Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(6):2540-2546

Received: 23-09-2017
Accepted: 26-10-2017

TD Jayabal
PG Scholar, Department of Entomology, Agricultural College and Research Institute, Madurai, Tamil Nadu, India

C Chinniah
Professor and Head, Department of Entomology, Agricultural College and Research Institute, Madurai, Tamil Nadu, India

M Kalyanasundaram
Professor Entomology, Directorate of Open and Distance Learning, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Correspondence
TD Jayabal
PG Scholar, Department of Entomology, Agricultural College and Research Institute, Madurai, Tamil Nadu, India

Impact of trichomes on the incidence of two spotted spider mite *Tetranychus urticae* (Koch) on okra *Abelmoschus esculentus* L. (Moench)

TD Jayabal, C Chinniah and M Kalyanasundaram

Abstract
The trichome density on leaves of okra germplasms collections was maximum 177/ cm^2 of leaf area on IC 117235 and it was minimum 9/ cm^2 leaf area in IC 014600. The correlation studies (r) between trichome density and *T. urticae* incidence revealed that the number of trichomes / cm^2 leaf area on upper surface, lower surface, midrib, veins and total trichome density revealed a significant negative impact on the *T. urticae* population build up in the okra entries screened. From the correlation analysis, it is evident that an increase in total trichome density by one unit / cm^2 leaf area, there was a significant decline in population of *T. urticae* by 0.13 per cent. As for as trichome length is concerned, it was the maximum 25.51µm on IC 031850 on the upper surface, EC 329421 and IC 018532 (29.59µm) on the lower surface, IC 031850 (35.65µm) on the midrib and veins (29.82µm) of IC 031850. The correlation studies (r) between trichome length and *T. urticae* population revealed that the trichome length exhibited significant negative correlation on okra entries screened. Multiple linear regression fit revealed that the contribution of trichome density and length towards the population build up of *T. urticae* in okra was significant to an extent of 92.80% and 92.23 % respectively. Thus, presence of trichomes acts as a major resistant factor against bhendi mites.

Keywords: Trichomes, Okra germplasm collections, Resistance, *Tetranychus urticae*

Introduction
Okra *Abelmoschus esculentus* L. (Moench), is cultivated in area of 485 thousand ha with an annual production of 11.4 mt/ha (Indiastat) [1] Recently, there is a shift in pest scenario; as a result plant feeding mites are emerging a serious threat to okra. The two spotted spider mite, *Tetranychus urticae* **(**Koch) causes considerable economic loss, throught the season. This crop is infested mainly by six different mite pest species, *viz*., *Tetranychus urticae*, *T. macfarlanei*, *T. ludeni*, *Brevipalpus phoenicis* and *Polyphagotarsonemus latus* [2]. However among these, *T. urticae* is a generalist feeder and the most polyphagous species on more than 1,100 host plants belonging to more than 140 families, including those that are known to produce toxic compounds [3, 4]. *T. urticae* is responsible for causing loss of foliage of the crop resulting in reduction in yield of fruits ranging from 20-45% depending upon cropping season and agroclimatic conditions [5, 6].
The morphological feature of host plant significantly alters the behaviour of the herbivores *viz.*, host plant selection, feeding and oviposition thereby playing a vital role in host plant resistance against herbivore [7]. Sheeba *et al.* [8] confirmed that morphological trait namely trichomes (length & density) exhibited negative effect on the mite population development on different okra entries. Yadwad *et al.* [9] reported that trichome length and density had negative correlation mites, *Polypagotarsonemus latus* in other crops like chilli also.
The role of key structural traits, such as spinescence, pubescence, sclerophylly and raphides, in protecting plants from herbivore attack [10]. Hence, the objective of this study is to evaluate the impact of morphological plant traits such as trichome density and length for resistance/ susceptibility against two spotted spider mite *Tetranychus urticae* (Koch) population build up and feeding activity.

Materials and Methods
Okra germplasms including local varieties, landraces and popular commercial hybrids were collected from farmers, seed dealers, National Bureau of Plant Genetic Resources (NBPGR) to screen for resistance of these accessions against TSSM *Tetranichus urticae* (Koch) under

screen house condition. The morphological factors attributing for resistance or susceptibility against two spotted spider mite *Tetranichus urticae*, observations on plant characters *viz*., trichome density and trichome length were recorded.

Estimation of Trichome density

The trichome density (Plate 1) from leaf lamina, midrib and veins were counted under stereo zoom microscope by selecting top three leaves from each okra germplasm. The trichome density on different okra accession was estimated by adopting the method suggested by Maite *et al*. [11]. The third fully opened leaf was chosen for sampling. Three replicates were maintained for each leaf sample collected at random which were cut into one square centimeter bits and boiled with 20 ml of water in small glass vials for 15 min in hot water bath at 85 °C. The water was then poured out retaining the leaf bits alone which were again boiled after adding 20 ml of 96 per cent ethyl alcohol for 20 min at 80 °C.

Then the alcohol was poured off and the boiling process with alcohol was repeated to remove the chlorophyll completely from the leaves. Alcohol was again poured off and 90 per cent lactic acid was added. The vials were stoppered and heated at 85 °C until leaf segments were fully cleared (approximately 30-45 min.). The vials were cooled and the leaf segments were taken and mounted on clean slides using a drop of lactic acid to observe the trichome density. The number of trichomes per square centimeter area was counted under steriozoom microscope

at 10 X magnification for each leaf samples. The trichome density of the leaves was correlated with the incidence of mites.

Estimation of Trichome length (µm)

The trichome length (**Plate 2**) was measured by image analyzer, fit to stereo zoom microscope (STEMI 508) after making the fine cut from the plant tissue.

