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Screening of okra genotypes against whitefly *Bemisia tabaci* (Gennadius) and yellow vein mosaic virus under field and glass house condition

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Abstract
Field trials were conducted at Tamil Nadu Agriculture University, Vegetable orchard to evaluate the thirty three okra genotypes against whitefly and yellow vein mosaic virus under field and glasshouse condition. The result revealed the highest mean number of whitefly was recorded on EC 359995 (11.08/plant) while the minimum mean whitefly population was observed on EC 305607 (1.83/plant) followed by EC 306703 (2.10/plant), EC 014026 (2.29/plant) and EC 305741 (2.57/plant). The result indicated that EC 305740 and EC 359995 genotypes showed the morphological traits long and broader leaf size positively correlated to whitefly population development. The result indicated that trichome density positively correlated with the whitefly population development. The genotype EC 359995 showed highest trichome density were recorded on adaxial (48.50 trichomes / cm^2), abaxial (103.75 trichomes / cm^2) and mid rib (60.17 trichomes / cm^2). The genotype AE 65 showed minimum trichome density on adaxial (17.25 trichomes / cm^2), abaxial (34.67 trichomes / cm^2) and mid rib (24.62 trichomes / cm^2). The genotype EC 359995, EC 306703, CO 1 and AE 65 showed high whitefly population and high yield produce tolerance effect in high yielded genotype.

Keywords: whitefly, yellow vein mosaic virus, okra, trichomes and fruit yield

Introduction
Okra (*Abelmoschus esculentus* L.) is commonly known as bhendi or lady's finger belongs to family Malvaceae, and is an important vegetable crop growing in India throughout the year. It is an important component in human diet due to its dietary fibers, and rich in magnesium folate, antioxidants, potassium, vitamins C, K1 and A (Hughes, 2008) [5].

The whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is one of the most devastating insect pests in agriculture crops worldwide (Brown *et al.*, 1995, De Barro *et al.*, 2000) [2, 3]. *B. tabaci* causes economic damage to bhendi by feeding on phloem sap, there by contaminating leaves and fruits with honey dew that causes sooty mould formation (Oliveira *et al.*, 2001) [8].

YVMV disease is characterized by various levels of chlorosis and yellowing of veins and veinlets, smaller leaves, fewer and smaller fruits and stunting (Venkataravanappa *et al.*, 2012) [11]. Crop age influences the disease intensity and yield loss (Sastri and Singh, 1974; Ali *et al.*, 2005) [9, 1]. If the disease occurs in the first 20 days of crop growth, the total yield loss may reach up to 94% (Sastri and Singh, 1974) [9]. Plants of 50 and 65 days age suffer a yield loss as high as 84 and 49%, respectively (Ali *et al.*, 2005) [1]. The loss in yield, due to YVMV and/or OELCV in bhendi was found ranging from 30 to 100% depending on the age of the plant at the time of infection (Singh, 1996) [10]. Infection of 100% plants in a field is very common with yield loss going somewhere in the range of 50 and 94% (Fajinmi and Fajinmi, 2010) [4].

Under field conditions, infected plants were found to be associated with heavy infestations of the whitefly *B. tabaci*, the vector of begomoviruses (Venkataravanappa *et al.*, 2015a) [11]. The loss in yield, due to YVMV and/or OELCV in bhendi was found ranging from 30 to 100% depending on the age of the plant at the time of infection (Singh, 1996) [10]. With this background, the present study was undertaken to screening the okra accessions against whitefly and yellow vein mosaic virus under field and glass house conditions.

Materials and Methods
Field experiment was conducted in Tamil Nadu Agriculture University, vegetable orchard,

Coimbatore during June-August, 2018. The screening experiment was carried out in Randomized Complete Block design with two replications. Each test entry was sown in six meter row. After every 5 rows of test entries, one row of susceptible check (Arka Anamika) was raised to ensure whitefly infestation. The susceptible check sown in 2-4 rows surrounding the experimental area served as border crop. This border crop aids as a reservoir for the multiplication of whitefly population. Row to row and plant to plant spacing was 60cm and 30 cm. In the field screening, instead of inoculation, natural population buildup of test insects were allowed and population assessment was made from 15 to 90 days after sowing. No insecticide application was given to ensure maximum multiplication of whitefly under natural conditions.

