Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(5): 2306-2313
Received: 24-07-2019
Accepted: 25-08-2019

Pasupathi E
Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University (TNAU), Madurai, Tamil Nadu, India

Murugan M
Department of Agricultural Entomology TNAU, Coimbatore, Tamil Nadu, India

Harish S
Department of Plant Pathology, Agricultural College and Research Institute, TNAU, Madurai, Tamil Nadu, India

Chinnaiah C
Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University (TNAU), Madurai, Tamil Nadu, India

Corresponding Author:
Pasupathi E
Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University (TNAU), Madurai, Tamil Nadu, India

Screening of okra germplasm for resistance to whitefly, *Bemisia tabaci* and okra enation leaf curl virus (OELCV) under field conditions

Pasupathi E, Murugan M, Harish S and Chinnaiah C

Abstract
Field screening of 88 okra germplasm was done for resistance against the sweet potato whitefly, *B. tabaci* and the begomoviruses, okra enation leaf curl virus (OELCV) and bhendi yellow vein mosaic virus (BYVMV) during two seasons (March, June sowing) of 2018 at Attur, Salem Distrct, Tamil Nadu. The lowest mean population of whiteflies was recorded in the okra accessions *viz.*,Upl mona 2 (0.35), Co 1 (0.4), *Abelomoschus moschattus* (0.65), Sona (0.78), where as accessions AE 66, IC 113920 and IC 282274 recorded the highest number of whiteflies with a mean population of 3.94, 3.45 and 3.24 adults per leaf. Among the accessions, one wild accession, *A. moschattus* and one cultivated accession *Upl mona 2* did not show any signs of OELCV and BYVMV infection throughout the crop period and exhibited immune reaction (0%) and *Upl mona 2* recorded the maximum yield. The highest OELCV per cent disease incidence (PDI) was recorded on AE 66 (100) followed by AE 64 (80) and AE 65 (80), while the PDI recorded susceptible check was 100%. The OELCV infected young leaves of selected okra accessions were collected from the screening field and was analyzed using DNA marker specific to coat protein based primer in polymerase chain reaction (PCR). The PCR amplified fragments were sequenced and compared for OELCV, and showed 99% similar sequence homology of already reported in NCBI data base. The finding could be highly useful in okra breeding programs against OELCV.

Keywords: Okra germplasm, Whitefly, OELCV, BYVMV, resistance field screening, PCR

Introduction
India ranks first in the world in okra/bhendi/ladies finger [*Abelmoschus esculentus* (L.) Moench] production with an annual yield of 5.853 mt from an area of 0.507 mha (Horticultural Statistics at a Glance, 2015). Okra is an important source of vitamins, calcium, potassium and other minerals, which are often lacking in the diet of the people in developing countries. Its' medicinal value has also been reported to cure ulcers and to relieve from hemorrhoids. Okra has found medical application as a plasma replacement or blood volume expander and also useful in genito-urinary disorders, spermatorrhoea and chronic dysentery (Abidia *et al*., 2014) [1]. The production and quality of okra fruits are affected by an array of sucking and fruit boring pests from the seedling phase until harvest. The key sucking pests of okra are whiteflies, aphids, jassids, thrips and mites (Anitha and Nandihalli, 2008) [2]. Among the sucking pests, the sweet potato whitefly, *Bemisia tabaci* Gennadius causes economic damage to okra by feeding on phloem sap, there by contaminating leaves and fruits with honey dew that causes sooty mould formation (Oliveira *et al*., 2001) [15]. Besides, the main challenge of *B. tabaci* comes from being the vector for begomoviruses on okra. Severe incidence of Bhendi yellow vein mosaic virus (BYVMV) and Okra enation leaf curl virus (OELCV) diseases are limiting the economic prospects of small growers of okra and thus discouraging them from cultivating the crop. The OELCV incidence has reached serious proportions in recent years both in Northern India (Sanwal *et al*., 2014) [19] and Southern India as well (Sayed *et al*., 2014) [20]. Infestations of *B. tabaci* may be reduced by applying insecticides (Hemadri *et al*., 2018) [8], adopting cultural techniques (Luko Hilje *et al*., 2001) [11] and using biological control agents (Hoddle *et al*., 1998) [9]. However, wider host adaptability, cryptic species status, and virus transmission capabilities have rendered the management of *B. tabaci* a worrisome practice (De Barro *et al*., 2011) [4]. *B. tabaci* has tremendous potential to develop resistance to insecticides and to date, this species had shown resistance to more than 40 active ingredients of insecticides (Whalon *et al*., 2013) [22]. Insecticides have been the mainstay of controlling *B. tabaci* in diverse agricultural production systems and historically, cotton and vegetables have accounted for more than 50 percent of insecticide usage in India (Gutierrez *et al*., 2015) [7], which may drastically damage the environment in longer-term. Alternatively, genetic plant resistance to pests requires no or low additional input costs and therefore receives immense attention.

Host plant resistance is an economically sound and ecologically safe method for managing insect pests including *B. tabaci* (Luko Hilje *et al*., 2001) [11]. Identification and categorization of sources of resistance is a prerequisite for developing arthropod resistant cultivars. The present paper utilized the hotspot region of OELCV occurrence to screen the available germplasms of okra for resistance against the incidence of begomoviruses (OELCV and BYVMV) on okra and its vector, *B. tabaci*.