Mite population (no/ cm^2)

In the screening experiment two spotted spider mite *Tetranychus urticae* population was assessed 10 days after inoculation and recorded at 10 days interval starting from 40 DAS to 90 DAS. Mite populations were assessed in one cm^2 area on top, middle and bottom leaves of each plant from each test entries, covering sufficient replications.

Statistical Analysis

The mean density data were subjected to square root transformation. The data obtained from pot culture and laboratory experiments were subjected to Analysis of Variance (ANOVA) using the software AGRESS. The significance of differences was tested by F-tests, while the significance of difference between the treatment mean values was compared by LSD at 5 per cent probability.

Correlation and Regression

This analysis was adopted to find out the relationship between the occurrence of mite population and the possible impact of morphological characters *viz.*, trichome density and length. The observation of mean mite population and morphological characters were related to work out the correlation coefficient [12]. The data were subjected to correlation and multiple linear regression analysis using SPSS ver.17.0 software. The multiple linear regression analysis was carried out to assess the degree and extents of influence of the trichomes on the population buildup of *T. urticae* in okra germplasm screened.

Results and Discussion

Morphological characters *viz.*, trichome density, trichome length on the lower surface, upper surface, midrib and veins of okra germplasm collections were observed and correlated with mite population.

Effect of trichome density on two spotted spider mite

The results on trichome density (Table 1) on leaf surface revealed a highly significant difference among the germplasms screened. The maximum trichome density was recorded on the upper surface of EC 305743 (50/ cm2 leaf area), lower surface of IC 031850 (59/ cm^2 leaf area), midrib of EC 305743 (29/ cm) and veins of IC 117235 (47/ cm^2 leaf area). The least number of trichomes were recorded in germplasm IC 014600 (2/ cm^2 leaf area) on the upper surface, IC 022232 (2/ cm^2 leaf area) on the lower surface, IC 014600 (1/ cm) on the midrib and IC 117238 (1/ cm^2 leaf area) on the veins. The maximum total trichome density per centimeter square leaf area was recorded on the leaves of IC 117235 (177/ cm^2) and the minimum number (9/ cm^2 leaf area) was recorded in case of IC 014600. Nain and Rathee [13] also reported that the lowest number of trichomes was recorded in genotype HBT-6-15-3-7 and it was highly susceptible to mite *Tetranychus urticae* Koch. Genotype HB-02-14-1-1 with the highest number of trichomes was the least susceptible.

The correlation studies (Table 2) (r) between trichome density and *T. urticae* population revealed that the number of trichomes per cm^2 leaf area on upper surface, lower surface, midrib, veins and total trichome density revealed a significant negative relationship (r = -0.948, -0.944, -0.948, -0.940 and -0.962 respectively) in the okra entries screened. In cotton variety NIAB-999 that maximum hair density (504/cm^2) on leaf lamina was the main criteria which resulted in maximum resistance against mites [14].

From the correlation analysis, it is evident that an increase in trichome density by 1 unit/ cm^2 leaf area in upper surface resulted in decrease of *T. urticae* population by 0.46 per cent, where as an increase in trichome density by 1 unit / cm^2 leaf area in lower surface resulted in decrease of *T. urticae* population by 0.39 per cent. Similarly, an increase in trichome density by 1 unit / cm in midrib region resulted in decrease of *T. urticae* population by 0.79 per cent, where as an increase in trichome density by 1 unit / cm^2 leaf area on vein region resulted in decrease of *T. urticae* population by 0.55 per cent. From the present investigation, it is evident that an increase in total trichome density by 1 unit / cm^2 leaf area resulted in decrease of *T. urticae* population by 0.13 per cent. Multiple linear regression analysis (Table 3) corroborated that the coefficient of determination was significantly high (R^2 = 0.928), which implies that these trichome density i.e., on upper surface, lower surface, midrib, veins and total trichome density contributes directly towards the population growth of *T. urticae* in okra germplasm screened to the extent of 92.80 per cent. Trichome density exhibited a strong and negative correlation (r = - 0.621) with respect to shoot infestation of brinjal shoot and fruit borer, *Leucinodes orbonalis* [15].

From the multiple linear regression analysis it is evident that trichome density on lower surface also had significant negative impact on *T. urticae* in okra entries. Sheeba *el al*. [8] also has published similar findings that the morphological trait namely trichomes (length & numbers) exhibited negative effect on the mite population and development on different okra entries. Therefore, it is construed that the trichome density plays a significant role in reduction of population buildup with reference to *T. urticae* in okra germplasm chosen

for *in vitro* screening.

Effect of trichome length on two spotted spider mite

The present investigation on trichome length (Table 4) of different okra germplasm collections revealed a highly significant difference among the germplasms evaluated. The maximum trichome length was recorded in IC 031850 (25.51µm) on the upper surface,

EC 329421 and IC 018532 (29.59µm) on the lower surface, IC 031850 (35.65µm) on the midrib and veins of IC 031850 (29.82µm). The least length of trichomes was recorded in germplasm IC 014600 (1µm) on the upper surface (6.77µm) on the lower surface and 10.28µm on the midrib respectively. IC 022232 recorded minimum trichome length (5.95µm) on the veins. The present findings are in close agreement with the findings of [9] who opined that the trichome length and density was negatively correlated with thrips, *Scirtothrips dorsalis* and mites, *Polypagotarsonmeus latus* on chilli.

The correlation studies (Table 5) (r) between trichome length and *T. urticae* population revealed that the trichome length (µm) on upper surface, lower surface, midrib and veins exhibited significant negative relationship (r = -0.949, -0.905, -0.954 and -0.895 respectively) on okra entries screened. This is in conformity with the observations made by Nain and Rathee [13] who proved that there was a significant positive correlation between length of trichomes and number of eggs laid.