Observations were recorded at weekly interval right from whitefly appearance to last picking of fruits of the crop. The number of whitefly was recorded in early morning hours by visual counting (absolute counting). For this, five plants were randomly selected, tagged in each plot, and three leaves (top, middle and bottom) from each plant were assessed. YVMV infestation was recorded based on the disease symptoms of YVMV and damage score (0-6 scale) were used for grading the per cent disease incidence. The percent disease index in each cultivar / line were recorded at 30, 45, 60, 75 and 90 days after sowing (DAS) and they were grouped into different categories according to scale given by (Ali *et al*., 2005) [1] from Immune (I) to highly susceptible (HS).

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

Disease rating scale (Ali *et al*., 2005) [1]

Rating scale	Severity Range (%)	Severity Grade
0	0.0	Immune
1	<10	Highly resistant (HR)
2	10 – 20	Resistant (R)
3	20 – 30	Moderately resistant (MR)
4	30 – 50	Moderately susceptible (MS)
5	50 – 70	Susceptible (S)
6	>70	Highly susceptible (HS)

Yield

From each entry, fruit yield was recorded individually from randomly selected 5 plants, until the plants died due to whitefly infestation. Data on fruit yield per plant were recorded from five randomly selected plants.

Mass culturing of whitefly

Bhendi, (*Abelmoschus esculentus* L. Moench), (cv. Arka Anamika) crop was raised in pots for culturing whitefly for screening and laboratory studies. These potted plants were kept in isolated area under glass house conditions, so as to avoid infestation from outside sources. The plants were allowed to grow and at the age of 30 days the test insect, *B. tabaci* was collected from naturally infested, insecticide free bhendi field and after confirming the identity they were introduced for development and maintenance of culture for further studies. The temperature and humidity of the glasshouse where the culture was maintained ranged from 25-32°C and 60-70% RH. The whiteflies were confined to potted plants covered with mylar cages with muslin cloth at the top to facilitate ventilation and handling of insects. The insects were transferred to healthy plants in pots whenever necessary using an aspirator. Care was taken to maintain an isogenic culture of the insect.

Pot culture screening

Studies were carried out to confirm results from field screening against whitefly, *B. tabaci* based on per leaf population density count under artificial infestation condition. Selected genotypes of bhendi were raised in Insectary, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore.

Seeds of test entries were sown in earthen pots and a single plant represents a replicate and each entry was replicated three times. Recommended pot mixture was used in each pot to raise the plants. Experiment was conducted using Completely Randomized Design (CRD) with three replications. No pesticide was sprayed on seedlings. After 30 days of sowing, 10 whiteflies per plant were released and observation on number of whiteflies per plant was recorded at 15 days interval. Whitefly population was counted on top, middle and bottom leaf of each replication.

Trichome density

The trichome density from leaf lamina, midrib and veins were enumerated from the leaves of selected okra entries. The trichome density on different okra accession was estimated by adopting the method suggested by (Maite *et al*., 1980) [6]. The leaf samples were collected from different okra germplasm and were cut into one square centimetre size. The leaf samples were heated in 20 ml of water in small glass vials for 15 minutes at 85 ^{o}C. Then the water was poured out and 20 ml of 96 per cent ethyl alcohol were added. The samples were boiled at 80 ^{o}C for 20 min. Then the alcohol were decanted and fresh alcohol were added till completely remove the chlorophyll from leaves. The leaf samples were boiled at 85 ^{o}C by adding 90 per cent concentrated lactic acid until the leaf segments were cleared. The leaf segments were mounted on clean slides using a drop of lactic acid to observe the trichome density. The number of trichomes per square centimetre area was counted under steriozoom microscope at 10 X magnification for each leaf samples.

Results and Discussion

The result revealed that none of the okra genotype was found to be completely free from whitefly infestation. The whitefly adult population was observed in all okra genotypes varied with significant difference ($p<0.05$). The highest mean number of whitefly was recorded on EC 359995 (11.08/plant) followed by EC 305740 (10.44/plant), EC 359898 (9.68/plant), EC 015036 (9.20/plant), EC 305714 (9.15/plant) and EC 305635 (9.05/plant). Moderate mean number of whitefly was recorded on genotypes EC 305769 (8.81/plant), CO 1 (8.53/plant), Arka Anamika (8.20/plant), AE 23 (7.65/plant), EC 02934 (7.54/plant), EC 359954 (7.50/plant) respectively. The lesser mean population was observed on EC 305607 (1.83/plant) followed by EC 306703 (2.10/plant), EC 014026 (2.29/plant) and EC 305741 (2.57/plant).

