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Screening and Identification of Resistant Sources of okra, *Abelmoschus esculentus* L. accessions against Whitefly, *Bemisia tabaci* Gennadius

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ABSTRACT: Field screening studies were conducted with 30 okra germplasm accessions against whitefly (*Bemisia tabaci* G.) and okra yellow vein mosaic virus (OYVMV) incidence during the summer season of 2022 at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli district of Tamilnadu. Among the 30 accessions screened none of the accession was found completely free from the whitefly population, although they differed significantly in pest number. The highest whitefly population was found during 18th and 19th standard meteorological weeks. The accessions IC 417885 (3.80/3 leaves/plant), NO 315 (3.02/3 leaves/plant), AE 65 (2.70/3 leaves/plant), EC 755648 (2.90/3 leaves/plant) and Arka Anamika (3.34/3leaves/plant) which was recorded maximum whitefly population. The accessions, GED 15, GED 11, AE 11, AE 62, AE 64, IC 43743, and Pusa Bhendi 5 recorded the lowest mean population of 1.16, 1.24, 1.08, 1.05, 1.01, 1.01 and 1.11 per 3 leaves per plant respectively. The percent disease incidence (PDI) was recorded against OYVMV for 30 okra accessions. The least PDI of 15.56 percent is recorded in the accession of GED 15 followed by the accessions AE 11, AE 62, AE 63, IC 43743, and Pusa Bhendi 5. The morphological parameters analysed in the selected okra accessions indicated that, among the morphological parameters the germplasm accessions possessing high trichome density, dark green leaf colour and less leaf area offered resistance mechanism against the whitefly and OYVMV. The identified highly resistant accessions *viz*, GED 15, GED 11, AE 11, AE 62, AE 64, IC 43743, and Pusa Bhendi 5 possessing the above characters were completely free from OYVMV, while the susceptible accession Arka Anamika possessing less trichome density, more leaf area, light green leaf colour were highly preferred by whitefly and OYVMV. The correlation studies revealed that, leaf area had positive correlation with whitefly and OYVMV, trichome density and dark green leaf colour had significant negative correlation with whitefly and OYVMV incidence.

Keywords: Okra accessions, whitefly, OYVMV, morphological parameters.

INTRODUCTION

Vegetables constitute an important source of human diet supplying carbohydrates, minerals, vitamins, proteins, dietary fibres, besides having medicinal value and provides nutritional security to the predominately vegetarian population. Among the many vegetables grown, okra, *Abelmoschus esculentus* L. the queen of vegetables is one of the important vegetables belongs to the family malvaceae and is locally known as okra or Lady's finger. Okra is predominantly grown in many tropical and subtropical parts of the world throughout the year for immature green non fibrous edible fruits (Singh *et al.*, 2014). India ranks second in vegetable production in the world, after China with an area of about 8.75 m.ha that contributes for 128243 MT and 14.66 MT/ha of production and productivity, respectively. India occupies first position in okra production with an area, production, and productivity of 498 thousand ha, 5784 thousand tons and 11.6 mt/ha, respectively. Okra requires a long, warm, and humid growing period. It can be successfully grown in hot humid areas. It is sensitive to frost and extremely low temperatures (Choudhary *et al.*, 2015).

One of the important limiting factors in the cultivation of okra is insect pests. Many of the insect pests occurring on cotton are found to ravage okra crop. As high as 72 species of insects have been recorded on okra (Srinivasa and Rajendran 2003) of which, the sucking pests causes significant damage to the crop.

Among the sucking pests whitefly causes significant damage to okra by feeding on phloem sap, thereby contaminating leaves and fruits with honey dew that causes sooty mould formation. Besides causing direct damage, it also transmits an economically important viral disease caused by okra yellow vein mosaic virus (OYVMV), resulting in significant yield loss especially when it occurs in the early stages crop growth (Nath and Saikia 1993). OYVMV belongs to the genus begomovirus of the family geminiviridae. Geminiviruses make up a large diverse family of plant viruses and causes heavy crop losses worldwide (Varma *et al.,* 2003). Several OYVMV resistant okra varieties have been released, but none of them had retained resistance for long (Usha *et al.,* 2003). Therefore, the ideal way of controlling this viral disease in okra would be to develop the resistant cultivars against the virus as well as the vector. Hence, the present study was undertaken to screen okra accessions to identify resistant sources against whitefly vector and YVMV disease incidence.

MATERIALS AND METHODS

The present field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli district during the season of summer 2022, to screen the okra accessions under natural infection condition without any plant protection measures. For this study, 30 okra accessions were screened to find out the resistance source against whitefly and OYVMV. Each okra accession/germplasm was sown in 2 rows with a spacing of 60×45 cm and 3 replications were maintained. All the recommended agronomic practices given in tnauagri portal (https://agritech.tnau.ac.in) were followed to raise the crop.