From the correlation analysis it is evident that an increase in trichome length by 1 µm in upper surface resulted in decrease of *T. urticae* population by 0.91 per cent, where as an increase in trichome length by 1 µm in lower surface resulted in decrease of *T. urticae* population by

0.83 per cent. Similarly, an increase in trichome length by 1 µm in midrib resulted in decrease of

T. urticae population by 0.87 per cent, where as an increase in trichome length by 1 µm on vein resulted in decrease of *T. urticae* population by 0.78 per cent. Multiple linear regression analysis (Table 6) revealed that the coefficient of determination was highly significantly (R^2 = 0.922), which implies that these trichome length i.e., on upper surface, lower surface, midrib and veins contributed directly towards the population growth of *T. urticae* in okra germplasm screened to an extent of 92.23 per cent. Also from the multiple linear regression analysis it is evident that among the trichome length, trichome length on midrib had significant negative impact with *T. urticae* on okra.

Table 1: Comparison of trichome density (mean) on okra germplasm collections, (*Abelmoshus esculentus* L.)

S.NO	Okra entries	Overall Mean mite population/ cm^2	Trichome density / cm^2 area of leaf *				Total number of trichomes/ cm^2 area of leaf
			Upper surface	Lower surface	Midrib	Veins	
1	IC 043748	17.33 (4.16)^{d}	32.00 (5.66)^{l}	42.00 (6.48)^{h}	15.00 (3.87)^{h}	22.00 (4.69)^{k}	111.00 (10.54)^{h}
2	IC 282278	20.33 (4.51)^{h}	34.00 (5.83)^{k}	45.00 (6.71)^{g}	18.00 (4.24)^{e}	27.00 (5.20)^{f}	124.00 (11.14)^{def}
3	IC 140927	18.00 (4.24)^{de}	35.00 (5.92)^{jk}	47.00 (6.86)^{ef}	17.00 (4.12)^{f}	25.00 (5.00)^{h}	124.00 (11.14)^{def}
4	IC 128092	13.00 (3.61)^{a}	42.00 (6.48)^{f}	52.00 (7.21)^{c}	26.00 (5.10)^{d}	32.00 (5.66)^{e}	152.00 (12.33)^{c}
5	IC 128095	14.67 (3.83)^{b}	48.00 (6.93)^{b}	55.00 (7.42)^{b}	28.00 (5.29)^{b}	35.00 (5.92)^{d}	166.00 (12.88)^{b}
6	IC 128122	22.00 (4.69)^{i}	22.00 (4.69)^{p}	33.00 (5.74)^{k}	11.00 (3.32)^{l}	16.00 (4.00)^{o}	82.00 (9.06)^{k}
7	EC 329421	20.67 (4.55)^{h}	30.00 (5.48)^{m}	43.00 (6.56)^{h}	16.00 (4.00)^{g}	24.00 (4.90)^{i}	113.00 (10.63)^{h}
8	EC 305743	13.33 (3.65)^{a}	50.00 (7.07)^{a}	56.00 (7.48)^{b}	29.00 (5.39)^{a}	36.00 (6.00)^{d}	171.00 (13.08)^{b}
9	EC 305771	20.33 (4.51)^{h}	35.00 (5.92)^{jk}	46.00 (6.78)^{fg}	17.00 (4.12)^{f}	27.00 (5.20)^{f}	125.00 (11.18)^{def}
10	EC 306737	15.67 (3.96)^{a}	46.00 (6.78)^{cd}	58.00 (7.62)^{a}	26.00 (5.10)^{d}	38.00 (6.16)^{c}	168.00 (12.96)^{b}
11	IC 003307	19.33 (4.40)^{g}	37.00 (6.08)^{hi}	47.00 (6.86)^{ef}	18.00 (4.24)^{e}	28.00 (5.29)^{f}	130.00 (11.40)^{r}
12	IC 003573	17.67 (4.20)^{de}	39.00 (6.24)^{g}	49.00 (7.00)^{d}	16.00 (4.00)^{g}	25.00 (5.00)^{h}	129.00 (11.36)^{s}
13	IC 014600	32.33 (5.69)^{q}	2.00 (1.41)^{z}	3.00 (1.73)^{s}	1.00 (1.00)^{s}	3.00 (1.73)^{t}	9.00 (3.00)^{t}
14	IC 015435	23.67 (4.87)^{j}	25.00 (5.00)^{o}	35.00 (5.92)^{j}	14.00 (3.74)^{i}	17.00 (4.12)^{n}	91.00 (9.54)^{j}
