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Effect of structural traits of okra genotypes on biology of two spotted mite, *Tetranychus urticae* Koch (Acarina: Tetranychidae)

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Abstract
Preliminary investigations were carried out to ascertain the antibiosis mechanism of resistance through varietal preference of the pest as well as the relationship between the morphological features of the plant and intensity of mite infection at the CCS Haryana Agricultural University, Hisar. Lowest number of trichomes were recorded in highly susceptible genotype HBT-6-15-3-7 and highest were observed in least susceptible genotype HB-02-14-1-1. There was significant positive correlation between length of trichomes and number of eggs laid. Correlation of length of trichome with larval plus nymphal survival (r= 0.82) was positively significant. Shortest incubation period (4.57days), larval period (3.97 days), nymphal period (4.22 days), larval plus nymphal period (8.18 days) and total life period (17.85 days) was observed on least susceptible genotypes (HB-02-14-1-1 and HB-02-17-1). Shortest oviposition period was observed on HB-02-14-1-1(5.66 days) and longest on BB1 (8.61 days) and shortest longevity of female was found on okra genotype HB-02-14-1-1(8.28 days) and longest on HBT-6-15-3-7 (11.71days). Female to male ratio was found maximum on moderately susceptible genotype of okra namely HRB-107-4-1(4.3:1) and minimum on least susceptible genotypes HB-02-14-1-1(2.4:1).

Keywords: Two spotted mite, morphological characters, biology, okra

1. Introduction
Among various vegetables, okra; *Abelmoschus esculentus* (L.) Moench commonly called as lady's finger or bhindi is a prime vegetable crop of tropical and sub- tropical parts of the world. It is an important warm season vegetable crop; a number of varieties are extensively cultivated throughout year in India for its tender green fruit over an area of 3.59 lac hectares of with a production of 35.25 lac tones and an average productivity of 9.59 tonnes per hectare [1]. The crop is prone to attract a number of insect and mite pests. Besides insect-pests, several mite species that belong to the genus *Tetranychus* cause a considerable loss in the yield of fruits ranging from 7 to 48 per cent [2]. Among mite species, Two spotted mite; *Tetranychus urticae* Koch (Acarina: Tetranychidae) is considered as predominant pest, infest okra crop occasionally to a very serious extant in India [3]. Heavy infestation is common in summer crop season, causes substantial economic losses in okra production, as it is difficult to contain mites satisfactorily even with chemical treatments. Moreover, acaricides are being the primary control tactic for mite pest adopted by many farmers that also leads to the development of resistance, destruction of natural enemies, causes environmental pollution and residue contamination in the produce. Different plant leaf characters like leaf area, leaf hairs density, length of leaf, leaf thickness play a significant impact in the searching capability and population of mites and theirs predators [4] that can be point of resistance in okra plant to look out. Therefore, it would be wise to go for better alternative like resistant varieties to cover a long way in the management tactics programme for any insect-pest in IPM. A preliminary study was therefore under taken to ascertain the varietal preference of the pest as well as the relationship between the morphological features of the plant and intensity of mite infestation at the Research Farm, CCS Haryana Agricultural University, Hisar-125004.

2. Materials and Methods
The present studies were carried out at the Entomology Research Farm and in the Laboratories of Department of Entomology during *Kharif* season, 2010-11. Sampling of two leaves from each strata *i.e.* top, Middle and bottom per plant were examined from ten randomly selected

plants of each genotype. Mites (per cm^2 of leaf area) were counted with the help of magnifying lens (10X) on both adaxial and abaxial surface of leaves.

Trichomes are microscopic hairs present on leaf lamina. Density and length of trichomes on leaf lamina and thickness of leaf lamina influence the feeding and ovipositional behaviour of *Tetranychus urticae* to a great extent [5-7]. The total number of trichomes present on leaf lamina in a single microscopic field was recorded with the help of compound microscope. Trichomes were counted both on lower and upper surface of leaf pieces. The length of trichomes was measured with the help of an ocular micrometer from the pieces of leaf lamina at 40 X magnification. All the ocular micrometer readings were converted into millimeter with the help of stage micrometer [8].

Thickness of leaf lamina was measured with the help of digital caliper. For the determination of leaf area (cm^2) with the help of portable area meter (Model-LI-3000), leaves from each okra genotype were selected at random by taking fourth leaf from the top of a plant.

Leaf disc technique was used to study the biology of two spotted mite *Tetranychus urtiace* Koch. Female mites were released with the help of 00 series camel hair brush on the abaxial surface of mite free leaves of different okra genotype placed over moist cotton swabs in petri dishes (10 cm diameter). Rate of development of two spotted mite was studied at 25°C.