Whitefly population per leaf on various okra genotypes (Table 1) was showed the minimum number of population were appeared at 15 days old crop (0.80-4.50/plant) to 29 days old crop (1.50-5.10/plant). Afterwards the whitefly populations gradually increased and multiplied from 36 days old crop (1.50-5.10/plant) to 64 days old crop (2.90-21.0/plant). The whitefly populations fully decline from 71 days old crop

(1.80-22.30/plant) to 78 days (1.60-16.70/plant) old crop due to plant growth affected by YVMV symptoms.

The result indicated that EC 305740 and EC 359995 genotypes showed the morphological traits long and broader leaf size positively correlated to whitefly population development. The bhendi germplasm reaction to whiteflies (Nataraja *et al.,* 2013) [7] reported that wild bhendi germplasm accessions viz., IC331217, IC332453 and IC342075 and cultivars *viz.,* Manisha-211 and Arka Anamika were negligibly preferred over other genotypes/cultivars by whiteflies.

Since field screening was conducted without pesticide application, other non insect pests such as red spider mite, *Tetranychus urticae* also caused damage to okra crop. Hence, to assess resistance to whitefly alone, artificial screening under in pots under glasshouse condition was taken up with the selected six genotypes from field screening.

YVMV incidence

The data presented in Table 2 indicate that during *summer*, 2018 crop season the mean yellow vein mosaic disease incidence varied from 38.04 to 81.02 per cent. Among the thirty three genotypes, none of the genotypes showed resistant. The genotype AE 65 was categorized as moderately resistant (MR) with over all mean 38.04 per cent disease incidence. The genotype AE 64 and AE 66 were categorized as moderately susceptible (MS) with (30 – 50) per cent disease incidence of Grade-4. The genotype EC 305635, EC 305714, EC 359995, EC 359637, EC 360001, EC 013356, EC 305718 and Arka Anamika were rated as highly susceptible (HS) with (>70) per cent disease incidence of Grade-6. The remaining genotype exhibited (50-70) per cent disease incidence of Grade-5 and was categorized as susceptible (S) to YVMV.

The genotype Arka Anamika, AE 23, AE 27 and EC 305769 showed minimum per cent disease incidence of 27.78, 13.89, 8.33 and 5.56 at 15 days after sowing (DAS). The okra genotype EC 305718 showed highest per cent disease incidence of 100% was recorded at 45 days old crop. Nataraja *et al.,* (2013) [7] found genotypes viz., IC331217, IC332453 and IC342075 and cultivars viz., Manisha-211 and Arka Anamika tolerant against YVMV disease. The result indicated that highest per cent disease incidence (100%) was recorded at 75th and 90th days old crop whereas the early stage showed minimum yellow vein mosaic per cent disease incidence was observed at pre-flowering and flowering days.

Table 1: *Bemisia tabaci* Gen. infestation in okra genotypes (Field experiment – TNAU Vegetable orchard – June to August, 2018)