15	IC 018532	21.00 (4.58)^{h}	38.00 (6.16)^{gh}	43.00 (6.56)^{h}	16.00 (4.00)^{g}	24.00 (4.90)^{i}	121.00 (11.00)^{fg}
16	IC 018537	19.00 (4.36)^{fg}	32.00 (5.66)^{l}	45.00 (6.71)^{g}	18.00 (4.24)^{e}	26.00 (5.10)^{g}	121.00 (11.00)^{fg}
17	IC 018540	17.67 (4.20)^{de}	36.00 (6.00)^{ij}	47.00 (6.86)^{ef}	17.00 (4.12)^{f}	28.00 (5.29)^{f}	128.00 (11.31)^{d}
18	IC 022232	32.00 (5.66)^{q}	3.00 (1.73)^{y}	2.00 (1.41)^{t}	3.00 (1.73)^{q}	4.00 (2.00)^{s}	12.00 (3.46)^{s}
19	IC 022285	19.00 (4.36)^{fg}	39.00 (6.24)^{g}	48.00 (6.93)^{de}	17.00 (4.12)^{f}	23.00 (4.80)^{j}	127.00 (11.27)^{d}
20	IC 031850	15.33 (3.92)^{b}	45.00 (6.71)^{de}	59.00 (7.68)^{a}	27.00 (5.20)^{c}	39.00 (6.24)^{bc}	170.00 (13.04)^{b}
21	IC 033854C	18.33 (4.28)^{ef}	35.00 (5.92)j^{k}	42.00 (6.48)^{h}	18.00 (4.24)^{e}	27.00 (5.20)^{f}	122.00 (11.05)^{efg}
22	IC 034190A	27.00 (5.20)^{n}	12.00 (3.46)^{v}	25.00 (5.00)^{n}	7.00 (2.65)^{n}	12.00 (3.46)^{r}	56.00 (7.48)^{o}
23	IC 034190C	33.67 (5.80)^{r}	6.00 (2.45)^{w}	8.00 (2.83)^{p}	4.00 (2.00)^{p}	2.00 (1.41)^{u}	20.00 (4.47)^{q}
24	IC 045132	24.67 (4.97)^{kl}	25.00 (5.00)^{o}	36.00 (6.00)^{j}	13.00 (3.61)^{j}	18.00 (4.24)^{m}	92.00 (9.59)^{j}
25	IC 099746	18.33 (4.28)^{ef}	34.00 (5.83)^{k}	45.00 (6.71)^{g}	17.00 (4.12)^{f}	23.00 (4.80)^{j}	119.00 (10.91)^{g}
26	IC 105742	13.67 (3.70)^{a}	44.00 (6.63)^{e}	56.00 (7.48)^{b}	28.00 (5.29)^{b}	40.00 (6.32)^{b}	168.00 (12.96)^{b}
27	IC 111514	28.33 (5.32)^{o}	13.00 (3.61)^{u}	27.00 (5.20)^{lm}	7.00 (2.65)^{n}	12.00 (3.46)^{r}	59.00 (7.68)^{no}
28	IC 112476	29.67 (5.45)^{p}	16.00 (4.00)^{s}	28.00 (5.29)^{l}	8.00 (2.83)^{m}	14.00 (3.74)^{q}	66.00 (8.12)^{l}
29	IC 117228	20.67 (4.55)^{h}	36.00 (6.00)^{ij}	46.00 (6.78)^{fg}	16.00 (4.00)^{g}	28.00 (5.29)^{f}	126.00 (11.22)^{de}
30	IC 117235	13.33 (3.65)^{a}	47.00 (6.86)^{bc}	55.00 (7.42)^{b}	28.00 (5.29)^{b}	47.00 (6.86)^{a}	177.00 (13.30)^{a}
31	IC 117238	35.67 (5.97)^{q}	5.00 (2.24)^{x}	7.00 (2.65)^{q}	2.00 (1.41)^{r}	1.00 (1.00)^{v}	15.00 (3.87)^{r}
32	IC 117260	20.33 (4.51)^{h}	38.00 (6.16)^{gh}	49.00 (7.00)^{d}	16.00 (4.00)^{g}	25.00 (5.00)^{h}	128.00 (11.31)^{d}
33	IC 117308	29.67 (5.45)^{p}	19.00 (4.36)^{q}	26.00 (5.10)^{mn}	7.00 (2.65)^{n}	14.00 (3.74)^{q}	66.00 (8.12)^{l}
34	IC 205147	25.33 (5.03)^{lm}	27.00 (5.20)^{n}	36.00 (6.00)^{j}	12.00 (3.46)^{k}	17.00 (4.12)^{n}	92.00 (9.59)^{j}
35	IC 469666	25.67 (5.45)^{m}	29.00 (5.39)^{m}	38.00 (6.16)^{i}	14.00 (3.74)i	16.00 (4.00)^{o}	97.00 (9.85)^{i}
36	Arka anamika	29.67 (5.45)^{p}	18.00 (4.24)^{r}	27.00 (5.20)^{lm}	8.00 (2.83)^{m}	12.00 (3.46)^{r}	65.00 (8.06)^{lm}
37	Indus 161	34.33 (5.86)^{r}	16.00 (4.00)^{s}	5.00 (2.24)^{r}	3.00 (1.73)^{q}	1.00 (1.00)^{v}	25.00 (5.00)^{p}
38	Red bhendi	24.33 (4.93)^{jk}	24.00 (4.90)^{o}	39.00 (6.24)^{i}	13.00 (3.61)^{j}	18.00 (4.24)^{m}	94.00 (9.70)^{ij}
39	Mayco 10	28.33 (5.32)^{o}	12.00 (3.46)^{v}	28.00 (5.29)^{l}	7.00 (2.65)^{n}	15.00 (3.87)^{p}	62.00 (7.87)^{mn}