The reaction of okra accessions against whitefly was recorded by counting the number of whiteflies from five randomly selected and tagged plants in each replication. Whitefly population was recorded on three leaves (top, middle and bottom) of each randomly selected plants at weekly intervals from one month after sowing to harvest stage. The data was converted into mean population per three leaves per plant.

OYVMV infestation was recorded based on the yellowing symptoms of the plant and damage score was used for grading the percent disease incidence (Narayanan *et al.,* 2017). The observations were made at 30, 45 and 60 DAS to assess the YVMVD incidence and the severity grades were designated using the 0-4 scale based on visual observations. To quantify the disease severity, the calculations were made using the percent disease incidence with respect to the number of diseased plants and total number of plants observed per plot (Bag *et al.,* 2013).

The Percent Disease Incidence (PDI) was calculated by the given formula:

$$\text{PDI} = \frac{\text{Number of diseased plants}}{\text{Total number of plants observed}} \times 100$$

The coefficient of infection (CI) was calculated by multiplying the percent disease incidence to the response value assigned for each severity grade. Thus, the coefficient value combines the amount of infection and its severity. Based on the scaling, the coefficient of infection (CI) was calculated by multiplying the percent disease incidence (PDI) to the response value (RV) assigned for each severity grade.Coefficient of infection, which was expressed as a product of the PDI and severity grade (Response value), was more useful in selecting suitable accession resistant to YVMD.

$$\text{CI} = \text{PDI} \times \text{RV}$$

Morphological Parameters of the Okra Accessions. The following morphological parameters were recorded in the selected okra accessions.

Estimation of Trichome Density. The trichome density of the 14 selected okra accessions were assessed by counting the number of trichomes in a 1 cm^2 round disc cut from the distal part of the fully opened leaf of the plant. Three discs from each each of five plants (standardized stage) from each replication of the treatment were examined. The total number of trichomes were counted under a binocular stereo zoom microscope at 40x magnification and expressed as trichomes per cm^2 area (Jindal *et al.,* 2011).

Plant Height, Leaf Area, Leaf Colour. The plant height was taken at 50% flowering stage in five plants of each replication and expressed as cm. The leaf area was measured by recording the length and width at 50% flowering stage in five plants of each replication and expressed as cm^2.Leaf colour of the germplasm lines was recorded based on visual observation at 50% flowering stage in five plants of each replication using the leaf colour chart.

Statistical Analysis. The population of the whitefly, during the crop period was converted to mean population per plant. The population counts of whitefly, PDI of OYVMV and morphological parameters were analysed statistically by using Factorial Randomized Block Design (FRBD). To find out the influence of morphological parameters on pest and disease occurrence in different accessions, simple correlation coefficients were worked out between the incidence of whitefly and OYVMV with morphological parameters.

RESULT AND DISCUSSION

Screening of okra accessions under field conditions was undertaken against the whitefly and OYVMV to identify the resistant sources for utilization in breeding programme.

Reaction of okra Accessions against Whitefly. The results of mean population of whitefly obtained from the pooled data on the evaluation of okra accessions against whiteflies during summer 2022 are presented in (Table 1). Among the 30 okra accessions screened, the highest mean population of whiteflies per 3 leaf was recorded in IC 417885(3.80), NO 315 (3.02), AE 65 (2.70), EC 755648 (2.90), Arkaanamika (3.34) and there are on par with each other. The accessions GED 15, GED 11, AE 11, AE 62, AE 64, IC 43743, and Pusa Bhendi 5 recorded the lowest number of whiteflies per leaf with a mean population of 1.16, 1.24, 1.08, 1.05, 1.01, 1.01 and 1.11 respectively.

Table 1: Screening of okra germplasm against whitefly under field conditions during summer 2022 (Pooled data).