For recording incubation period, ten or more gravid females were taken from mite culture and released on leaf dices of different okra genotypes for obtaining sufficient number of eggs. After 24 hour of release, female were removed and eggs laid were counted and observed till hatching. For recording different parameters of mite development on different okra genotypes, one newly emerged larva per leaf disc was released and replicated thrice. Thirty leaf discs per genotype were used.

During larval and nymphal development, observations were recorded twice at 6.00 AM and 6.00 PM. Survival of larvae, nymphs were studied on the leaves of different genotypes on okra. Per cent mortality during each stage was recorded. Observations regarding pre-oviposition and post-oviposition periods, fecundity and longevity, daily sex ratio, total immature development (larval + nymphal), reproductive life span and total life duration (immature + adult) were also recorded [9].

For all the biological studies, stereoscopic binocular microscope was used. Five leaf discs per genotype were used. Experiments were replicated five times. One pair of mite was released on the leaf disc (2 cm). Female mite was shifted to fresh leaf disc after 24 hours. All the eggs obtained were counted and daily observations were recorded to find out the development, fecundity and number of eggs laid/day of mites on okra genotypes. Mites were transferred to fresh excised leaves whenever needed for the completion of one life cycle. The procedure was being repeated after every 24 hour till the female died following the standard methodology of Leaf disc technique [10].

3. Results and Discussion

Density of trichomes (number of trichomes per microscopic field 40X) on leaf surface of different genotypes of okra varied significantly ($p<0.05$) (Table 1). It varied from18.95 lowest in highly susceptible okra genotype HBT-6-15-3-7 to 42.12 trichomes highest in least susceptible HB-02-14-1-1. Length of trichomes on leaf surface ranged from 0.27 mm in HB-02-17-1 to 0.31mm in Hisar Unnat. There was significant positive correlation between length of trichomes and number of eggs laid. Thickness of leaf lamina of different genotypes of okra varied from 0.05mm in okra genotype HTB-1-17-5 to 0.08 mm in HB-02-14-1-1. Maximum leaf area (443.23 cm^2) exhibited in okra genotype HRB-107-4-1 while BB1 (294.76 cm^2) was of minimum leaf area. Leaf area of okra genotype HRB-107-4-1 and HB-02-17-1 was significantly higher than BB1and Hisar Unnat (Table 1). There was no relationship between leaf area and susceptibility to mite in different genotypes of okra (Table 2).

Table 1: Morphological leaf characteristics of selected okra genotypes

Sr. No.	Genotype	Leaf area (cm^2)	No of trichomes / microscopic field	Thickness of leaf lamina (mm)	Length of trichomes (mm)
1	HB-02-14-1-1 (LS)	332.61	42.12	0.08	0.29
2	HB-02-17-1 (LS)	425.48	22.25	0.06	0.27
3	HTB-1-17-5 (MS)	420.01	25.21	0.05	0.28
4	HRB-107-4-1 (MS)	443.23	27.61	0.07	0.29
5	BB1 (HS)	294.76	33.28	0.06	0.30
6	HBT-6-15-3-7 (HS)	306.62	18.95	0.07	0.29
7	Hisar Unnat (SC)	296.63	22.64	0.06	0.31
SE(m)±		9.69	1.26	0.01	0.01
CD($P<0.05$)		30.18	3.53	0.01	0.02
Correlation coefficient with number of eggs/ leaf disc		-0.38	-0.53	-0.34	0.57*

* Significant at 5%

Observations and results inference that as that of earlier record were found; least number of trichomes as in highly susceptible [11] okra genotypes IC-117240 (3.0/plant) followed IC-117235 (4.5/plant) and high number of trichomes in least susceptible genotype IC-141065 (28.0/plant). Cotton variety NIAB-999 showing maximum hair density (504/cm^2) on leaf lamina showed maximum resistance against mite population due to maximum hair density and minimum hair length on leaf among the genotypes [12] and significant negative (r= -0.76) correlation of leaf area with mite population [13]. Resistant okra varieties namely; TC 90049 and TC 117235 had more number of glandular hairs as compared to susceptible varieties [11] supported the present finding.

Morphological characteristics of okra leaf like leaf area, density and length of trichomes and thickness of leaf lamina were correlated with incubation period, larval period, nymphal period and larval plus nymphal survival. Only length of trichomes showed positive and significant correlation (r = 0.82*) with larval plus nymphal survival, but other leaf characteristics like leaf area, trichomes density and thickness of leaf lamina had non-significant impact on incubation period, larval period, nymphal period and larval plus nymphal survival (Table 2).