40	Sakthi	26.33 (5.13)^{mn}	27.00 (5.20)^{n}	35.00 (5.92)^{j}	14.00 (3.74)^{i}	19.00 (4.36)^{l}	95.00 (9.75)^{ij}
41	Co 4 Bhendi hybrid	31.33 (5.60)^{q}	14.00 (3.74)^{t}	24.00 (4.90)^{o}	6.00 (2.45)^{o}	14.00 (3.74)^{q}	58.00 (7.62)^{o}
CD(p=0.05)		0.09	0.101	0.099	0.070	0.099	0.216
SEd		0.05	0.051	0.050	0.035	0.048	0.108

*Each value is the mean of three replications.
Figures in parentheses are square root transformed values
In a column, means sharing similar letter(s) are not significantly different by LSD at P=0.05%.

Table 2: Correlation Matrix: Impact of trichome density on population of TSSM (*T. urticae* Koch) on Okra

Population	Correlation	Trichome density / cm2 area of leaf				
		Upper surface	Lower surface	Midrib	Veins	Total number of trichomes
Two spotted spider mites, *Tetranychus urticae* Koch	R	-0.948**	-0.944**	-0.948*	-0.940**	-0.962**
	Y = a + bx	35.80-0.46X	37.40-0.39X	34.26-0.79X	34.46-0.55X	36.29-0.13X
	Significance (P = 0.05*)	0.000	0.000	0.027	0.000	0.000
	Non-Significant	-	-	-	-	-

**Significant at 1% Probability
*Significant at 5% Probability

Table 3: Multiple linear regression models for trichome density on population of TSSM (*T. urticae* Koch) on Okra

Population	No. of observations	Constant	Trichome density / cm2 area of leaf				
			Upper surface	Lower surface	Midrib	Veins	Total number of trichomes
T. urticae (Y)	41	36.137	0.082	-0.392**	-0.179	0.086	-0.147

Multiple Linear regression equation: $Y = 36.137+0.082X_1-0.392^{**}X_2-0.179X_3+0.086X_4-0.147^{*}X_5$
Coefficient of determination (R^2) = 0.928
**Significant at 1% Probability.
*Significant at 5% Probability.

Table 4: Mean comparison of trichome length of okra germplasm, (*Abelmoshus esculentus* L.)

S.NO	Okra entries	Overall Mean mite population/ cm^2	Trichome length (µm) / cm^2 area of leaf *			
			Upper surface	Lower surface	Midrib	Veins
1	IC 043748	17.33 (4.16)^{d}	16.13 (4.02)^{k}	21.78 (4.67)^{i}	26.22 (5.12)^{h}	22.78 (4.77)^{i}
2	IC 282278	20.33 (4.51)^{h}	18.18 (4.26)^{fg}	22.12 (4.70)^{hi}	28.35 (5.32)^{ef}	25.12 (5.01)^{f}
3	IC 140927	18.00 (4.24)^{de}	17.81 (4.22)^{fgh}	25.85 (5.08)^{d}	29.51 (5.43)^{d}	23.85 (4.88)^{gh}
4	IC 128092	13.00 (3.61)^{a}	20.78 (4.56)^{d}	26.27 (5.13)^{d}	32.15 (5.67)^{c}	27.28 (5.22)^{e}
5	IC 128095	14.67 (3.83)^{b}	22.25 (4.72)^{c}	28.72 (5.36)^{bc}	34.10 (5.84)^{b}	28.74 (5.36)^{bc}
6	IC 128122	22.00 (4.69)^{i}	11.28 (3.36)^{o}	16.28 (4.03)^{l}	22.50 (4.74)^{k}	16.25 (4.03)^{m}
7	EC 329421	20.67 (4.55)^{h}	19.82 (4.45)^{e}	23.02 (4.80)^{fgh}	28.21 (5.31)^{efg}	21.15 (4.60)^{j}
8	EC 305743	13.33 (3.65)^{a}	21.72 (4.66)^{c}	28.83 (5.37)^{bc}	35.53 (5.96)^{a}	30.78 (5.55)^{a}
9	EC 305771	20.33 (4.51)^{h}	16.12 (4.01)^{k}	24.18 (4.92)^{f}	27.81 (5.27)^{efg}	6.81 (2.61)^{t}
10	EC 306737	15.67 (3.96)^{a}	23.13 (4.81)^{b}	29.54 (5.44)^{ab}	34.35 (5.86)^{b}	29.45 (5.43)^{bc}
11	IC 003307	19.33 (4.40)^{g}	16.91 (4.11)^{ij}	24.28 (4.93)^{e}	28.28 (5.32)^{efg}	22.82 (4.78)^{i}
12	IC 003573	17.67 (4.20)^{de}	18.47 (4.30)^{f}	23.08 (4.80)^{fg}	27.67 (5.26)^{fg}	23.80 (4.88)^{gh}
13	IC 014600	32.33 (5.69)^{q}	1.00 (1.00)^{y}	6.77 (2.60)^{e}	10.28 (3.21)^{r}	7.78 (2.79)^{s}
14	IC 015435	23.67 (4.87)^{j}	10.91 (3.30)^{o}	17.98 (4.24)^{fg}	23.57 (4.85)^{j}	17.89 (4.23)^{l}
15	IC 018532	21.00 (4.58)^{h}	19.82 (4.45)^{e}	23.35 (4.83)^{s}	26.02 (5.10)^{h}	24.53 (4.95)^{fg}
16	IC 018537	19.00 (4.36)^{fg}	16.64 (4.08)^{jk}	21.71 (4.66)^{k}	28.20 (5.31)^{efg}	21.17 (4.60)^{l}
17	IC 018540	17.67 (4.20)^{de}	16.58 (4.07)^{jk}	22.21 (4.71)^{e}	27.31 (5.23)^{g}	23.12 (4.81)^{hi}
18	IC 022232	32.00 (5.66)^{q}	3.81 (1.95)^{u}	8.59 (2.93)^{i}	11.81 (3.44)^{q}	5.95 (2.44)^{uv}
19	IC 022285	19.00 (4.36)^{fg}	19.69 (4.44)^{e}	24.19 (4.92)^{fghi}	28.54 (5.34)^{def}	22.91 (4.79)^{hi}
20	IC 031850	15.33 (3.92)^{b}	25.51 (5.05)^{a}	30.28 (5.50)^{q}	35.65 (5.97)^{a}	29.82 (5.46)^{ab}
21	IC 033854C	18.33 (4.28)^{ef}	18.44 (4.29)^{f}	23.10 (4.81)^{e}	26.18 (5.12)^{h}	21.01 (4.58)^{j}
22	IC 034190A	27.00 (5.20)^{n}	6.78 (2.60)^{s}	11.25 (3.35)^{a}	16.25 (4.03)^{o}	11.52 (3.39)^{r}
23	IC 034190C	33.67 (5.80)^{r}	2.18 (1.48)^{x}	7.34 (2.71)^{fg}	13.23 (3.64)^{p}	6.43 (2.54)^{ltu}
24	IC 045132	24.67 (4.97)^{kl}	12.68 (3.56)^{n}	18.19 (4.26)^{p}	24.84 (4.98)^{i}	18.19 (4.26)^{j}
25	IC 099746	18.33 (4.28)^{ef}	16.89 (4.11)^{ij}	22.23 (4.71)^{fghi}	29.56 (5.44)^{d}	23.32 (4.83)^{dhi}
26	IC 105742	13.67 (3.70)^{a}	24.82 (4.98)^{a}	28.25 (5.32)^{c}	34.56 (5.88)^{ab}	28.52 (5.34)^{c}
27	IC 111514	28.33 (5.32)^{o}	8.53 (2.92)^{q}	12.45 (3.53)^{o}	18.82 (4.34)^{lm}	12.54 (3.54)^{q}
28	IC 112476	29.67 (5.45)^{p}	7.67 (2.77)^{r}	14.47 (3.80)^{m}	19.65 (4.43)^{l}	14.74 (3.84)^{n}
29	IC 117228	20.67 (4.55)^{h}	17.75 (4.21)^{gh}	21.59 (4.65)^{i}	27.65 (5.26)^{fg}	21.12 (4.60)^{j}
30	IC 117235	13.33 (3.65)^{a}	23.23 (4.82)^{b}	29.59 (5.44)^{ab}	33.84 (5.82)^{b}	27.60 (5.25)^{de}
31	IC 117238	35.67 (5.97)^{q}	3.38 (1.84)^{v}	6.28 (2.51)^{s}	11.92 (3.45)^{q}	7.82 (2.80)^{s}
32	IC 117260	20.33 (4.51)^{h}	17.37 (4.17)^{hi}	7.54 (2.75)^{r}	28.72 (5.36)^{de}	28.45 (5.33)^{cd}
33	IC 117308	29.67 (5.45)^{p}	9.93 (3.15)^{p}	13.92 (3.73)^{mn}	18.47 (4.30)^{mn}	12.29 (3.51)^{q}