Sr. No	Name of the Accessions	Population of Whitefly/three leaves/plant*										Mean
		14 SMW	**15 SMW**	**16 SMW**	**17 SMW**	**18 SMW**	**19 SMW**	**20 SMW**	**21 SMW**	**22 SMW**	**23 SMW**	
1.	GED-19	0.21 (0.84)	0.64 (1.07)	0.77 (1.13)	2.33 (1.68)	2.54 (1.74)	2.96 (1.86)	2.06 (1.60)	1.86 (1.54)	1.45 (1.40)	1.24 (1.32)	1.61 (1.45)
2.	GED-545	0.46 (0.98)	0.78 (1.13)	1.07 (1.25)	1.95 (1.57)	2.08 (1.61)	2.35 (1.69)	1.66 (1.47)	1.02 (1.23)	1.64 (1.46)	1.33 (1.35)	1.43 (1.39)
3.	GED-509	1.32 (1.35)	1.76 (1.50)	1.96 (1.57)	3.02 (1.88)	3.26 (1.94)	3.44 (1.98)	3.01 (1.87)	2.76 (1.81)	2.44 (1.71)	2.43 (1.71)	2.54 (1.74)
4.	GED-15	0.23 (0.86)	0.46 (0.98)	0.72 (1.11)	1.64 (1.46)	1.85 (1.53)	2.14 (1.62)	1.37 (1.37)	1.26 (1.33)	1.08 (1.26)	0.88 (1.17)	1.16 (1.29)
5.	GED-11	0.28 (0.88)	0.51 (1.01)	0.83 (1.15)	1.73 (1.49)	1.92 (1.55)	2.28 (1.67)	1.46 (1.40)	1.35 (1.36)	1.16 (1.29)	0.92 (1.19)	1.24 (1.32)
6.	IC 417885	1.87 (1.54)	1.53 (1.42)	2.54 (1.74)	4.95 (2.33)	5.25 (2.40)	5.52 (2.45)	4.77 (2.29)	4.25 (2.18)	3.74 (2.06)	3.55 (2.01)	3.80 (2.07)
7.	NO-315	1.66 (1.47)	1.86 (1.54)	2.23 (1.65)	3.76 (2.06)	3.83 (2.08)	4.35 (2.20)	3.55 (2.01)	3.48 (1.99)	2.86 (1.83)	2.64 (1.77)	3.02 (1.88)
8.	EC 16394	0.81 (1.14)	0.66 (1.08)	0.85 (1.16)	2.26 (1.66)	2.53 (1.74)	2.82 (1.82)	1.91 (1.55)	1.61 (1.45)	1.51 (1.42)	1.25 (1.32)	1.62 (1.46)
9.	SB-2	0.21 (0.84)	0.63 (1.06)	1.24 (1.32)	1.96 (1.57)	2.04 (1.59)	2.35 (1.69)	2.02 (1.59)	1.73 (1.49)	1.53 (1.43)	1.36 (1.36)	1.51 (1.42)
10.	AE-11	0.25 (0.87)	0.42 (0.96)	0.67 (1.08)	1.45 (1.40)	1.56 (1.44)	1.76 (1.50)	1.38 (1.37)	1.25 (1.32)	1.19 (1.30)	0.86 (1.17)	1.08 (1.26)
11.	AE-62	0.31 (0.90)	0.53 (1.01)	0.64 (1.07)	1.35 (1.36)	1.57 (1.44)	2.09 (1.61)	1.25 (1.32)	1.09 (1.26)	0.94 (1.20)	0.73 (1.11)	1.05 (1.25)
12.	AE-63	0.52 (1.01)	0.64 (1.07)	0.84 (1.16)	1.85 (1.53)	2.09 (1.61)	2.26 (1.66)	1.63 (1.46)	1.48 (1.41)	1.25 (1.32)	1.16 (1.29)	1.37 (1.37)
13.	AE-64	0.27 (0.88)	0.42 (0.96)	0.64 (1.07)	1.34 (1.36)	1.44 (1.39)	1.94 (1.56)	1.24 (1.32)	1.08 (1.26)	0.96 (1.21)	0.74 (1.11)	1.01 (1.23)
14.	AE-65	1.65 (1.47)	1.54 (1.43)	2.27 (1.66)	3.24 (1.93)	3.55 (2.01)	3.82 (2.08)	2.96 (1.86)	2.75 (1.80)	2.61 (1.76)	2.57 (1.75)	2.70 (1.79)
15.	AE-66	0.46 (0.98)	0.54 (1.02)	0.94 (1.20)	2.16 (1.63)	2.45 (1.72)	2.86 (1.83)	1.86 (1.54)	1.66 (1.47)	1.55 (1.43)	1.46 (1.40)	1.59 (1.45)