S. No	Okra genotype	Mean whitefly numbers/three leaves*										Mean(No./ plant)
		15 DAS	22 DAS	29 DAS	36 DAS	43 DAS	50 DAS	57 DAS	64 DAS	71 DAS	78 DAS	
1	AE 27	1.10 (1.05)^{abcde}	1.60 (1.26)^{abcdef}	2.10 (1.45)^{abcdef}	2.90 (1.70)^{abc}	4.0 (2.00)^{bcd}	5.90 (2.43)^{efg}	7.80 (2.79)^{efgh}	9.20 (3.03)^{e}	8.10 (2.85)^{cde}	6.80 (2.61)^{fg}	4.95
2	AE 65	1.60 (1.26)^{cdef}	2.30 (1.52)^{defghi}	2.90 (1.70)^{defghi}	3.30 (1.82)^{bcde}	3.90 (1.97)^{bcd}	5.10 (2.26)^{def}	6.20 (2.49)^{defg}	7.60 (2.76)^{cd}	5.60 (2.37)^{b}	4.20 (2.05)^{bcde}	4.27
3	AE 66	1.10 (1.05)^{abcde}	1.80 (1.34)^{bcdefg}	2.00 (1.41)^{abcdef}	2.90 (1.70)^{abc}	4.40 (2.10)^{bcd}	6.30 (2.51)^{efg}	8.20 (2.86)^{fgh}	9.50 (3.08)^{ef}	8.90 (2.98)^{de}	7.10 (2.66)^{g}	5.22
4	AE 23	2.60 (1.61)^{ghijk}	2.80 (1.67)^{ghijk}	2.80 (1.67)^{defgh}	4.10 (2.02)^{cdefg}	4.60 (2.14)^{bcd}	8.20 (2.86)^{ghi}	11.40 (3.38)^{klm}	14.30 (3.78)^{ijk}	14.70 (3.83)^{g}	11.00 (3.32)^{hi}	7.65
5	AE 64	1.80 (1.34)^{defg}	2.40 (1.55)^{efghi}	2.80 (1.67)^{defgh}	3.80 (1.95)^{cdefg}	4.40 (2.10)^{bcd}	4.90 (2.21)^{cde}	6.30 (2.51)^{defg}	6.70 (2.59)^{bc}	5.70 (2.39)^{b}	4.90 (2.21)^{cdef}	4.37
6	CO 1	2.20 (1.48)^{fghi}	3.20 (1.79)^{ijklm}	3.50 (1.87)^{ghijk}	5.0 (2.24)^{fgh}	5.40 (2.32)^{def}	8.70 (2.95)^{ij}	12.40 (3.52)^{klmn}	15.20 (3.90)^{jk}	16.90 (4.11)^{hi}	12.80 (3.58)^{ij}	8.53
7	EC 305635	2.80 (1.67)^{hijk}	3.40 (1.84)^{jklm}	3.30 (1.82)^{fghij}	4.60 (2.14)^{defgh}	6.90 (2.63)^{fg}	10.10 (3.18)^{jkl}	12.80 (3.58)^{klm}	15.20 (3.90)^{jk}	18.10 (4.25)^{ij}	13.30 (3.65)^{jk}	9.05
8	EC 305769	3.20 (1.79)^{jk}	3.90 (1.97)^{lmn}	4.30 (2.07)^{ijk}	5.60 (2.37)^{h}	7.30 (2.70)^{gh}	10.80 (3.29)^{klm}	12.70 (3.56)^{klm}	15.20 (3.90)^{jk}	14.10 (3.75)^{gh}	11.00 (3.32)^{hi}	8.81
9	EC 014026	0.50 (0.71)^{ab}	0.80 (0.89)^{a}	1.00 (1.00)^{ab}	1.90 (1.38)^{ab}	2.10 (1.45)^{a}	3.10 (1.76)^{abc}	3.60 (1.90)^{ab}	3.70 (1.92)^{a}	3.30 (1.82)^{a}	2.90 (1.70)^{abc}	2.29
10	EC 305714	2.70 (1.64)^{ghijk}	3.70 (1.92)^{klmn}	3.80 (1.95)^{hijk}	5.0 (2.24)^{bcdef}	6.40 (2.53)^{efg}	10.20 (3.19)^{jkl}	13.50 (3.67)^{lmno}	15.40 (3.92)^{jk}	17.90 (4.23)^{ij}	12.90 (3.59)^{ij}	9.15
11	EC 305768	1.60 (1.30)^{cdef}	2.50 (1.58)^{fghij}	2.90 (1.70)^{defghi}	4.0 (2.00)^{cdefg}	4.30 (2.07)^{bcd}	5.50 (2.35)^{ef}	6.60 (2.57)^{defg}	8.30 (2.88)^{cde}	7.20 (2.68)^{bcd}	5.70 (2.39)^{defg}	4.87