Materials and Methods

Plant Material

Eighty eight okra germplasm accessions and two susceptible checks were screened to find out the resistance sources against whitefly, OELCV and BYVMV. Of these, one accession was from National Bureau of Plant Genetic Resources (NBPGR) New Delhi, 27 accessions were from NBPGR, Regional Station, Thrissur, 40 accessions were from the Tamil Nadu Agricultural University, Coimbatore, 20 accessions were from Indian Institute of Horticultural Research (IIHR), Bengaluru, Karnataka and the susceptible checks were received from Rasi Seeds Pvt. Ltd, Attur.

Field experiments

The field screening was conducted during March and June, 2018 seasons at Attur (Latitude and longitude: 11.598116, 78.596802), Salem District, Tamil Nadu. Each accession was raised in one row of 10 m with a spacing of 45 × 30 cm. The crop was raised as per the recommended package of practices and was without plant protection measures.

The performance of okra accessions against whitefly was recorded by counting the number of whiteflies from five randomly selected plants in each independent rows including susceptible and resistant checks. The whitefly adult population was observed on the lower surface of the leaves selected representing top, middle and bottom leaf canopy. The OELCV and BYVMV infestation was recorded based on the disease symptoms and damage score. A damage score of 0-6 scale [0 = immune (No plants showing any symptoms); 1 = Highly resistant (1-10% plants exhibiting symptoms); 2 = Moderately resistant (11-25% plants exhibiting symptoms); 3 = Tolerant (26-50% plants exhibiting symptoms); 4 = Moderately susceptible (51-60% plants exhibiting symptoms); 5 = Susceptible (61-70% plants exhibiting symptoms); 6 = Highly susceptible (71-100% plants exhibiting symptoms)] was used for grading the disease severity range (DSR) and per cent disease incidence (PDI) was calculated using the formula given below (Manjua *et al*., 2018) [12].

$$\text{Percent Disease Incidence (\%)} = \frac{\text{Number of plants infected}}{\text{Total number of plant}} \times 100$$

The accessions were categorized based on the PDI, DSR values and damage score. The scoring was recorded once at vegetative (30 days after sowing DAS) and second at flowering (60DAS) stages.

Molecular confirmation of OELCV

Selected OELCV symptom expressing and non-expressing okra accession leaves were collected from field trial at Attur, Salem District, Tamil Nadu and were stored in ice-cold boxes, transported to the laboratory and used for the study. The work was carried out at the Centre of Innovation, Department of Plant Biotechnology, Agricultural College and Research institute, TNAU, Madurai, Tamil Nadu.

DNA Extraction and Isolation

The protocol reported by Doyle and Doyle (1987) [6] in CTAB method was employed as briefly stated below with some modifications: 50-60mg of OELCV infected/non-infected fresh leaves of selected okra accessions were taken and ground with liquid nitrogen, after thawing again was ground in clean mortar with a preheated CTAB extraction buffer (1.5ml/sample) with 0.2% 2-beta mercaptoehanol. Then was incubated at 65 ^{0}C for 1 hour, and after that 1.5µL of RNase was added and incubated at 37 ^{0}C for 20 min. Then, it was centrifuged at 12000 rpm for 10 min to pellet the debris. Then, equal volume of chloroform: isoamyl alcohol (24:1 v/v) was added to the supernatant, gently vortexed for 10 min and centrifuged at 13000 rpm for 10 min. The supernatant was transferred in to 0.7 volume of ice-cold isopropanol and 0.15 volume ammonium acetate to precipitate DNA at -20 ^{0}C for 30 min. The precipitate was washed twice by adding 500µL of 70% chilled ethanol to remove ions and then absolute ethanol. The centrifugation was done at 13000 rpm for 1 min to pellet the DNA, then air dried and re-suspended in 50µL of TE buffer.

PCR Amplification

The universal primers (DengA/DengB), were used (Deng *et al*., 1994) [5] to detect begomovirus infections, was used initially to confirm the association of begomoviruses. For detection of OELCV, 100 ng of total DNA was used for PCR reaction using JKOE34F 5'-AAGAATTATGTCGAA GCGTCCTGCT T-3' (Forward primer) and JKOE35R 5'-AAGAATCGTAGA AGTAACTCCTAACTT-3' (Reverse primer) (Rakesh Kumar *et al*., 2016) [18]. The primer sequences were synthesized by Eurofins Genomics India (Bangaluru, India).

The cocktail for PCR amplification was prepared that contained: Template DNA (100ng/µl): 2.0 µl, Master mix: 10.0 µl, 10 m of forward primer: 2.0 µl, 10 m of reverse primer: 2.0 µl, Sterile double distilled water: 4.0 µl and Total: 20.0 µl. The reaction mixture was given a short spin for through mixing of the cocktail components. The PCR was conducted in a fast PCR machine (Medline, U.K) as programmed with the amplification reaction of 4 min initial denaturaion at 94 ^{0}C, 35 cycles of 30 seconds denaturaion at 94 ^{0}C, 30 seconds annealing at 50 ^{0}C and 45 seconds extension at for, 72 ^{0}C. A final 20 min extension step at 72 ^{0}C was performed after 35 cycles.