34	IC 205147	25.33 (5.03)^{lm}	13.52 (3.68)^{m}	18.59 (4.31)^{jk}	24.42 (4.94)^{ij}	19.95 (4.47)^{k}
35	IC 469666	25.67 (5.45)^{m}	14.16 (3.76)^{l}	17.92 (4.23)^{k}	22.57 (4.75)^{k}	18.29 (4.28)^{l}
36	Arka anamika	29.67 (5.45)^{p}	8.48 (2.91)^{q}	13.61 (3.69)^{n}	17.88 (4.23)^{n}	13.61 (3.69)^{op}
37	Indus 161	34.33 (5.86)^{r}	2.53 (1.59)^{w}	8.84 (2.97)^{q}	10.82 (3.29)^{r}	5.48 (2.34)^{v}
38	Red bhendi	24.33 (4.93)^{jk}	12.27 (3.50)^{n}	19.38 (4.40)^{j}	23.64 (4.86)^{j}	17.83 (4.22)^{l}
39	Mayco 10	28.33 (5.32)^{o}	7.87 (2.81)^{r}	12.32 (3.51)^{o}	18.25 (4.27)^{mn}	14.23 (3.77)^{no}
40	Sakthi	26.33 (5.13)^{mn}	13.88 (3.73)^{lm}	18.19 (4.26)^{k}	24.72 (4.97)^{i}	18.19 (4.26)^{l}
41	Co 4 Bhendi hybrid	31.33 (5.60)^{q}	6.07 (2.46)^{t}	14.43 (3.79)^{m}	19.51 (4.42)^{l}	13.43 (3.66)^{p}
CD(P=0.05)		0.09	0.079	0.097	0.095	0.100
SEd		0.05	0.398	0.048	0.048	0.050

*Each value is the mean of three replications.
Figures in parentheses are square root transformed values.
In a column, means sharing similar letter(s) are not significantly different by LSD at P=0.05%

Table 5: Correlation Matrix: Impact of trichome length on population of TSSM (*T. urticae* Koch) on Okra

Population	Correlation	Trichome length (µm)			
		Upper surface	Lower surface	Midrib	Veins
Two spotted spider mites, *Tetranychus urticae* Koch	R	-0.949**	-0.905**	-0.954**	-0.895**
	Y = a + bx	35.83-0.91X	38.71-0.83X	44.30-0.87X	37.78-0.78X
	Significance (P = 0.05*)	0.000	0.000	0.000	0.000
	Non-Significant	-	-	-	-

**Significant at 1% Probability
*Significant at 5% Probability

Table 6: Multiple linear regression models for trichome length on population of TSSM (*T. urticae* Koch) on Okra

Population	No. of observations	Constant	Trichome length (µm)			
			Upper surface	Lower surface	Midrib	Veins
T. urticae Koch (Y)	41	41.246	-0.246	-0.151	-0.412**	-0.102

Multiple Linear regression equation: $Y = 41.246-0.246X_1-0.151X_2-0.412X_3-0.102X_4$
Coefficient of determination (R^2) = 0.922
**Significant at 1% Probability.
*Significant at 5% Probability.

