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Influence of Host Plants on the Biological Parameters of Two spotted Spider Mite, *Tetranychus urticae* Koch.

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The *in-vitro* study on the biology of two spotted spider mite *Tetranychus urticae* Koch. on some of the preferred host plants *viz.,* okra, egg plant, french bean, pumpkin, tomato, tapioca and mulberry revealed that the egg, larval, protonymphal and duetonymphal stages, adult longevity, pre-oviposition period and post-oviposition period were the shortest on okra followed by egg plant, french bean, tomato, tapioca, pumpkin and mulberry. The oviposition period, sex ratio and the fecundity were more and prolonged on okra followed by egg plant, french bean, tomato, tapioca, pumpkin and mulberry. *T. urticae* showed relatively better performance on okra, which might be attributed to increased level of total chlorophyll, total sugars, protein and lesser wax content, phenol and silica compared to rest of the host plants.

Key words: Biological parameters, Host plants, Population, *Tetranychus urticae*

The two spotted spider mite (TSSM), *T. urticae* is a member of the family Tetranychidae that contains many harmful species of plant-feeding mites. It was first described by Koch in 1836 and thought to originate from temperate climates. *T. urticae* is a generalist feeder and the most polyphagous arthropod herbivore, feeding on more than 1,100 host plant species belonging to more than 140 families, including those that are known to produce toxic compounds (Van Leeuwen *et al*., 2012). *T. urticae* threatens greenhouse production, field, vine and orchard crops, destroying economically important annual and perennial crops worldwide such as tomato, red pepper, cucumber, strawberry, corn, apples, grape, hop, almond, peppermint, and citrus. However, the population growth parameters of *T. urticae* such as developmental rate, survival, reproduction and longevity may vary on the basis of their suitability as hosts for pests (insects and mites) in terms of survival and longevity, host plant nutrition, cultivar kind, phenological stage etc**.** Host plants of spider mites differ in the degree of food quality, which either depend on the level of primary plant metabolites, or on the quantity and nature of secondary plant metabolites.

Biological parameters are good indices of population growth under a given set of conditions. Many researchers use life table parameters of the mite as an appropriate end point to reveal the effect of different host plants or varieties on the mite (Greco *et al*., 2006). Therefore, data relating to the biological parameters may be helpful in planning pest management programme and also to expand a successful integrated pest management (IPM) programme for spider mite; it is essential to understand its Biological parameters on diverse host plants. Hence, the goal of this study was to evaluate the population growth characteristics of TSSM on various preferred host plants of diversified families.

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Materials and Methods

Biological parameters of T. urticae Koch on various host plants

A laboratory study was conducted at the Acarology Laboratory, Department of Agricultural Entomology, Agricultural College and Research Institute, Madurai during 2015 to test the development and life table parameters of *T. urticae* on various host plants *viz.,* okra, *Abelmoschus esculentus* (L.) Moench; egg plant, *Solanam melongena* (L.); tomato, *Lycopersicon esculentum* Mill; tapioca, *Manihot esculenta* Crantz; french bean, *Phasiolus vulgaris* (L.); pumpkin, *Cucurbita pepo* (L.) and mulberry, *Morus alba* (L.) in *in-vitro* conditions at 27±2ºC, 70±5% relative humidity. In this regard, a pair of male and female was selected from the stock culture and transferred to a fresh leaf disc of each host plant. Fresh leaf discs of respective host plant were made which were square in appearance. The leaf discs were placed on cotton bed in Petri dish facing under surface upward. The cotton bed was kept wet by soaking with water twice daily so that the leaf discs remained fresh. Twenty four hours later, the eggs laid were collected from these leaf discs and individually transferred with a fine camel hair brush onto new leaf discs of respective hosts. All the transferred eggs and subsequent stages (larva, nymph and adult) were carefully monitored daily until reaching adulthood and their survival and moulting to the next stage were recorded. As soon as the adults emerged, the females were differentiated by their round caudal end against males with pointed caudal ends. Based on these observations apart from the hatchability of eggs were calculated immature survivorship and the sex ratio.