Statistical analysis

The whitefly population counts from different okra accessions were analyzed using randomized block design (RBD) considering each plant of individual accession being a replicate.

Results and Discussion

Screening of okra accessions under field conditions was taken up against the incidence of whitefly, OELCV and YVMV to identify the resistant sources and the results of the screening trial is reported hereunder.

Reaction of okra accessions against whitefly, *B. tabaci*

The results obtained from field evaluation of okra accessions against whiteflies during the two seasons of 2018 are presented in Table 2.

Out of the eighty eight okra accessions screened, the lowest mean population of whiteflies was recorded in Upl mona 2 (0.35), Co 1 (0.4), *A. moschattus* (0.65) and Sona (0.78) and

were on par with each other. The germplasm accessions, AE 66, IC 113920 and IC 282274 recorded the highest number of whiteflies with a mean population of 3.94, 3.45 and 3.24 whiteflies per leaf as compared to the OELCV check (4.09) and BYVMV check (7.93). Thus, AE 66, IC 113920 and IC 282274 were regarded as highly susceptible accessions by whiteflies. From the present results, it is evident that the whitefly population showed differential preference to okra accessions and both the accessions as well as crop age significantly influenced the whitefly population. The present findings are in agreement with another study on okra germplasm reaction to whitefly population (Prabhu and Warade, 2010) [17] which revealed that the wild accessions, viz., *A. moschatus* and *A. angulosus* were found to have minimum mean whitefly population per leaf, while maximum population per leaf was recorded on cultivated *A. esculentus* cultivars. Similar results were also reported in Nataraja *et al*. (2013) [14], wherein the okra accessions *viz*., IC331217, IC332453 and IC342075 and cultivars *viz*., Manisha-211 and *Arka anamika* were negligibly preferred over other genotypes/cultivars by whiteflies. The least preference of the okra accessions might be due to the varied morphological, nutritional and biochemical properties of the okra plants, which may interfere with the feeding, settling and ovipositional preference of *B. tabaci*. When it comes to host preference and colonization, there shall be a combination of visual, olfactory stimuli, nutritional characteristics of the phloem sap as well as specific toxic or attractive chemicals prevalent in the host plant arena are responsible. When the plants display resistance in phloem, there shall be increased xylem feeding, an indicator of dehydration, suggests that whiteflies are not ingesting enough phloem sap (Spiller *et al*., 1990; Powell and Hardie, 2002) [21, 16]. Phloem transmission of virus particles are pertinent for begomoviruses to establish in the plant hosts. Least preferred hosts were probed belatedly in comparison to a preferred host plant and such difference is equally noticed for the mean duration of phloem ingestion events (Milenovic *et al*., 2019) [13]. Hence, the okra accessions that are having less number of adult whiteflies identified from the present study might have disturbed the feeding process of the adult whiteflies.

Reaction of okra accessions against OELCV and BYVMV

The results obtained from the field trial on the evaluation of okra accessions against OELCV and BYVMV are presented in Table 2.

Screening studies indicated that at 60 DAS, one wild accession *A. moschattus* and one cultivated accession Upl mona 2 (Plate 1) did not show any signs of OELCV and BYVMV infections and were immune in reaction (0% PDI) and Upl mona 2 recorded the maximum yield (data not shown). The highest OELCV PDI was recorded on AE 66 (100) followed by AE 64 (80) and AE 65 (80), which were at par with the susceptible check (100%) whereas for BYVMV, the fifty one accessions are highly susceptible reaction.

Plate 1: Screening of okra germplam against sweet potato whitefly, *B. tabaci*, OELCV and BYVMV incidence in the field condition at Attur, Salem district, Tamil Nadu. Reaction of okra accessions to OELCV, Upl Mona 2 (Immune), Co 1 (Moderately Resistant) and AE 64 (Highly Susceptible). Symptoms exhibited by okra, AE 66 plants in close proximity in the field. Shown are the initial severe upward leaf curling and associated vein swelling and small enations on minor veins.

Based on pooled data of PDI recorded for the two seasons during 2018, the okra accessions were categorized and are presented in Table 2. Four accessions *viz*., Co 1, Samrat, AVT 14/4 and IC069303 exhibited moderately resistant reaction, whereas *Arka anamika*, AVT 14/5 and 307-10-1 exhibited moderately susceptible reaction to OELCV with an incidence range of 51-60 per cent. The okra accessions, AE 64, AE 65, AE 66, AVT 14/11 and AVT 14/10 showed a highly susceptible reaction to OELCV along with the susceptible check.