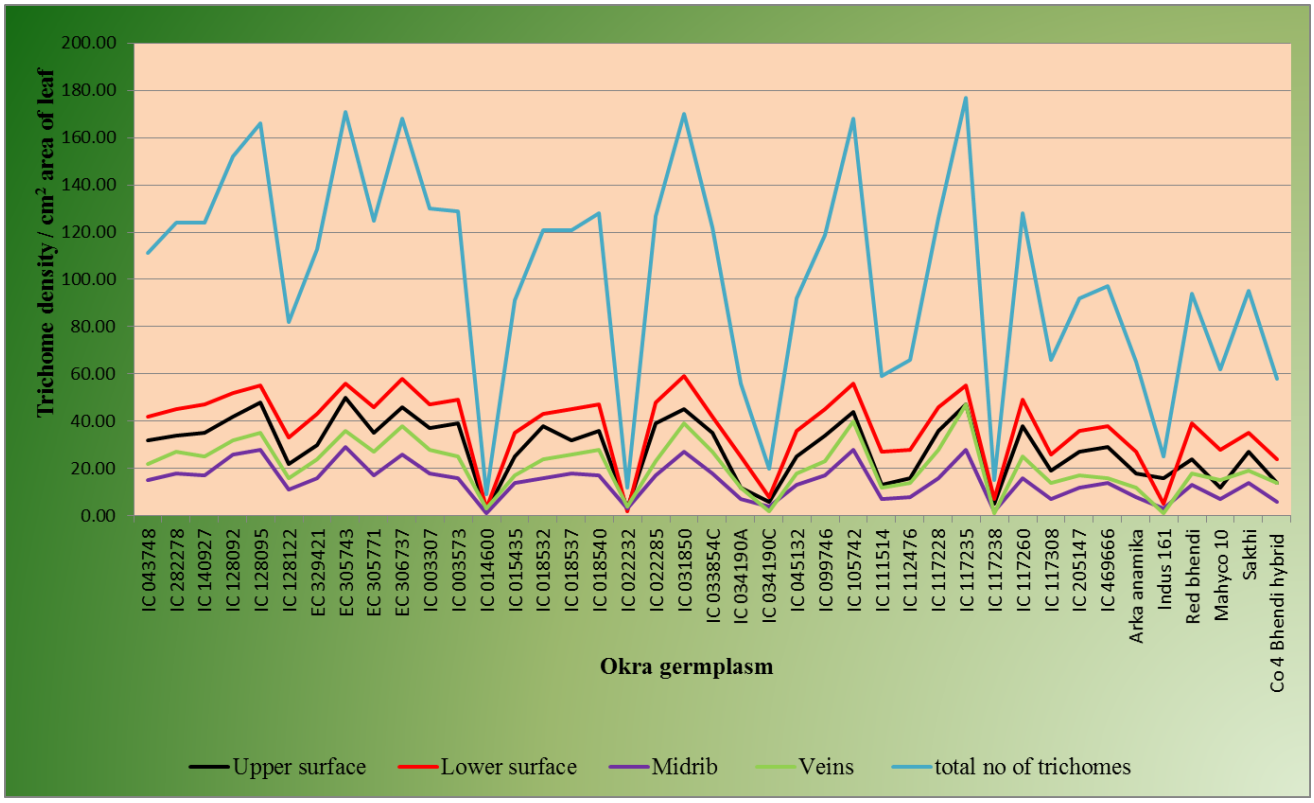


Fig 1: Comparison of trichome density (mean) on okra germplasm collections, (*Abelmoshus esculentus* L.)

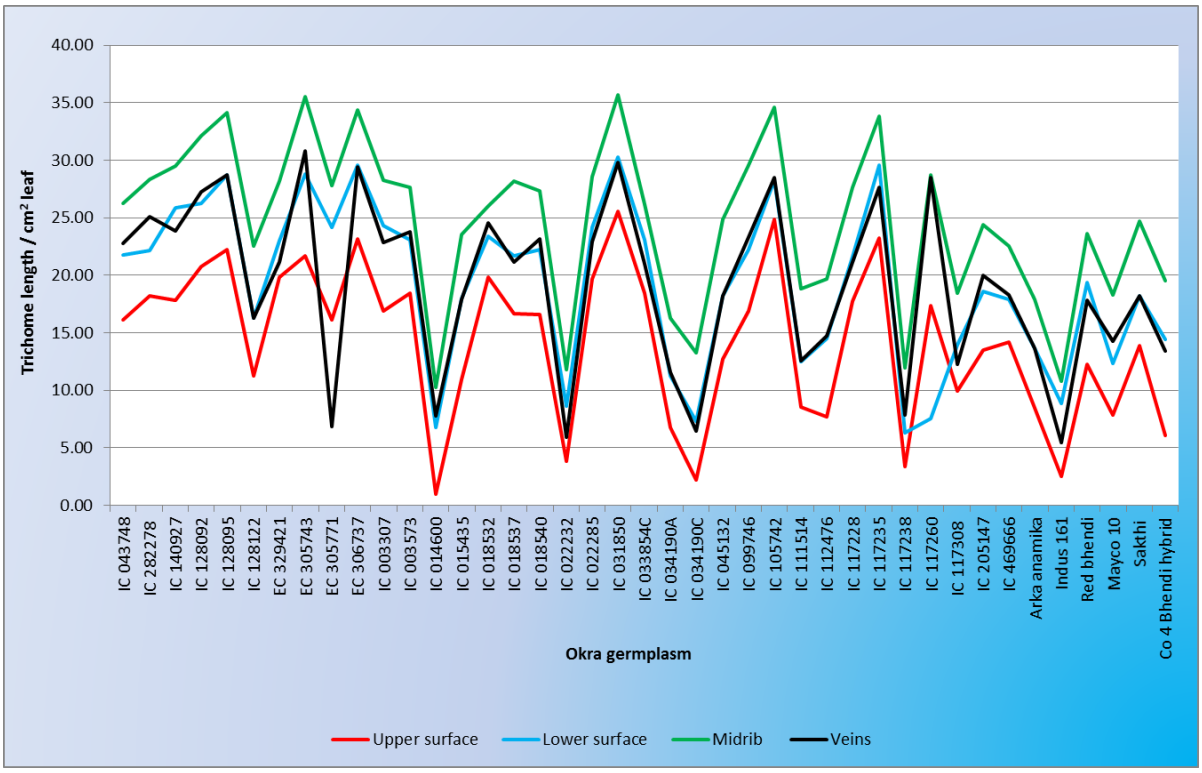
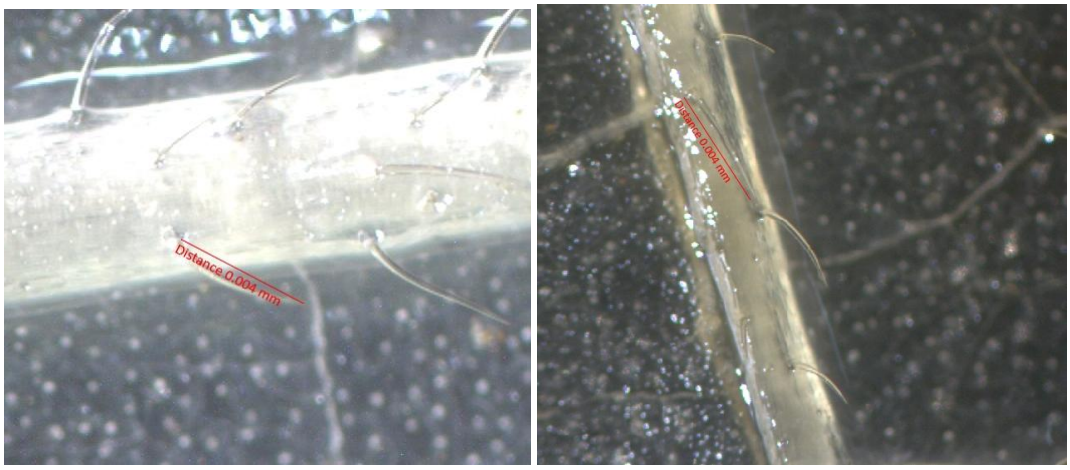