12	EC 359954	2.00 (1.41)^{efgh}	2.40 (1.55)^{efghi}	2.50 (1.58)^{cdefgh}	4.10 (2.02)^{cdefgh}	6.70 (2.59)^{fg}	8.80 (2.97)^{ijk}	10.90 (3.30)^{ijk}	13.90 (3.73)^{ij}	13.70 (3.70)^{fg}	10.00 (3.16)^{h}	7.50
13	EC 306700	0.90 (0.95)^{abcd}	1.50 (1.22)^{abcde}	1.80 (1.34)^{abcd}	2.70 (1.64)^{abc}	4.30 (2.07)^{bcd}	6.60 (2.57)^{efgh}	9.10 (3.02)^{ghi}	11.30 (3.36)^{fg}	8.80 (2.97)^{de}	6.40 (2.53)^{efg}	5.34
14	EC 305607	0.20 (0.45)^{a}	0.80 (0.89)^{a}	1.20 (1.10)^{abc}	2.0 (1.41)^{ab}	2.20 (1.48)^{a}	2.70 (1.64)^{a}	2.90 (1.70)^{a}	2.90 (1.70)^{a}	1.80 (1.34)^{a}	1.60 (1.26)^{a}	1.83
15	EC 305740	3.30 (1.82)^{k}	4.10 (2.02)^{mn}	4.30 (2.07)^{jk}	5.0 (2.24)^{fgh}	7.50 (2.74)^{gh}	10.20 (3.19)^{jkl}	13.80 (3.71) ^{no}	18.50 (4.30)^{l}	22.10 (4.70)^{k}	15.60 (3.95)^{kl}	10.44
16	EC 359995	3.20 (1.79)^{jk}	4.50 (2.12)^{n}	4.80 (2.19)^{kl}	5.10 (2.26)^{gh}	7.30 (2.70)^{gh}	11.10 (3.33)^{mn}	14.90 (3.86)^{o}	21.00 (4.58)^{m}	22.20 (4.71)^{k}	16.70 (4.09)^{l}	11.08
17	EC 359898	3.00 (1.73)^{ijk}	3.70 (1.92)^{klmn}	3.80 (1.95)^{hijk}	4.90 (2.21)^{efgh}	7.10 (2.66)^{g}	9.80 (3.13)^{klmn}	13.60 (3.69)^{lmno}	16.10 (4.01)^{k}	19.60 (4.43)^{j}	15.20 (3.90)^{k}	9.68
18	EC 305731	0.70 (0.84)^{abc}	1.50 (1.22)^{abcde}	2.30 (1.52)^{bcdefg}	2.80 (1.67)^{abc}	3.40 (1.84)^{abc}	5.20 (2.28)^{ef}	5.60 (2.37)^{cdef}	6.70 (2.59)^{cd}	5.90 (2.43)^{bc}	4.00 (2.00)^{abcd}	3.81
19	EC 306697	1.50 (1.22)^{cdef}	2.30 (1.52)^{defghi}	3.00 (1.73)^{defghij}	3.40 (1.84)^{bcdef}	4.10 (2.02)^{bcd}	5.50 (2.35)^{ef}	6.40 (2.53)^{defg}	7.60 (2.76)^{cde}	5.70 (2.39)^{b}	4.30 (2.07)^{bcde}	4.38
20	EC 306703	0.70 (0.84)^{abc}	0.90 (0.95)^{ab}	0.90 (0.95)^{a}	1.50 (1.22)^{a}	2.0 (1.41)^{a}	2.80 (1.67)^{ab}	3.70 (1.92)^{abc}	3.40 (1.84)^{a}	3.00 (1.73)^{a}	2.10 (1.45)^{ab}	2.10
21	EC 359637	1.40 (1.18)^{bcdef}	2.20 (1.48)^{defghi}	2.80 (1.67)^{defghij}	3.90 (1.97)^{cdefg}	4.40 (2.10)^{bcd}	5.70 (2.39)^{ef}	6.40 (2.53)^{bcde}	7.80 (2.79)^{cde}	7.20 (2.68)^{bcde}	5.10 (2.26)^{cdefg}	4.69
22	EC 305741	0.80 (0.89)^{abc}	1.10 (1.05)^{abc}	1.80 (1.34)^{abcd}	2.10 (1.45)^{ab}	3.0 (1.73)^{ab}	3.20 (1.79)^{abcd}	4.10 (2.02)^{abcd}	4.70 (2.17)^{ab}	3.40 (1.84)^{a}	1.50 (1.22)^{ab}	2.57