From the present results, it is evident that seventy six okra accessions including the one wild accession *A. moschattus* exhibited immune reaction, whereas four accessions showed moderately resistant reaction, three accessions exhibited moderately susceptible and five accessions showed a highly susceptible reaction to OELCV. But, in contradiction to their reaction for OELCV incidence, much of the accessions showed YVMV infection symptoms, except the one wild accession *A. moschattus*, Upl mona 2, AE 64, AE 65 and AE 66. In a study made by Bag *et al*. (2012), okra germplasm with resistant reaction to BYVMV were identified reporting 7 resistant and 19 moderately resistant okra accessions. However, in the present study peculiar results were obtained and it is intriguing that in the similar condition, disease reactions varied with the okra accessions where the same group of viruses (begomoviruses: OELCV and BYVMV) that are transmitted by neither seed or sap and at the same time being transmitted by one and the same vector species, *B. tabaci*. This could be due to the variability in acquisition access and inoculation access periods for the individual viruses based on feeding process of the vector, *B. tabaci* or else could be the kind of resistance offered by the factors in the pathway of feeding by *B.t abaci* adults to reach the phloem of okra plants. Research prospects addressing the above aspects will shed the light to resolve the issues behind such a variation in the disease reaction of okra.

Molecular confirmation

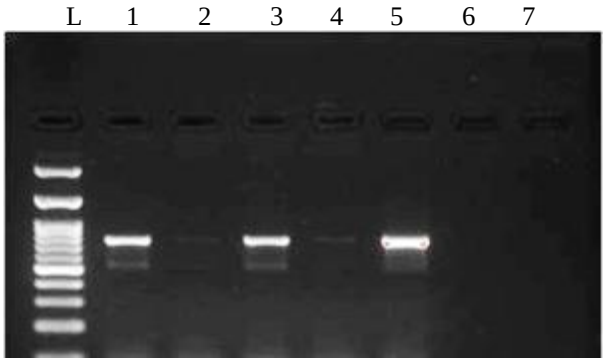

Plate 2: Polymerase chain reaction amplification of coat protein gene of OELCV using

JK primers (JKOE34F = 5'AAGAATTATGTCGAAGCGTC CTGCTT3'; JKOE35R - 5'AAGAATCGTAGAAGTAACTC CTAACTT3') from leaf samples of selected okra accessions from field screening experiment at Attur, Tamil Nadu in March 2018 Lane L) - Marker (100 bp Ladder), Lane 1 - AE 64, Lane 2 - Upl Mona 2, Lane 3 - AE 65, Lane 4 - Samrat, Lane 5 - AE 66, Lane 6 - Co1, Lane 7 - *A. moschattus*
Amplification of OELCV using specific primers (JKOE34F, JKOE35R) produced 796 bp band (Plate.2) from okra leaves. The sequenced DNA fragment had yielded 99% homology with OELCV coat protein (CP) gene deposited in the National Center for Biotechnology Information (NCBI). There was no amplification of the CP gene fragment from the resistant accessions *viz.*, Upl Mona 2, Samrat and Co1 whereas there was successful amplification noticed with the susceptible AE64, AE65 and AE 66 accessions. This had indicated that the resistant sources of the OELCV identified from the present study had not taken up the infection of the OELCV inspite of heavy load of the pathogen in the locality as the susceptible lines were expressing severe disease symptoms.

Conclusion

In India, okra crop is highly susceptible to BYVMV and OELCV disease probably due to warm tropical climate and intensive and continous crop cultivation, which supports survival of whitefly population round the year. Host plant resistance to virus is one of the most practical, economical and environmental friendly strategies for reducing yield loss in okra. In the present study, one of the cultivated accession Upl mona 2 and one wild accession *A. moschattus* showed immune reaction to both OELCV and BYVMV during both the seasons. Upl Mona 2 possessed good yield attributes. The wild accession *A. moschattus* should be exploited for transfer of resistance to okra infecting begomoviruses. Understanding the resistance characteristics of the okra accessions at the laboratory level to know the mechanisms is important, because only few lines have registered resistant reaction to both the OELCV and BYVMV incidences and others were either susceptible to OELCV and BYVMV. This phenomena needs to be explored in the near future.

Table 1: Screening of okra, *Abelmoschus* germplasm against the incidence of whitefly *B. tabaci* and the begomoviruses OELCV and YVMV diseases vectored by whitefly under field conditions in two seasons during, 2018