16.	IC 22237	0.44 (0.97)	0.65 (1.07)	0.93 (1.20)	2.05 (1.60)	2.13 (1.62)	2.36 (1.69)	1.93 (1.56)	1.77 (1.51)	1.38 (1.37)	1.08 (1.26)	1.47 (1.40)
17.	EC 755648	1.24 (1.32)	1.56 (1.43)	1.66 (1.47)	3.96 (2.11)	4.67 (2.27)	5.24 (2.40)	3.54 (2.01)	2.96 (1.86)	2.21 (1.65)	1.94 (1.56)	2.90 (1.84)
18.	IC 43743	0.23 (0.85)	0.42 (0.96)	0.67 (1.08)	1.35 (1.70)	1.64 (1.74)	1.85 (1.98)	1.23 (1.57)	1.06 (1.50)	0.95 (1.41)	0.73 (1.16)	1.01 (1.40)
19.	EC 755647	0.56 (1.03)	0.53 (1.01)	0.66 (1.08)	2.37 (1.70)	2.52 (1.74)	3.44 (1.98)	1.97 (1.57)	1.74 (1.50)	1.45 (1.40)	0.97 (1.21)	1.62 (1.46)
20.	IC 18960	0.34 (0.91)	0.40 (0.95)	0.46 (0.98)	2.23 (1.65)	2.43 (1.71)	2.75 (1.80)	1.97 (1.57)	1.75 (1.50)	1.48 (1.41)	0.85 (1.16)	1.47 (1.40)
21.	IC 417875	0.63 (1.06)	0.84 (1.16)	1.28 (1.33)	3.24 (1.93)	3.54 (2.01)	3.63 (2.03)	2.53 (1.74)	2.25 (1.66)	1.85 (1.53)	1.48 (1.41)	2.13 (1.62)
22.	IC 111370	0.42 (0.96)	0.66 (1.08)	0.76 (1.12)	2.56 (1.75)	2.73 (1.80)	2.97 (1.86)	2.23 (1.65)	1.86 (1.54)	1.45 (1.40)	1.27 (1.33)	1.69 (1.48)
23.	IC 332457	0.52 (1.01)	0.65 (1.07)	0.96 (1.21)	1.93 (1.56)	2.05 (1.60)	3.16 (1.91)	1.85 (1.53)	1.44 (1.39)	1.26 (1.33)	1.15 (1.28)	1.50 (1.41)
24.	IC 411880	0.75 (1.12)	0.80 (1.14)	1.45 (1.40)	2.35 (1.69)	2.92 (1.85)	3.33 (1.96)	2.54 (1.74)	2.34 (1.69)	1.92 (1.56)	1.75 (1.50)	2.02 (1.59)
25.	IC 433532	0.44 (0.97)	0.52 (1.01)	0.62 (1.06)	1.35 (1.36)	1.95 (1.57)	2.43 (1.71)	1.27 (1.33)	1.14 (1.28)	0.91 (1.19)	0.75 (1.12)	1.14 (1.28)
26.	IC 112449	0.60 (1.05)	0.73 (1.11)	0.97 (1.21)	2.15 (1.63)	2.53 (1.74)	2.93 (1.85)	1.95 (1.57)	1.65 (1.47)	1.58 (1.44)	1.15 (1.29)	1.62 (1.46)
27.	IC 105675	0.27 (0.88)	0.45 (0.98)	0.86 (1.17)	3.59 (2.02)	3.75 (2.06)	3.34 (1.96)	2.66 (1.78)	3.95 (2.11)	1.76 (1.50)	1.36 (1.36)	2.20 (1.64)
28.	IC 433533	0.83 (1.15)	0.95 (1.21)	1.24 (1.32)	2.86 (1.83)	3.35 (1.96)	3.44 (1.98)	2.12 (1.62)	2.08 (1.61)	1.85 (1.53)	1.68 (1.48)	2.04 (1.59)
29.	Pusa Bhendi 5	0.23 (0.85)	0.52 (1.01)	0.72 (1.10)	1.43 (1.39)	1.69 (1.48)	1.93 (1.56)	1.36 (1.36)	1.25 (1.32)	1.06 (1.25)	0.94 (1.20)	1.11 (1.27)
30.	Arkaanamika	1.32 (1.35)	1.74 (1.50)	1.93 (1.56)	4.52 (2.24)	5.44 (2.44)	5.83 (2.52)	3.98 (2.12)	3.48 (1.99)	2.84 (1.83)	2.26 (1.66)	3.34 (1.96)
SE.d		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-
CD (p=0.05)		0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.02	0.01	0.02	-