23	EC 305736	1.4 (1.18)^{bcdef}	1.90 (1.38)^{cdefgh}	2.90 (1.70)^{defghi}	3.90 (1.97)^{cdefg}	4.40 (2.10)^{bcd}	5.40 (2.32)^{ef}	6.50 (2.55)^{defg}	8.40 (2.90)^{de}	6.80 (2.61)^{bcde}	5.50 (2.35)^{defg}	4.71
24	EC 360001	1.80 (1.34)^{defg}	2.70 (1.64)^{ijklm}	3.20 (1.79)^{efghij}	4.10 (2.02)^{cdefgh}	5.50 (2.35)^{def}	7.20 (2.68)^{ghi}	8.40 (2.90)^{hij}	11.90 (3.45)^{gh}	9.40 (3.07)^{e}	6.60 (2.57)^{efg}	6.08
25	EC 013999	1.10 (1.05)^{abcde}	1.60 (1.26)^{abcdef}	2.50 (1.58)^{cdefgh}	3.50 (1.87)^{bcdefg}	4.60 (2.14)^{bcd}	5.70 (2.39)^{efg}	6.20 (2.49)^{defg}	8.50 (2.92)^{de}	7.70 (2.77)^{bcde}	5.00 (2.24)^{cdefg}	4.64
26	EC 013356	1.00 (1.00)^{abcd}	1.50 (1.22)^{abcde}	2.20 (1.48)^{abcdef}	2.80 (1.67)^{abc}	3.50 (1.87)^{abc}	5.20 (2.28)^{ef}	6.60 (2.57)^{defg}	8.00 (2.83)^{cd}	6.10 (2.47)^{bc}	3.40 (1.84)^{abc}	4.03
27	EC 433641	0.80 (0.89)^{abc}	1.40 (1.18)^{abcd}	1.90 (1.38)^{abcde}	2.70 (1.64)^{abc}	3.30 (1.82)^{abc}	4.80 (2.19)^{bcdef}	5.90 (2.43)^{bcdef}	6.80 (2.61)c^{d}	5.70 (2.39)^{b}	3.50 (1.87)^{abcd}	3.68
28	EC 015036	2.30 (1.52)^{fghij}	3.10 (1.76)^{hijkl}	3.50 (1.87)^{ghijk}	4.80 (2.19)^{efgh}	6.50 (2.55)^{fg}	10.20 (3.19)^{jkl}	13.90 (3.73)^{mno}	16.00 (4.00)^{k}	17.60 (4.20)^{ij}	14.10 (3.75)^{jk}	9.20
29	EC 009856	1.50 (1.22)^{cdef}	2.30 (1.52)^{defghi}	2.30 (1.52)^{bcdefg}	3.40 (1.84)^{bcdef}	4.90 (2.21)^{cde}	7.10 (2.66)^{fghi}	11.40 (3.38)^{ikl}	13.10 (3.62)^{ghi}	11.90 (3.45)^{f}	7.00 (2.65)^{fg}	6.49
30	EC 02934	2.70 (1.64)^{ghijk}	3.20 (1.79)^{ijklm}	3.40 (1.84)^{jk}	3.90 (1.97)^{cdefg}	4.80 (2.19)^{cd}	8.40 (2.90)^{hij}	11.20 (3.35)^{jkl}	13.80 (3.71)^{hij}	13.90 (3.73)^{gh}	10.10 (3.18)^{h}	7.54
31	EC 0133664	1.10 (1.05)^{abcde}	1.80 (1.34)^{bcdefg}	2.30 (1.52)^{bcdefg}	3.0 (1.73)^{abcd}	4.40 (2.10)^{bcd}	6.10 (2.47)^{efg}	7.40 (2.72)^{efgh}	9.30 (3.05)^{e}	8.40 (2.90)^{de}	5.60 (2.37)^{defg}	4.94
32	EC 305718	1.00 (1.00)^{abcd}	1.50 (1.22)^{abcde}	2.30 (1.52)^{bcdefg}	3.40 (1.84)^{bcdef}	4.30 (2.07)^{bcd}	5.00 (2.24)^{cde}	6.10 (2.47)^{cdef}	7.90 (2.81)^{cde}	6.90 (2.63)^{bcde}	4.80 (2.19)^{cdefg}	4.32
33	ArkaAnamika S*	3.20 (1.79)^{jk}	4.10 (2.02)^{mn}	5.60 (2.37)^{l}	7.60 (2.76)^{i}	8.70 (2.95)^{h}	12.5 (3.54) ^{n}	14.70 (3.83) ^{no}	11.70 (3.42)^{g}	7.80 (2.79)^{bcde}	4.60 (2.14)^{cdef}	8.05
	df	32	32	32	32	32	32	32	32	32	32	
	F values (0.05)	10.170	13.890	7.238	10.444	12.198	23.382	24.070	51.436	99.550	48.959	