Germplasm	I Season, 2018 (March)						II Season, 2018 (June)					
	No. of whitefly adults/leaf/plant*		Percent Disease Incidence				No. of whitefly adults/leaf/plant*		Percent Disease Incidence			
			OELCV		YVMV				OELCV		YVMV	
	30 DAS	60DAS	30DAS	60DAS	30DAS	60DAS	30 DAS	60DAS	30DAS	60DAS	30DAS	60DAS
AE 36	2.00	0.67	0	0	100	100	0.20	0.47	0	0	60	80
IC45806	3.73	1.00	0	0	80	100	0.67	1.00	0	0	30	60
Co 1	4.27	0.40	10	10	0	33.3	0.4	0.53	10	20	30	40
AE 24	2.47	1.80	0	0	100	100	0.33	1	0	0	90	100
VROB 178	2.27	0.80	0	0	77.7	100	0.60	0.73	0	0	10	100
AVT 14/4	1.87	1.27	0	0	44.4	88.8	0.33	0.53	0	20	10	90
Arka anamika	3.80	1.67	0	0	62.5	100	0.07	2.67	0	0	40	100
AVT 14/5	2.53	1.00	60	60	40	50	0.40	0.20	10	60	10	40
IC 45792	8.33	0.33	0	0	100	100	2.3	1.07	0	0	80	100
AE 65	3.5	0.7	70	80	0	0	0.33	0	80	80	0	0
IC 45802	8.20	0.87	0	0	100	100	0.6	0.40	0	0	40	80
AE 64	5.60	1.27	80	80	0	0	0.60	0.3	70	80	0	0
AE 42	2.60	0.93	0	0	77.7	100	0.67	0.40	0	0	35.7	100
IC 189926	4.07	0.47	0	0	10	20	0.53	0.93	0	0	7.1	100
Samrat	2.47	1.07	0	10	10	10	0.73	0.20	0	20	20	20
AE 23	2.87	0.40	0	0	100	100	0.73	0.53	0	0	13.3	100
AE 66	15.00	0.17	100	100	0	0	0.13	0.47	100	100	0	0
AE 26	4.73	0.67	0	0	100	100	0.6	0.67	0	0	66.6	100
AE 35	2.73	0.67	0	0	77.7	100	0.33	0.60	0	0	21.4	100
AE 63	2.27	1.13	0	0	100	100	0.33	0.53	0	0	53.5	100
IC 218886	3.80	0.80	0	0	100	100	0.2	1.07	0	0	44.4	88.8
SB 2	3.67	0.73	0	0	100	100	0.47	0.07	0	0	22.2	87.5
VROB 178	3.07	1.13	0	0	71.4	85.7	0.13	0.73	0	0	10	80
Kashi Lalima	2.89	0.33	0	0	100	100	0.53	0.60	0	0	11.1	88.8
Kashi Sathabahar	2.67	1.27	0	0	90.9	90.9	0.73	1.13	0	0	30	40
IC 113920	10.47	1.80	0	0	83.3	100	0.73	0.80	0	0	40	70
AE 14	2.00	1.00	0	0	100	100	0.20	0.87	0	0	40	60
IC 128126	5.53	1.3	0	0	100	100	0.4	0.33	0	0	10	70
IC 282239	4.5	0.5	0	0	88.8	100	0.33	1.13	0	0	50	80
AE 6	3.27	1.33	0	0	70	100	0.2	0.47	0	0	80	90
IC 069232	7.0	0.33	0	0	100	100	0.40	0.47	0	0	70	90