(Figures in the parentheses are square root transformed values, * Mean Population)

These accessions are least preferred by whiteflies because some of the resistant characters like trichome density, dark leaf colour, less leaf area, were present in these accessions to deter the colonization of whitefly. Presence of these positive attributes might be the reason for resistance against whitefly when compared with other accessions.

The whitefly population counts recorded during different standard meterological weeks, indicated that, initially the whitefly population per 3 leaves was less during 14th (0.21), 15th (0.64) and 16th (0.77) standard weeks, then they reached peak population during 18th (2.54) and 19th (2.96) standard weeks. From the results obtained, it is evident that the whitefly population showed differential preference to the okra accessions. The present findings are in close conformity with another study on okra germplasm reaction to whitefly population (Manjua *et al.*, 2018).

Table 2: Scale for screening for their reactions against the whitefly.

Symptoms	Severity grade	Response value	Coefficient of infection	Reaction
Symptoms absent	0	0.0	0-4	Highly Resistant
Very mild up to 25% leaves	1	0.25	5-9	Resistant
Appearance of symptom in 26-50% of leaves	2	0.50	10-19	Moderately Resistant
Appearance of symptom in 51-75% of leaves	3	0.75	20-39	Moderately Susceptible
Severe disease infection at 75% leaves		1.00	40-69	Susceptible
Above 75% leaves	>4	>1.00	70-100	Highly Susceptible

(Kumari *et al.*, 2018 : Narayanan *et al.*, 2017)

Table 3: Screening of okra germplasm against OYVMV under field condition during summer 2022.

Sr. No	Accessions	Percent Disease Incidence (PDI)			Mean
		30 DAS	45 DAS	60 DAS	
1.	GED-19	36.67	30.00	33.33	33.33
2.	GED-545	33.33	30.00	33.33	32.22
3.	GED-509	50.00	50.00	43.33	47.78
4.	GED-15	16.67	13.33	16.67	15.56
5.	GED-11	13.33	20.00	16.67	16.67
6.	IC 417885	56.67	53.33	50.00	53.33
7.	NO-315	53.33	50.00	56.67	53.33
8.	EC 16394	26.67	33.33	30.00	30.00
9.	SB-2	36.67	33.33	30.00	33.33
10.	AE-11	13.33	16.67	20.00	16.67
11.	AE-62	20.00	16.67	13.33	16.67
12.	AE-63	26.67	16.67	16.67	20.00
13.	AE-64	20.00	26.67	26.67	24.44
14.	AE-65	53.33	56.67	50.00	53.33
15.	AE-66	33.33	36.67	33.33	34.44
16.	IC 22237	23.33	23.33	33.33	26.67
17.	EC 755648	60.00	63.33	53.33	58.89
18.	IC 43743	16.67	13.33	20.00	16.67
19.	EC 755647	30.00	33.33	36.67	33.33
20.	IC 18960	36.67	30.00	33.33	33.33
21.	IC 417875	56.67	53.33	50.00	53.33
22.	IC 111370	50.00	56.67	53.33	53.33
23.	IC 332457	46.67	50.00	43.33	46.67
24.	IC 411880	46.67	50.00	43.33	46.67
25.	IC 433532	23.33	33.33	40.00	32.22
26.	IC 112449	33.33	30.00	36.67	33.33
27.	IC 105675	50.00	56.67	43.33	50.00
28.	IC 433533	46.67	43.33	50.00	46.67
29.	Pusa Bhendi 5	16.67	13.33	20.00	16.67
30.	ArkaAnamika	56.67	50.00	53.33	53.33

Reaction of okra germplasm against OYVMV. Screening of okra accessions was done against the yellow vein mosaic virus disease resistance, and their level of resistance is presented in Table 4.

Of the 30 okra accessions screened, the percent disease incidence was obtained from 15.56 to 58.89 per cent. The least percent disease incidence (PDI) of 15.56 per cent is recorded in the accession GED 15 and exhibited the reaction as highly resistant. This was followed by the accessions *viz.*, AE 11, AE 62, IC 43743, and Pusa Bhendi 5 which was recorded the least PDI of 16.67 and AE 63 which was recorded the PDI of 20. The maximum PDI of 58.89 per cent was recorded in the accession of EC 755648, followed by the accessions of IC 417885, NO 315, AE 65, IC 417875, IC 4111370, Arka Anamika which was recorded the high PDI of 53.33 per cent and response value of different accessions ranged from 0.00 to 1.00. The response value was high in EC 755648 (1.00) followed by GED 509, IC 417885, NO 315, AE 65, IC 411880, and Arkaanamika in the range of 0.75. Lowest response value of 0.00 was recorded in the accessions of GED 15, AE 64, IC 43743, Pusa Bhendi 5. The coefficient of infection was more in EC 755648(58.89). The least coefficient of infection of 0.00 was recorded in the accessions of GED 15, AE 64, IC 43743, and Pusa Bhendi 5.

Table 4: Reaction of okra germplasm against OYVMV under field conditions during summer 2022.