Fig 2: Mean comparison of trichome length of okra germplasm, (*Abelmoshus esculentus* L.)

a. Trichomes before processing (leaf lamina) **b.** Presence of trichomes on midrib

Plate 1: Trichome density on different parts of okra



a. Trichome length on midrib **b.** Trichome length on vein

Plate 2: Trichome length of different okra germplasms

Conclusion

In line of wanting, the findings of present study concluded that the host plant resistance of okra's morphological traits such as trichome density and length had significant negative effect against two spotted spider mite *T. urticae.*

Acknowledgment

We gladly acknowledge NBPGR, New Delhi for being supplied the precious germplasm materials for screening study.

References

1. https://www.indiastat.com/___table/ agriculture/ 2/ ladysfinferokra/ 23059/ 14905/ data.aspx. 2016.
2. Gupta SK. Hand book of plant mites of India. Zoological Survey of India, Calcutta, India. 1985, 520.
3. Grbic M. The genome of *Tetranychus urticae* (Koch) reveals herbivorous pest adaptations. Nature. 2011; 479:487-492.
4. Van Leeuwen TV, Dermauw W, Grbic M, Tirry L, Feyereisen R. Spider mite control and resistance management: does a genome help? Pest Management Science. 2012; 69(2):156-159.
5. Mondel M, Ara N. Biology and fecundity of the two spotted spider mite, *Tetranychus urticae* Koch. (Acari: Tetranychidae) under laboratory conditions.Journal of life and earth science. 2006; 1:43-47.
6. Kumaran N, Douressamy S, Ramaraju K, Kuttalam S. Estimation of damage and yield loss due to *Tetranychus urticae* Koch (Acari : Tetranychidae) on okra under artificial infestation. International Journal of Acarology. 2007; 17:4-6.
7. Rebe M, Van Den Berg J, Mcgeoch MA. Colonization of cultivated and indigenous graminaceous host plants by *Busseola fusca* (Fuller) (Lepidoptera: Noctuidae) and *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) under field conditions. African Entomology. 2004; 12:187-199.
8. Sheeba S, Roseleen J, Ramaraju K. Effect of okra entries on biology of two spotted spider mite *Tetranychus urticae* (Koch), Annals of Plant Protection Sciences. 2011; 19(1):67-70.
9. Yadwad A, Sridevi O, Salimath PM. Leaf trichomes-based resistance in chilli (*Capsicum annuum*) to thrips and mites. Indian Journal of Agricultural Sciences. 2008; 78:518-521.
10. Hanley ME, Lamont BB, Fairbanks MM, Rafferty CM. Plant structural traits and their role in anti-herbivore defence. Perspectives in Plant Ecology, Evolution and Systematics. 2007; 8(4):157-178.
11. Maite RK, Bidinger FR, Sheshu Reddy KV, Davies JC. Nature and occurrence of trichomes in sorghum lines with resistance to the sorghum shootfly, Joint Progress Rep. Sorghum physiology-3 Sorghum Entomology -3 ICRISAT, Patancheru, India. 1980, 159.
12. Regupathy A, Dhamu KP. Statistical work book for insecticide toxicology. Softeck computers, Coimbatore. 2001, 22-24.
13. Nain J, Rathee M. Effect of leaf morphology and phytochemistry of okra on development and survival of two spotted spider mite, *Tetranychus urticae* Koch. Indian Journal of Entomology. 2017; 79(1):32-36.
14. Muhammad H, Afzal, Nadeem MS, Nadeem MK. Morphological characters of different cotton cultivars in relation to resistance against Tetranychid mites. Pakistan Journal of Zoology. 2009; 41(3):241-244.
15. Wagh SS, Pawar DB, Chandele AG, Ukey NS. Biophysical mechanisms of resistance to brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen in brinjal. Pest Management in Horticultural Ecosystem. 2012; 18(1):54-59.