IC 069303	5.40	0.73	0	10	75	87.5	0.07	0	0	20	10	90
Abelomoschus moschattus	1.67	0	0	0	0	0	0.27	0.67	0	0	0	0
IC 140896	4.13	0.33	0	0	75	87.5	0.67	0.67	0	0	33.3	100
AE 30	4.87	1.07	0	0	100	100	0.20	0.73	0	0	53.3	100
IC 282275	6.33	0.33	0	0	100	100	0.8	0.33	0	0	40	60
AVT 14/11	2.56	0.89	70	80	0	20	0.73	0.13	7.14	88.8	21.4	37.5
IC 282274	12.33	0.25	0	0	100	100	0.13	0.27	0	0	30	70
IC 111466	9.27	0.53	0	0	100	100	0.89	0.11	0	0	66.6	100
AE 16	7.07	0.73	0	0	80	90	0.53	0.73	0	0	40	80
IC 069263	7.5	0.2	0	0	100	100	0.4	0.87	0	0	60	70
AE 5	4.5	0.3	0	0	100	100	0.33	0.20	0	0	70	70
IC 43720	6.5	0.4	0	1	87.5	100	0.40	0.27	0	0	60	80
AE 19	5.6	1.2	0	0	100	100	0.60	0.60	0	0	53.3	66.6
IC 139340	3.2	0.5	0	0	75	100	0.47	0.2	0	0	50	60
IC 113922	7.3	0.8	0	0	100	100	0.53	0.33	0	0	46.6	53.3
AE 3	6.9	1.2	0	0	40	100	0.47	0.13	0	0	53.3	66.6
AE 10	3.0	0.6	0	0	100	100	1.40	0.60	0	0	40	70
AE 7	2.7	0.7	0	0	100	100	0.20	0.67	0	0	40	80
IC 282251	5.5	0.7	0	0	100	100	0.20	0.40	0	0	40	90
AE 22	5.3	1.3	0	0	100	100	1.27	0.53	0	0	80	90
IC 282252	6.0	0.3	0	0	100	100	0.27	0.73	0	0	30	90
IC 169358	5.3	0.5	0	0	100	100	0.27	0.13	0	0	40	90
AE 4	5.3	0.9	0	0	100	100	0.08	0.60	0	0	90	100
IC 069237	5.4	0.3	0	0	100	100	1.00	0.13	0	0	88.8	100
AE 8	2.3	0.7	0	0	100	100	1.33	0.47	0	0	20	80
IC 069211	4.5	0.3	0	0	100	100	0.87	0.60	0	0	40	70
IC 085581	5.60	0.47	0	0	100	100	1.2	0	0	0	90	100
AE 27	5.87	0.47	0	0	80	100	0.60	0.93	0	0	20	100
IC 069113	5.27	0.27	20	20	60	90	0.33	0.47	0	0	30	40
IC 069290	4.78	0.22	0	0	70	100	0.6	0.40	0	0	40	70
Upl mona 2	0.87	0.07	0	0	0	0	0.33	0.13	0	0	0	0
NO 315	3.60	1.27	0	0	50	90	0.60	1.2	0	0	10	80
IC 069242	1.60	0.60	0	0	100	100	0.40	0.73	0	0	70	90
IC 282242	4.47	1.67	0	0	100	100	1.2	0.93	0	0	11.1	88.8
AVT 14/10	4.93	0.73	77.77	77.77	0	20	0.33	0.40	70	80	10	30
IC 069172	4.47	0.93	0	0	100	100	0.47	0.27	0	0	30	70
IC 069304	4.33	0.33	0	0	100	100	0.20	0.20	0	0	60	80
AE 1	3.53	0.60	0	0	70	100	0.53	0.47	0	0	40	70
307-10-1	4.13	1.07	60	60	20	40	0.47	0.13	13.33	55.5	33.3	100
AE 12	3.80	0.53	0	0	80	100	0.20	0.93	0	0	66.6	100
AE 13	5.60	0.53	0	0	80	100	1.00	1	0	0	50	70
IC 329361	3.67	0.25	0	0	40	100	0.40	0	0	0	40	80
IC 282235	8.33	1.67	0	0	100	100	0.27	0.33	0	0	70	100
AE 15	7.60	0.53	0	0	20	100	1.6	0.67	0	0	40	90
IC 33301	6.40	0.40	0	0	100	100	0.53	0	0	0	20	70
Kashi Satadhari	5.67	0.60	0	0	80	90	0.73	1.13	0	0	60	80
IC 111527	6.07	0.40	0	0	66.6	100	0.11	0.33	0	0	20	40
AE 62	15.00	1	0	0	40	60	1.00	0.47	0	0	40	80
IC 003345	7.87	1.27	0	0	100	100	0.47	0.27	0	0	60	80
IC 085583	2.33	0.67	0	0	50	60	0.60	0.47	0	0	40	70
IC 069258	7.40	0.93	0	0	100	100	0.47	0.33	0	0	90	100
IC 069302	4.13	0.73	0	0	100	100	0.4	0.40	0	0	44.4	88.8
AE 17	2.87	0.67	0	0	70	100	0.00	0.73	0	0	40	80
IC 45802	4.78	0.22	0	0	66.6	100	0.6	0.40	0	0	40	80
IC 43720	7.00	0.40	0	0	88.8	100	0.40	0.27	0	0	60	70
Sona	1.67	0.67	0	10	20	40	0.40	0.4	10	10	30	30
IC 45806	7.67	0.33	0	0	100	100	0.27	0.73	0	0	20	60
OELCV Check	14.20	1.27	100	100	0	0	0.60	0.3	100	100	0	0
YVMV Check	6.33	0.93	0	0	100	100	0.27	0.40	0	0	100	100
SEd	0.3488	0.3946					0.3596	0.3391				
CD(.05)	0.6860	0.7761					0.7071	0.6668				

* Average of observation on five plants

Table 2: Mean incidence of Whitefly, *B. tabaci* and the begomoviruses OELCV and YVMV in the field screening of okra, *Abelmoschus* germplasm over two seasons during, 2018