Sr. No.	Accessions	PDI	Severity grade	RV	CI	Reaction
1.	GED-19	33.33	2	0.50	16.67	MR
2.	GED-545	32.22	1	0.25	8.06	R
3.	GED-509	47.78	3	0.75	35.84	MS
4.	GED-15	15.56	0	0.00	0.00	HR
5.	GED-11	16.67	1	0.25	4.17	HR
6.	IC 417885	53.33	3	0.75	40.00	S
7.	NO-315	53.33	3	0.75	40.00	S
8.	EC 16394	30.00	1	0.25	7.50	R
9.	SB-2	33.33	2	0.5	16.67	MR
10.	AE-11	16.67	1	0.25	4.17	HR
11.	AE-62	16.67	1	0.25	4.17	HR
12.	AE-63	20.00	1	0.25	5.00	R
13.	AE-64	24.44	0	0.00	0.00	HR
14.	AE-65	53.33	3	0.75	40.00	S
15.	AE-66	34.44	2	0.50	17.22	MR
16.	IC 22237	26.67	1	0.25	6.67	R
17.	EC 755648	58.89	4	1.00	58.89	S
18.	IC 43743	16.67	0	0.00	0.00	HR
19.	EC 755647	33.33	2	0.50	16.67	MR
20.	IC 18960	33.33	1	0.25	8.33	R
21.	1C 417875	53.33	2	0.00	26.67	MS
22.	IC 111370	53.33	1	0.25	13.33	MR
23.	IC 332457	46.67	1	0.25	11.67	MR
24.	IC 411880	46.67	3	0.75	35.00	MS
25.	IC 433532	32.22	1	0.25	8.06	R
26.	IC 112449	33.33	2	0.50	16.67	MR
27.	IC 105675	50.00	2	0.50	25.00	MS
28.	IC 433533	46.67	2	0.50	23.34	MS
29.	Pusa Bhendi 5	16.67	0	0.00	0.00	HR
30.	Arka Anamika	53.33	4	1.00	40.00	S

HR-Highly Resistant, R-Resistant, MR-Moderately Resistance, MS-Moderately Susceptible, S-Susceptible

Morphological parameters of the okra Accessions.

The morphological parameters include plant height, leaf area, trichome density and leaf colour were assessed in selected okra accessions which are identified as resistant accessions in the field screening against whitefly and OYVMV incidence. A total of 14 okra accessions *viz,* 7 highly resistant (GED 15, GED 11, AE 11, AE 62, AE 64, IC 43743, and Pusa bhendi 5), 6 resistant (GED 545, EC 16394, AE 63, IC 22237, IC 18960, and IC 433532) and one susceptible (Arkaanamika) accessions were selected to find out the relation of these parameters with whitefly and OYVMV resistance or susceptibility.

Plant Height. The plant height was recorded in 14 selected okra Accessions and expressed in cm (Table 6).

Among the 14 selected okra accessions, Arkaanamika which was susceptible to whitefly and OYVMV recorded maximum plant height of 42.83cm. The accessions GED 15, GED 11, AE 11, AE 64, IC 43743, Pusa bhendi 5 which were highly resistant to whitefly and OYVMV incidence recorded minimum plant heights of 19.15 cm, 18.92 cm, 20.93 cm, 21.82 cm, 23.26 cm respectively. The resistant accessions *viz,* GED 545 (14.32 cm), EC 16394 (21.56 cm), IC 22237 (21.75 cm), IC 18960 (30.41 cm), IC 433532 (23.37 cm) also recorded less plant heights. The moderate plant heights of 30.53 cm and 31.80 cm recorded in AE 62 and AE 63 respectively which shows highly resistant and resistant to whitefly and OYVMV incidence.

From the correlation data, (Table 7) it was observed that the plant height had a non-significant positive influence on whitefly population (r =0.692) and OYVMV (r =0.720) incidence. From the present study, it was evident that plant height did not have any significant influence on the whitefly population build up and OYVMV incidence, because the highly resistant accessions AE 62 and AE 63 have more plant heights than resistant accessions. The present findings are also in tune with the findings of Manju *et al.* (2021) studied the morphological and biochemical basis of resistance against whitefly in 25 okra germplasms who recorded the less plant height in susceptible check Pusa sawani and moderately susceptible germplasm RJR-110 which shows susceptible reaction to whitefly and YVMV, similarly less plant heights was recorded in IC 344598 and IC 141020 which shows highly resistant to pest and disease incidence.

Leaf Area. From the 14 selected okra accessions, GED 15, GED 11, AE 11, AE 62, AE 64, IC 43743, Pusa Bhendi 5 are found to be highly resistant to whitefly and OYVMV incidence recorded less leaf area of 87.28 cm^2, 89.10 cm^2, 88.37 cm^2, 88.01 cm^2, 81.93 cm^2, 77.17 cm^2, 78.28 cm^2 respectively, and it was followed by the entries identified as resistant accessions GED 545 (101.77 cm^2), EC 16394 (100.09 cm^2), AE 63(104.55 cm^2), IC 22237 (101.86 cm^2), IC 18960 (109.63 cm^2), IC 433532 (100.31 cm^2) also recorded less leaf area. (Table 6). The accession Arka Anamika which was susceptible to whitefly and OYVMV incidence recorded highest leaf area of 228.53 cm^2.