DAS – Days after sowing; S* - Susceptible check
Figures in the parentheses are transformed values
In a column, means with similar letter(s) is/are not significantly different by LSD at P=0.05

Table 2: YVMV incidence in okra accessions (Field experiment - TNAU Vegetable orchard – 2019)

S. No	Okra genotype	Per cent BYVMD incidence						Over all mean	Resistant category
		Fortnight interval							
		15 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS		
1	AE 27	8.33	30.56	41.67	61.11	80.55	86.10	51.38	S
2	AE 65	0.00	0.00	33.33	41.67	61.10	72.21	38.04	MR
3	AE 66	0.00	0.00	27.78	61.11	86.10	94.44	44.9	MS
4	AE 23	13.89	41.67	55.55	77.50	100	100	64.77	S
5	AE 64	0.00	0.00	30.56	69.44	88.88	100	48.14	MS
6	CO 1	0.00	22.22	63.89	88.89	100	100	62.49	S
7	EC 305635	0.00	38.89	80.55	100	100	100	76.84	HS
8	EC 305769	5.56	27.78	69.44	94.44	100	100	66.2	S
9	EC 014026	0.00	33.33	88.89	94.44	100	100	69.44	S
10	EC 305714	0.00	25.00	69.44	94.44	100	100	71.47	HS
11	EC 305768	0.00	41.67	69.44	88.89	94.44	94.44	64.81	S
12	EC 359954	0.00	30.56	63.89	88.89	94.44	94.44	62.03	S
13	EC 306700	0.00	19.44	63.89	77.78	94.44	100	59.26	S
14	EC 305607	0.00	27.78	69.44	88.89	100	100	64.35	S
15	EC 305740	0.00	25.00	58.33	77.78	88.88	94.44	57.41	S
16	EC 359995	0.00	44.44	94.44	100	100	100	73.15	HS
17	EC 359898	0.00	13.89	55.55	94.44	100	100	60.65	S
18	EC 305731	0.00	13.89	69.44	94.44	100	100	62.96	S
19	EC 306697	0.00	22.22	77.78	94.44	100	100	65.74	S
20	EC 306703	0.00	36.11	86.11	91.67	100	100	68.98	S
21	EC 359637	0.00	44.44	94.44	100	100	100	73.15	HS
22	EC 305741	0.00	47.22	77.78	83.33	94.44	100	67.13	S
23	EC 305736	0.00	38.89	63.89	88.89	100	100	65.28	S
24	EC 360001	0.00	41.67	88.89	100	100	100	71.76	HS
25	EC 013999	0.00	33.33	86.11	100	100	100	69.91	S
26	EC 013356	0.00	72.22	94.44	100	100	100	77.78	HS
27	EC 433641	0.00	33.33	80.55	100	100	100	68.98	S
28	EC 015036	0.00	41.67	61.11	86.11	100	100	64.81	S
29	EC 009856	0.00	27.78	58.33	86.11	100	100	62.04	S
30	EC 02934	0.00	27.78	36.11	77.78	94.44	94.44	55.09	S
31	EC 0133664	0.00	19.44	58.33	86.11	100	100	60.65	S
32	EC 305718	0.00	86.11	100	100	100	100	81.02	HS
33	Arka Anamika *S	27.78	61.11	80.55	94.44	100	100	77.31	HS
SEd		0.22	0.18	0.19	0.24	-	-		
CD (P=0.05)		0.46	0.38	0.40	0.51	-	-		

DAS – Days after sowing; S* - Susceptible check
R - Resistant; MR – Moderately Resistant; S- Susceptible; HS – Highly susceptible.

Fruit yield per plant

Yield per plant was higher in CO 1 compared to other genotypes**.** CO 1 registered 212.49 g/plant while the lowest yield was recorded in EC 305718 (31.96 g/plant). The genotype EC 305731, EC 359954, EC 433641, EC 359995 and EC 306703 observed highest fruit yield it was 137.31, 130.66, 129.25, 119.79 and 119.48 g/plant. The genotypes, AE 65 and Arka Anamika recorded minimum fruit yield of 111.1 and 90.61 g/plant, respectively (Table 3).