Table 2. Morphological characteristics of okra leaf in relation to biological parameters of *Tetranychus urticae*

Characteristic	Correlation Coefficient with incubation period	Correlation Coefficient with larval period	Correlation Coefficient with nymphal period	Correlation Coefficient with larval plus nymphal survival
No of trichomes /microscopic field	0.41	0.43	0.56	-0.49
Length of trichomes	-0.52	-0.64	-0.54	0.82*
Thickness of leaf lamina	0.23	0.51	0.39	-0.28
Leaf area	0.67	0.47	0.38	-0.45

* Significant at 5%

Leaf disc technique were used to studies the oviposition preference of *T. urticae* under controlled conditions in laboratory, by offering leaf disc (2cm) of promising genotypes to adult female of *T. urticae* [10]. One pair of *T. urticae* was released on single leaf disc and observations on number of eggs laid were counted after 12 h. The results of these studies revealed that HBT-6-15-3-7 was more preferred for egg laying (52.61 eggs/ leaf disc) followed by Hisar Unnat (49.22) and BB1 (47.79), Whereas, HRB-107-4-1 (42.54), HTB-1-17-5 (41.14), HB-02-17-1 (23.24) and HB-02-14-1-1 (18.66) genotypes supported less number of eggs (Table 3).

Table 3

Genotype	Fecundity (Eggs/ female)	Incubation period	Development period (days)				Duration (days)			Longevity (days)	Nymphal Survival (%)	Sex- ratio (Female: Male)
			Larval period	Nymphal period	Larval + nymphal period	Total life period	Pre-oviposition	Oviposition	Post- oviposition	Female		
HB-02-14-1-1 (LS)	18.66	4.57	4.09	4.48	8.57	17.85	2.06	5.66	0.56	8.28	13	2.4:1
HB-02-17-1 (LS)	23.24	3.44	3.97	4.22	8.18	18.01	2.46	6.72	0.64	9.82	15	3.3:1
HTB-1-17-5 (MS)	41.14	4.13	3.40	4.81	8.21	17.39	1.12	7.04	1.02	9.18	43	4.0:1
HRB-107-4-1 (MS)	42.54	4.27	3.46	4.67	9.13	18.19	1.72	7.20	0.14	9.06	46	4.3:1
BB1 (HS)	47.79	3.37	5.04	4.46	9.50	19.51	1.06	8.61	0.34	10.01	57	3.1:1
HBT-6-15-3-7 (HS)	52.61	3.16	5.16	4.32	9.48	20.19	1.86	8.38	1.47	11.71	73	3.3:1
Hisar Unnat (SC)	49.22	3.76	4.12	4.50	8.62	18.55	1.64	7.21	1.08	9.93	54	3.2:1
SE(m) ±	0.58	0.37	0.61	0.24	0.49	0.83	0.28	0.54	0.21	0.34	2.08	
CD(*P*<0.05)	1.64	1.04	1.71	N.S.	N.S.	2.34	0.82	1.57	0.63	0.96	6.47	

Least susceptible genotypes namely HB-02-14-1-1 and HB-02-17-1 were less preferred for egg laying by mite female as compared to highly or moderately susceptible genotypes. This indicated the presence of ovipositional antixenosis mechanism of resistance. Fecundity of female mite of *T. urticae* varied from 41.5 to 62.8 eggs in six varieties (Dharmapuri local, Pusa Sawani, Parbani Kranti, COBhHI, Mahyco 10 and Kasthuri bhendi) [14]. Number of eggs laid was less on the resistant wild type Kasthuri bhendi (41.5 eggs/female) as compared to the susceptible entry Mahyco 10 (77.1 eggs/female). Similar observation of resistant genotypes supporting less number of two spotted mite *T. urticae* eggs have been reported earlier also in okra [15-19].

Biology of *T. urticae* was studied on seven promising genotypes of okra in the laboratory. Ten freshly laid eggs were placed on the leaf discs (one egg/leaf disc). Various biological parameters (Table 3) were recorded on each genotype. Longest incubation period was found on HB-02-14-1-1 (4.57 days) followed by HRB-107-4-1 (4.27 days) and shortest incubation period was found on HBT-6-15-3-7(3.16 days) followed by BB1 (3.37 days). The finding of the study in corroborates with [14] and found that mean incubation period of *T. urticae* eggs was longer on resistant varieties, incubation period longest on resistant genotype Dharmapuri local (4.7 days) and shortest on susceptible genotype Mahyco 10 (3.4 days). Incubation period of *T. urticae* on okra of 2 days [18], (4.12 days) on okra in Hisar [20] and 5.84 days in okra [21] were recorded.