The correlation studies (Table 7) revealed that leaf area had significant positive correlation with whitefly population (r = 0.982) and OYVMV (r = 0.990) incidence. The results of the present investigation in agree with the findings of Taggar *et al.* (2012), who studied the preference of whitefly towards 9 blackgram genotypes and found that positive association with leaf area and whitefly population. The whitefly population positively influenced by leaf area and the reason for the susceptible genotypes possessing large leaf area may be due to the availability of more area for egg laying and whitefly feeding. The results obtained from the present study was closely related with the findings of Manju *et al.*, 2021 who reported that the oviposition, whitefly population are positively influenced by leaf area.

Table 5: Categorization of okra germplasm collections.

Reaction	Number of Accessions	Accessions/ germplasm
Highly Resistant	7	GED-15, GED-11, AE 11, AE 62, AE 64, IC 43743, Pusa Bhendi 5
Resistant	6	GED-545, EC 16394, AE-63, IC 22237, IC 18960, IC 433532
Moderately Resistant	7	GED-19, SB 2, AE 66, EC 755647, IC 111370, IC 332457, IC 112449
Moderately Susceptible	5	GED 509, 1C 417875, IC 411880, IC 105675, IC 433533
Susceptible	5	IC 417885, NO 315, AE 65, EC 755648, ArkaAnamika
Highly susceptible	0	-

Table 6: Biophysical parameters of selected okra Accessions screened against *B. tabaci* and OYVMV.

Sr. No.	Accessions	Entries identified as	Trichome density/cm^2			Plant height(cm)	Leaf area(cm^2)	Leaf colour
			Upper	Lower	Total			
1.	GED 545	R	35.87	42.67	78.54	14.32	101.77	DG
2.	GED 15	HR	53.27	73.87	127.14	19.15	87.28	DG
3.	GED 11	HR	57.73	65.80	123.53	18.92	89.10	DG
4.	EC 16394	R	34.80	43.93	78.73	21.56	100.09	DG
5.	AE 11	HR	63.33	64.80	128.13	20.97	88.37	DG
6.	AE 62	HR	58.93	66.17	125.10	30.53	88.01	DG
7.	AE 63	R	41.67	37.33	79.00	31.8	104.55	DG
8.	AE 64	HR	57.27	68.00	125.27	21.82	81.93	DG
9.	IC 22237	R	42.27	44.40	86.67	21.75	101.86	DG
10.	IC 43743	HR	54.13	73.47	127.60	23.26	77.17	DG
11.	IC 18960	R	47.40	35.20	82.60	30.41	109.63	DG
12.	IC 433532	R	32.73	48.00	80.73	23.37	100.31	DG
13.	Pusa Bhendi 5 (RC)	HR	56.87	66.33	123.20	22.19	79.28	DG
14.	Arka Anamika (SC)	S	12.80	14.93	27.73	42.83	228.53	LG
SEd			0.64	0.48	-	0.50	2.36	-
CD (p=0.05)			1.32	0.99	-	1.02	4.85	-

HR- Highly Resistant, R- Resistant, S- Susceptible, DG- Dark Green, LG- Light Green

Table 7: Correlation coefficients of *B. tabaci* population and OYVMV incidence with morphological parameters in selected okra Accessions.

Morphological parameters	Correlation Coefficient(r)	
	B.tabaci	**OYVMV**
Trichome density	-0.839**	-0.841**
Plant height	0.692	0.720
Leaf area	0.982**	0.990**

* Significant at 5 % level ** Significant at 1 % level

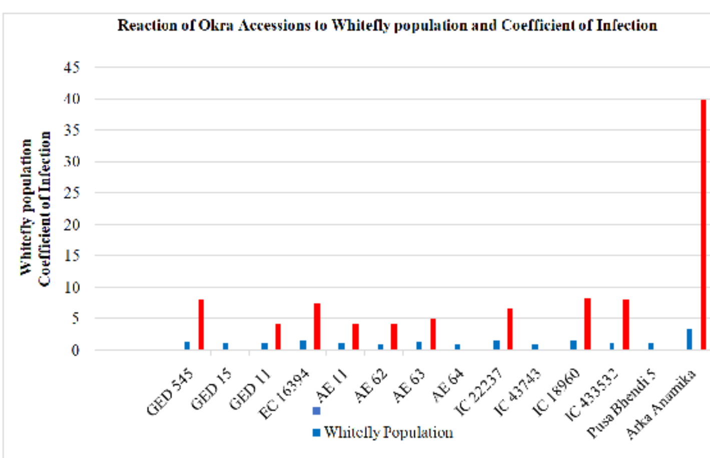

Fig. 1. Reaction of Okra Accessions to Whitefly population and Coefficient of Infection.