The result showed that fruit yield per plant highly correlated with the whitefly population in screening field condition. The genotype EC 359995, EC 306703, CO 1 and AE 65 showed high whitefly population and high yield produce tolerance effect in high yielded genotype.

Pot screening

The results showed that whitefly population build up started from 30 DAS where crop stage seemed more preferable for whitefly. The population of whitefly augmented with the crop age and high whitefly infestation was recorded from 60 to 75 DAS. There was significant difference in whitefly population in each genotype.

The data presented in Table 4 showed the genotype EC 359995, Arka Anamika and EC 306703 harbored the highest whitefly adult population with mean value of 43.19, 40.47 and 34.33 whitefly / plant. While, AE 65 showed comparatively less whitefly population with pooled mean value of 13.69 whitefly / plant. The genotype EC 305607 and EC 14026 showed minimum population of 16.08 and 23.11 whitefly / plant.

Conclusion

In India, okra crop is highly susceptible to BYVMV and OELCV disease probably due to warm tropical climate and intensive and continuous 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, two okra accessions EC 014026 and EC 306703 showed less whitefly population and susceptible to BYVMV. The okra accessions EC 014026 and EC 306703 possessed good yield attributes. The okra accession AE 65 should be exploited for transfer of resistance to okra infecting begomoviruses. This phenomena needs to be explored in the near future.

Table 3: Relationship between whitefly, *B. tabaci* incidence with fruit yield of okra

S. No	Okra genotype	Mean whitefly population (Nos./ plant)	Yield**/ plant (g)
1	AE 27	4.95	59.41
2	AE 65	4.27	111.67
3	AE 66	5.22	48.55
4	AE 23	7.65	56.45
5	AE 64	4.37	47.87
6	CO 1	8.53	212.49
7	EC 305635	9.05	67.96
8	EC 305769	8.81	69.44
9	EC 014026	2.29	107.63
10	EC 305714	9.15	86.60
11	EC 305768	4.87	98.08
12	EC 359954	7.50	130.66
13	EC 306700	5.34	44.12
14	EC 305607	1.83	106.57
15	EC 305740	10.44	32.11
16	EC 359995	11.08	119.79
17	EC 359898	9.68	65.19
18	EC 305731	3.81	137.31
19	EC 306697	4.38	98.08
20	EC 306703	2.10	119.48
21	EC 359637	4.69	79.34
22	EC 305741	2.57	60.69
23	EC 305736	4.71	63.32
24	EC 360001	6.08	84.44
25	EC 013999	4.64	75.42
26	EC 013356	4.03	75.64
27	EC 433641	3.68	129.25
28	EC 015036	9.20	80.84
29	EC 009856	6.49	88.94
30	EC 02934	7.54	73.35
31	EC 0133664	4.94	56.30
32	EC 305718	4.32	31.96
33	Arka Anamika S*	8.05	90.61
	SEd CD (P=0.05)	- -	

S*- Susceptible check

**Each value is the mean of five replications.

Figures in parentheses are square root transformed values.

In a column, means sharing similar letter(s) is /are not significantly different by LSD at P=0.05.

Table 4: Whitefly (*Bemisia tabaci)* infestation in okra genotypes (Pot screening)

S. No	Okra Genotype	Whitefly No./plant			Mean Whitefly (No./plant)
		45 DAS	60 DAS	75 DAS	
1	Arka Anamika	9.25 (3.04)^{c}	37.50 (6.12)^{c}	74.67 (8.64)^{d}	40.47
2	EC 359995	10.08 (3.18)^{c}	42.42 (6.51)^{d}	77.08 (8.78)^{d}	43.19
3	AE 65	5.00 (2.24)^{ab}	14.00 (3.74)^{a}	22.08 (4.70)^{a}	13.69
4	EC 014026	5.67 (2.38)^{ab}	23.17 (4.81)^{b}	40.50 (6.36)^{b}	23.11
5	EC 306703	6.17 (2.48)^{b}	38.50 (6.20)^{c}	58.33 (7.64)^{c}	34.33
6	EC 305607	4.75 (2.18)^{a}	16.17 (4.02)^{a}	27.33 (5.23)^{a}	16.08
P value		20.732 34.50	612.25 112.63	2236.0 31.66	

DAS – Days after sowing; S*- Susceptible check

Figures in the parentheses are √ X + 1 transformed values

In a column, means sharing similar letter(s) is /are not significantly different by LSD at P=0.05.

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