Germplasm	Whitefly adults/ leaf/ plant	OELCV occurrence at 60 DAS				YVMV occurrence at 60 DAS			
		Percent Disease Incidence (%)	Disease Severity Range (%)	Grade	Reaction	Percent Disease Incidence (%)	Disease Severity Range (%)	Grade	Reaction
AE 36	0.83	0	0	0	Immune	80	71-100	6	HS
IC45806	1.6	0	0	0	Immune	60	51-60	4	MS
CO 1	0.4	20	11-25	2	MR	40	26-50	3	Tolerant
AE 24	1.4	0	0	0	Immune	100	71-100	6	HS
VROB 178	1.1	0	0	0	Immune	100	71-100	6	HS
AVT 14/4	1	20	11-25	2	MR	90	71-100	6	HS
Arka anamika	2.05	0	51-60	4	MS	100	71-100	6	HS
AVT 14/5	1.03	60	51-60	4	MS	40	26-50	3	Tolerant
IC 45792	3.00	0	0	0	Immune	100	71-100	6	HS
AE 65	1.13	80	71-100	6	HS	0	0	0	Immune
IC 45802	2.51	0	0	0	Immune	80	71-100	6	HS
AE 64	1.94	80	71-100	6	HS	0	0	0	Immune
AE 42	1.15	0	0	0	Immune	100	71-100	6	HS
IC 189926	1.5	0	0	0	Immune	100	71-100	6	HS
Samrat	1.11	20	11-25	2	MR	30	26-50	3	Tolerant
AE 23	1.13	0	0	0	Immune	100	71-100	6	HS
AE 66	3.94	100	71-100	6	HS	0	0	0	Immune
AE 26	1.58	0	0	0	Immune	100	71-100	6	HS
AE 35	1.08	0	0	0	Immune	100	71-100	6	HS
AE 63	1.08	0	0	0	Immune	100	71-100	6	HS
IC 218886	1.46	0	0	0	Immune	88.8	71-100	6	HS
SB 2	1.23	0	0	0	Immune	87.5	71-100	6	HS
VROB 178	1.10	0	0	0	Immune	80	71-100	6	HS
Kashi Lalima	1.08	0	0	0	Immune	88.8	71-100	6	HS
Kashi Sathabahar	1.45	0	0	0	Immune	40	26-50	3	Tolerant
IC 113920	3.45	0	0	0	Immune	70	61-70	5	S
AE 14	1.01	0	0	0	Immune	60	51-60	4	MS
IC 128126	1.89	0	0	0	Immune	70	61-70	5	S
IC 282239	1.61	0	0	0	Immune	80	71-100	6	HS
AE 6	1.31	0	0	0	Immune	90	71-100	6	HS
IC 069232	2.05	0	0	0	Immune	90	71-100	6	HS
IC 069303	1.55	20	11-25	2	MR	90	71-100	6	HS
Abelomoschus moschattus	0.65	0	0	0	Immune	0	0	0	Immune
IC 140896	1.45	0	0	0	Immune	100	71-100	6	HS
AE 30	1.71	0	0	0	Immune	100	71-100	6	HS
IC 282275	1.94	0	0	0	Immune	60	51-60	4	MS
AVT 14/11	1.07	88.8	71-100	6	HS	37.5	26-50	3	Tolerant
IC 282274	3.24	0	0	0	Immune	70	61-70	5	S
IC 111466	2.7	0	0	0	Immune	100	71-100	6	HS
AE 16	2.26	0	0	0	Immune	80	71-100	6	HS
IC 069263	2.24	0	0	0	Immune	70	61-70	5	S
AE 5	1.33	0	0	0	Immune	70	61-70	5	S
IC 43720	1.89	0	0	0	Immune	80	71-100	6	HS
AE 19	2	0	0	0	Immune	66.6	61-70	5	S
IC 139340	1.09	0	0	0	Immune	60	51-60	4	MS
IC 113922	2.24	0	0	0	Immune	53.3	51-60	4	MS
AE 3	2.17	0	0	0	Immune	66.6	61-70	5	S
AE 10	1.4	0	0	0	Immune	70	61-70	5	S
AE 7	1.06	0	0	0	Immune	80	71-100	6	HS
IC 282251	1.7	0	0	0	Immune	90	71-100	6	HS
AE 22	2.1	0	0	0	Immune	90	71-100	6	HS
IC 282252	1.82	0	0	0	Immune	90	71-100	6	HS
IC 169358	1.55	0	0	0	Immune	90	71-100	6	HS
AE 4	1.72	0	0	0	Immune	100	71-100	6	HS
IC 069237	1.70	0	0	0	Immune	100	71-100	6	HS
AE 8	1.2	0	0	0	Immune	80	71-100	6	HS
IC 069211	1.56	0	0	0	Immune	70	61-70	5	S
IC 085581	1.81	0	0	0	Immune	100	71-100	6	HS
AE 27	1.96	0	0	0	Immune	100	71-100	6	HS
IC 069113	1.58	0	0	0	Immune	40	26-50	3	Tolerant
IC 069290	1.5	0	0	0	Immune	70	61-70	5	S
Upl mona 2	0.35	0	0	0	Immune	0	0	0	Immune
NO 315	1.66	0	0	0	Immune	80	71-100	6	HS

IC 069242	0.83	0	0	0	Immune	90	71-100	6	HS
IC 282242	2.06	0	0	0	Immune	88.8	71-100	6	HS
AVT 14/10	1.59	80	71-100	6	HS	30	26-50	3	Tolerant
IC 069172	1.53	0	0	0	Immune	70	61-70	5	S
IC 069304	1.26	0	0	0	Immune	80	71-100	6	HS
AE 1	1.28	0	0	0	Immune	70	61-70	5	S
307-10-1	1.45	55.5	51-60	4	MS	100	61-70	5	S
AE 12	1.36	0	0	0	Immune	100	71-100	6	HS
AE 13	2.03	0	0	0	Immune	70	61-70	5	S
IC 329361	1.08	0	0	0	Immune	80	71-100	6	HS
IC 282235	2.65	0	0	0	Immune	100	71-100	6	HS
AE 15	2.6	0	0	0	Immune	90	71-100	6	HS
IC 33301	1.83	0	0	0	Immune	70	61-70	5	S
Kashi Satadhari	2.03	0	0	0	Immune	80	71-100	6	HS
IC 111527	1.72	0	0	0	Immune	40	26-50	3	Tolerant
AE 62	4.36	0	0	0	Immune	80	71-100	6	HS
IC 003345	2.47	0	0	0	Immune	80	71-100	6	HS
IC 085583	1.01	0	0	0	Immune	70	61-70	5	S
IC 069258	2.28	0	0	0	Immune	100	71-100	6	HS
IC 069302	1.31	0	0	0	Immune	88.8	71-100	6	HS
AE 17	1.06	0	0	0	Immune	80	71-100	6	HS
IC 45802	1.5	0	0	0	Immune	80	71-100	6	HS
IC 43720	2.01	0	0	0	Immune	70	61-70	5	S
Sona	0.78	60	51-60	4	MS	30	26-50	3	Tolerant
IC 45806	2.25	0	0	0	Immune	60	51-60	4	MS
Oelcv Check	4.09	100	71-100	6	HS	0	0	0	Immune
YVMV Check	7.93	0	0	0	Immune	100	71-100	6	HS

HR- Highly Resistant; MR- Moderately Resistant; MS- Moderately Susceptible; S- Susceptible; HS- Highly Susceptible.
DAS- Days after sowing.