Trichome Density. Trichome density of 14 selected okra accessions was observed under light microscope and expressed as trichomes per cm^2 area (Table 6). The highest trichome density of 127.14, 123.53, 128.13, 125.1, 125.27, 127.6 and 123.2 was recorded in the highly resistant accessions of GED 15, GED 11, AE 11, AE 62, AE 64, IC 43743, and Pusa Bhendi 5 respectively, and the resistant accessions GED 545 (78.54), EC 16394 (78.73), AE 63(79), IC 22237 (86.67), IC 18960 (82.6), IC 433532 (80.73) also recorded high trichome densities. The susceptible accession of Arka Anamika which was recorded lowest trichome density of $27.73/cm^2$. The correlation studies (Table 7) indicated that, trichome density had a highly significant negative correlation ($r = -0.839$) with the population of whiteflies and OYVMV incidence ($r = -0.841$).

The findings obtained from the present research are closely agree with the findings of (Taggar *et al.*, 2012) who reported that trichome density was negatively correlated with whitefly eggs, nymphs, and adults in blackgram and Chandrasekaran, 2020 who studied the screening of okra accessions and found that the accessions possessing high trichome density exhibit resistant to whitefly. The resistant accessions possessing high trichome density may be due to the higher leaf hairiness is not preferred by the whiteflies for oviposition. Similarly Oriani *et al.* (2010) also evaluated the attractiveness and ovipositional preference of *B. tabaci* for 17 tomato genotypes. The results indicated that the glandular trichome density was negatively correlated with whiteflies attractiveness and oviposition.

Leaf Colour. The leaf colour of the 14 selected okra accessions were recorded based on visual observations by using a leaf colour chart at 50% flowering stage. The leaf colour ranged between slightly light green to dark green (Table 6). Among the 14 accessions, the highly resistant accessions *viz,* GED 15, GED 11, AE 11, AE 62, AE 64, IC 43743, and Pusa Bhendi 5, and also the identified resistant accessions *viz*, GED 545, EC 16394, AE 63, IC 22237, IC 18960, IC 433532, which was recorded lowest whitefly population and OYVMV incidence exhibited dark green (DG) leaf colour, whereas the susceptible accession Arka Anamika which was recorded highest population of whitefly and OYVMV incidence exhibited a light green leaf colour.

The results of the present investigation revealed that dark green leaf colour had a negative influence on whitefly population and subsequent OYVMV incidence. The present research findings are agreed with the findings of Abu *et al.* (2016) studied the leaf morphological characters for varietal preference of whitefly among egg plant varieties who observed a significant and negative correlation between the green leaf colour with the whitefly adult population and oviposition. The leaf lamina of the highly resistant varieties reflects long wavelength light than the susceptible varieties, and accordingly curtained the lowest whitefly population.

Based on the results obtained from the present study, it was evident that morphological parameters significantly influence the resistance or susceptibility against the whitefly vector and OYVMV incidence. Among the four morphological parameters studied, leaf area, leaf colour, and trichome density played a significant influence on vector and virus incidence. The leaf area had a positive effect on population of whiteflies and OYVMV incidence, whereas the okra accessions possessing dark green leaf colour and high trichome density had a negative effect on the whitefly vector as well as virus incidence. Therefore, the germplasm lines possessing the dark green colour leaves with more trichome density, and less leaf area are suited for plant resistant breeding programmes.

CONCLUSION

Okra is one of the most important vegetable crops which is grown all over the world including India. Many insect pests and disease attack on okra. Whitefly is one of the important pests and act as a vector of OYVMV incidence. In the present research which conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli district, Tamilnadu, out of 30 okra accessions screened based on whitefly population, OYVMV incidence and morphological characters, 7 accessions *viz*, GED 19, GED 11, AE 11, AE 62, AE 64, IC 43743, and Pusa Bhendi 5 showed highly resistant to vector and virus incidence. The accessions *viz*, GED 545, EC 16394, AE 63, IC 22237, IC 18960, and IC 433532 which were showed resistant to whitefly and OYVMV incidence and Arka Anamika shows susceptible reaction to whitefly and disease incidence. In the present field experiment, the identified resistant accessions which exhibit resistance mechanism to whitefly and YVMV incidence, suited for plant resistant breeding programmes.

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Conflict of Interest. None.

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