Larval duration (3.40 – 5.16 days) also varied significantly (p<0.05) on different genotypes. Longest larval period was found on HBT-6-15-3-7(5.16 days) followed by BB1 (5.04 days) and shortest larval period was found on HTB-1-17-5(3.40 days) followed by HB-02-17-1(3.97days). Present studies confirm results that longest larval period of *T. urticae* on resistant okra genotype Kasthuri bhendi (6.6 days) and shortest on susceptible genotypes namely Mahyco 10 (3.3 days) and Dharmapuri local (3.7 days) [14]. Larval period of 1.45 [15] and larval period in okra, (4.31 days) [21] of *T. urticae* on okra at 20^{0}C in Punjab and 1.65 days [20] larval period on okra.

Longest nymphal period (4.81and 4.67 days) was observed on moderately susceptible okra genotypes (HTB-1-17-5 and HRB-107-4-1), respectively while shortest nymphal period was recorded on least susceptible genotype HB-02-17-1 (4.22days). Total larval plus nymphal development period was completed in 8.18 days on HB-02-14-1-1 to 9.50 days on BB1. Findings of present investigations are in same line of inference that recorded shortest nymphal period of *T. urticae* on okra genotype Mahyco 10 (6.7 days) and longest on Kasthuri bhendi (13.2 days) [14]. Average nymphal period

recorded of (3.94 days) [15], (8.06 days) [21] and 8.21 days [20] of *T. urticae* on okra plant.

Total life period differed significantly ($p<0.05$) on different genotypes. Short total life periods were observed on okra genotypes HTB-1-17-5 (17.39) and HB-02-14-1-1 (17.85 days) respectively, while in highly susceptible genotypes HBT-6-15-3-7 (21.19 days) and BB1 (19.51 days) the total life periods were longer. Survival of *T. urticae* also differed significant ($p<0.05$) on different okra genotypes. Highest survival was observed on highly susceptible genotype HBT-6-15-3-7 (73%) followed by BB1 (57%) and lowest survival was observed on least susceptible genotype HB-02-14-1-1(13%) followed by HB-02-17-1 (15%) (Table 3) and a total life period 17.74 days [14] of *T. urticae* on okra in Punjab.

Pre-oviposition period of mite varied from 1.06 (BB1) to 2.46 days (HB-02-17-1) (Table 3). Oviposition period *i.e*. the total egg laying period was the highest on highly susceptible genotype BB1 (8.61 days) and followed by HBT-6-15-3-7 (8.38 days). Lowest oviposition period was recorded on least susceptible genotype HB-02-14-1-1(5.66 days). Post-oviposition period ranged from 0.14 days (HRB-107-4-1) to 1.47 days (HBT-6-15-3-7). So, there are also pre and post-oviposition period varied from 1.5 to 2.5 days and an average 2 days on okra [15]. Oviposition period (2.3 days) and post-oviposition period (8.8 days) of *T. urticae* female mite also recorded on okra confirms recorded observation in similar fashion as pre-oviposition (3.12 days), post-oviposition (2.75 days) and oviposition (11.19 days) period of *T. urticae* female mite on okra plant [21].

Highest longevity of female mite was recorded on highly susceptible genotypes HBT-6-15-3-7 (11.71 days) and minimum female longevity on least susceptible genotype HB-02-14-1-1 (8.28 days). Results advocates the finding of present study that longest longevity of female mite of *T. urticae* on susceptible okra genotype Mahyco 10 (20.4 days) and shortest on least susceptible Parbani Kranti (16.2 days) [14]. Similar trends of results on okra of female longevity 13.10 days in okra [15], [22] also reported.

Highest female to male ratio was found on moderately susceptible genotypes HRB-107-4-1 (4.3:1), HTB-1-17-5 (4.01:1) followed by HB-02-17-1(3.3:1) but lowest female to male ratio was found on least susceptible genotype HB-02-14-1-1(2.4:1). The observations of studies inferences that present study confirms, record of highest sex ratio of male and female of *T. urticae* on susceptible okra genotype Mahyco 10 (3.6) and lowest in resistant okra genotype Kasthuri bhendi (1.6) [14], male and female sex ratio of *T. urticae* as 1:2.19 [15] and sex ratio of *T. cinnabarinus* as 1:2.3 [23]. Several workers have also studied the biology of this mite on different crops like mint [24], Jasmine [17], cucurbits [25], bean [18], that too without compared biology on different genotypes of okra.

It may be concluded from the present workout that biological parameters like incubation period, larval period, total life period, survival of nymph, ovipositional period and longevity of female were adversely affected on least susceptible genotypes indicating antibiosis kind of mechanism of resistance in okra.

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