.586 (1.04) <sup>a</sup>	Moderate	0.476 (0.99) <sup>a</sup>	Moderate	EC361007	0.660 (1.08) <sup>ab</sup>	High	0.403 (0.95) <sup>a</sup>	Moderate	
EC360853	0.586 (1.04) <sup>a</sup>	Moderate	0.513 (1.01) <sup>a</sup>	Moderate	EC359828	0.696 (1.09) <sup>abc</sup>	High	0.513 (1.01) <sup>a</sup>	Moderate	
EC359787	0.586 (1.04) <sup>a</sup>	Moderate	0.403 (0.95) <sup>a</sup>	Moderate	EC360927	0.696 (1.09) <sup>abc</sup>	High	0.403 (0.95) <sup>a</sup>	Moderate	
EC360095	0.586 (1.04) <sup>a</sup>	Moderate	0.403 (0.95) <sup>a</sup>	Moderate	IC141055	0.696 (1.09) <sup>abc</sup>	High	0.550 (1.02) <sup>ab</sup>	Moderate	
EC360193	0.586 (1.04) <sup>a</sup>	Moderate	0.773 (1.13) <sup>abcd</sup>	High	EC359653	0.733 (1.11) <sup>abcd</sup>	High	0.513 (1.01) <sup>a</sup>	Moderate	
EC360953	0.586 (1.04) <sup>a</sup>	Moderate	0.476 (0.99) <sup>a</sup>	Moderate	EC360819	0.770 (1.13) <sup>abcde</sup>	High	0.550 (1.02) <sup>ab</sup>	Moderate	
EC361044	0.586 (1.04) <sup>a</sup>	Moderate	0.403 (0.95) <sup>a</sup>	Moderate	EC329394	0.806 (1.14) <sup>abcde</sup>	High	0.513 (1.01) <sup>a</sup>	Moderate	
EC361082	0.586 (1.04) <sup>a</sup>	Moderate	0.586 (1.04) <sup>abc</sup>	Moderate	EC360332	0.806 (1.14) <sup>abcde</sup>	High	0.476 (0.99) <sup>a</sup>	Moderate	
EC361231	0.586 (1.04) <sup>a</sup>	Moderate	0.550 (1.02) <sup>ab</sup>	Moderate	EC360855	0.843 (1.16) <sup>abcde</sup>	High	0.513	Moderate	
EC361264	0.586 (1.04) <sup>a</sup>	Moderate	0.476 (0.99) <sup>a</sup>	Moderate	IC140985	0.880	High	(1.01) a 0.550	Moderate	
EC316077	0.623 (1.06) <sup>ab</sup>	Moderate	0.476 (0.99) <sup>a</sup>	Moderate	EC360735	(1.17) abcde 0.916	High	(1.02) ab 0.513	Moderate	
EC360964	0.623 (1.06) <sup>ab</sup>	Moderate	0.550 (1.02) <sup>ab</sup>	Moderate	V R O - 6	(1.19) <sup>abcde</sup> 1.923	High	(1.01) <sup>a</sup> 1.996	High	
EC361003	0.623 (1.06) <sup>ab</sup>	Moderate	0.513 (1.01) <sup>a</sup>	Moderate	(Check) Pusa Sawani	(1.55) <sup>bcde</sup> 1.996		(1.58) <sup>bcd</sup>		
EC361020	0.623 (1.06) <sup>ab</sup>	Moderate	0.550 (1.02) <sup>ab</sup>	Moderate	(Check)	$(1.57)^{\text{cde}}$	Very high	2.070 (1.6)	High	
EC361178	0.623 (1.06) <sup>ab</sup>	Moderate	0.513 (1.01) <sup>a</sup>	Moderate	Parbhani Kranti (Check)	2.033 (1.59) <sup>de</sup>	Very high	2.033 (1.59) <sup>cd</sup>	High	
EC360484	0.660 (1.08) <sup>ab</sup>	High	0.513 (1.01) <sup>a</sup>	Moderate	Arka Anamika (Check)	2.036 (1.6) <sup>e</sup>	Very high	2.146 (1.63) <sup>d</sup>	Very high	
EC360736	0.660	High	0.513	Moderate	SEd	0.198		0.228		
EC329408	(1.08) <sup>ab</sup> 0.660 (1.08) <sup>ab</sup>	High	(1.01) <sup>a</sup> 0.586 (1.04) <sup>abc</sup>	Moderate	The values significantly di		column wit	0.5	letters are	

significantly different at 5% level of significance. Values inside parentheses are transformed for corresponding mean value.



Fig 2 Promising wild okra accessions against okra enation leaf curl disease. A: EC360794, B: EC360586, C: EC360830, D: EC361171.

or high preference. Among the checks only VRO-6 in *kharif* 2017 and Arka Anamika in *kharif* 2019 showed high preference, whereas rest showed very high preference of whiteflies (Table 2). Further, promising okra genotypes namely EC360586, EC360794, EC360830 and EC361171 showed moderate preference of whitefly population in both the years of field screening (Table 2).

Detection of OELCuV: PCR amplification of DNA-β of OELCuV confirmed using Beta01F/ Beta02R universal primer pair amplified at 1.3 Kb for two (EC359828 and EC360915) randomly selected wild okra symptomatic accession, while no DNA-β amplification noticed for two randomly selected promising wild okra accession EC360794 and EC360830. The PCR product of 1.3 Kb was sequenced and showed 95.92% to 98.23% sequence similarity with OELCuV.

Four accessions namely EC360794, EC360586, EC361171 and EC360830 found resistant against OELCuD may be used as potential source of viral disease resistant donors for the resistant cultivar breeding.

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