References

1. Abidia AB, Priya Singha, Varun Chauhana, Brahm Kumar Tiwaria, Shubhendra Singh Chauhan, Sobita Simonb and Bilalc S. An overview on okra (*Abelmoschus esculentus*) and it's importance as a nutritive vegetable in the world. International Journal of Pharmacy and Biological Sciences. 2014; 4(2):227-233.
2. Anitha KR, Nandihalli BS. Seasonal incidence of sucking pests in okra ecosystem. Karnataka Journal of Agricultural Sciences. 2008; 21:137-138.
3. Bag MK, Anirban R, Gangopadhyay KK, Dutta M. Evaluation of wild okra germplasm against yellow vein mosaic disease for their value added utilization to sustain livelihood through agriculture. National Bureau of Plant Genetic Resources, 2012.
4. De Barro PJ, Liu SS, Boykin, LM, Dinsdale AB. Bemisia tabaci: a statement of species status. Annu. Rev. Entomol. 2011; 56:1-19.
5. Deng D, McGrath PF, Robinson DJ, Harrison BD. Detection and differentiation of whitefly transmitted geminivirus in plants and vector insects by the polymerase chain reaction with degenerate primers. Ann Appl Biol. 1994; 125(2):327-336.
6. Doyle JJ, Doyle JL. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. Phytochem Bull. 1987; 19:11-15.
7. Gutierrez AP, Ponti L, Herren HR, Baumgärtner J, Kenmore PE. Deconstructing Indian cotton: weather, yields, and suicides. Environ. Sci. Eur. 2015; 27:1-17.
8. Hemadri T, Vijaykumar L, Somu G, Moulya MR. Management of whitefly, Bemicia tabaci in okra (*Abelmoschus esculents* L.) through new insecticide molecules. International Journal of Chemical Studies. 2018; 6(2):691-694.
9. Hoddle MS, Van Driesche RG, Sanderson JP. Biology and use of the Whitefly parasitoid encarsia Formosa. Annu. Rev. Entomol. 1998; 43:645-69.
10. http://www.ncbi.nlm.nlh.gov.
11. Luko Hilje, Heather S, Costa, Philip A, Stansly. Cultural practices for managing Bemisia tabaci and associated viral diseases. Crop Protection. 2001; 20:801-812.
12. Manjua KP, Vijaya Lakshmia K, Sarath Babub B, Anithab K. Evaluation of okra germplasm for their reaction to whitefly, Bemisia tabaci and Okra yellow vein mosaic virus (OYVMV). Journal of Entomology and Zoology Studies. 2018; 6(2):2491-2496.
13. Milenovic M, Wosula EN, Rapisarda C, Legg JP. Impact of Host Plant Species and Whitefly Species on Feeding Behavior of Bemisia tabaci. Front Plant Sci. 2019; 10:1. DOI: 10.3389/fpls.2019.00001.eCollection 2019.
14. Nataraja MV, Chalam MSV, Madhumathi T, Srinivasa Rao. Screening of okra genotypes against sucking pests and Yellow vien mosaic virus disease under field condition. Indian Journal of Plant Protection. 2013; 41:226-230.
15. Oliveira MRV, Henneberry TJ, Anderson P. History, current status, and collaborative research projects for Bemisia tabaci. Crop Protection. 2001; 20:709-723.
16. Powell G, Hardie J. Xylem ingestion by winged aphids, in Proceedings of the 11th International Symposium on Insect-Plant Relationships (Dordrecht: Springer), 2002, 103-108.
17. Prabhu T, Warade SD. Biochemical Basis of Resistance to Yellow Mosaic Virus in Okra. Journal of Vegetable Science. 2010; 36:283-287.
18. Rakesh Kumar, Ventata Rao, Ramchandra E, Sairam Reddy P. Global prospectives in virus disease management, International conference: virocon. Bengeluru, India, 2016.
19. Sanwal SK, Singh, Major, Singh B, Naik PS. Resistance to Yellow Vein Mosaic Virus and Okra Enation Leaf Curl Virus: challenges and future strategies. Current Science. 2014; 106(11):1470-1.

20. Sayed SS, Rana D, Krishna G, Reddy PS, Bhattacharya PS. Association of Begomovirus with Okra (*Abelmoschus esculentus* L.) leaf curl virus disease in southern India. SAJ Biotechnoly. 2014; 1:102.
21. Spiller NJ, Koenders L, Tjallingii WF. Xylem ingestion by aphids a strategy for maintaining water balance. Entomol. Exp. Appl. 1990; 55:101-104.
22. Whalon ME, Mota Sanchez D, Hollingworth RM, Gutierrez R. Michigan State University, Arthropod Pesticide Resistance Database, 2013. Available at: http://www.pesticideresistance.com/Accessed January 5, 2016.