Estimation of biochemical and physical profile

To find out the impact of various biochemical and physical constituents of various host plants on the biological parameters of *T. urticae*, biochemical components were estimated in leaf samples of host plants. Fresh leaf samples were collected from each host and analyzed for total chlorophyll (Mahadevan and Sridhar, 1986), protein content (Lowry *et al.,* 1951)**,** total sugars (Sadasivam and Manickam, 1996), total phenols (Malick and Singh, 1980), silica (Ram Prasad *et al.,* 2010), and bio-physical character such as surface wax of leaves as described by Woodhead and Padgham, (1988).

Results and Discussion

Biological parameters of T. urticae Koch on various host plants

The biology of *T. urticae* Koch studied on different host plants such as okra, egg plant, tomato, tapioca, french bean, pumpkin and mulberry under lab conditions corroborated that (Table. 1) the duration of egg period and larval duration was significantly shorter on okra (2.1 and 1.1 days) followed by egg plant (2.5 and 1.3 days), french bean (2.6 and 1.4 days), tomato (3.1 and 1.7 days), tapioca (3.6 and 1.8 days) and pumpkin (4.0 and 2.1 days). Egg and larval development was very slow on mulberry (4.4 and 2.7 days). The protonymphal and duetonymphal periods were comparatively shorter on okra (1.2 and 1.2 days) followed by egg plant (1.4 and 1.4 days), french bean (1.7 and 1.5 days), tomato (1.9 and 1.9 days), tapioca (2.2 and 2.3 days), pumpkin (2.5 and 2.5 days) and very slow on mulberry (3.2 and 3.3days). As for as the adult longevity of male and female mites are concerned the duration was the least on okra (9.1 and 14.5 days) followed by egg plant (9.4 and 14.9 days), french bean (10.2 and 15.4 days), tomato (10.3 and 16.1 days), tapioca (13.2 and 16.8 days) and pumpkin (14.0 and 17.5 days) and prolonged on mulberry (14.5 and 17.8 days).

The present investigation on the biology of *T. urticae* on host plants revealed that the life cycle consists of egg, larval, protonymphal and duetonymphal stages and adult stage which differ between host plants significantly. The duration of immature stages varied significantly among the host plants, which was the shortest on okra and egg plant followed by french bean, tomato, tapioca, pumpkin and mulberry. The incubation period of the egg was 2.1 days on okra followed by egg plant (2.5 days) and french bean (2.6 days), which are in agreement with the findings of Krishna and Bhaskar (2014) who has made similar observations. The present findings fall in line with the observations made by Vinoth Kumar *et al.* (2013) who reported that the larval period of *T. urticae* ranged from 2.5 to 4.0 days. From the present study it is evident that the protonymphal and deutonymphal periods were shorter on okra followed by egg plant and french bean which are the most preferred hosts. However mulberry recorded the longest protonymphal and deutonymphal period. This is in conformity with the observations made by Riahi *et al.* (2013) who opined that the protonymphal period varied between 1.09 to 1.14 days on okra so also Krishna and Bhaskar (2014) further confirmed that the deutonymphal period lasted for 0.93 days. The longevity of adults was the shortest on okra indicating that the adult can cause damage with in a shorter period on okra (9.1 to 14.5 days), followed by egg plant (9.4 to 14.9 days), french bean (10.2 to 15.4 days), tomato (10.3 to 16.1 days), tapioca (13.2 to 16.8 days), pumpkin (14.0 to 17.5 days) and mulberry (14.5 to 17.8 days). Riahi *et al.* (2013) also have confirmed that the adult longevity of *T. urticae* lasts for 11.25 to 11.72 days for male and 30.83 days in case of females.

Table 1. Impact of various host plants on the biological parameters of TSSM.

Host plants	Duration in days (Mean* ±S.D.)					
	Egg	Larva	Protonymph	Duetonymph	Adult longevity	
					♂	♀
Bhendi	2.1±0.08^{a}	1.1±0.03^{a}	1.2±0.02^{a}	1.2±0.03^{a}	9.1±0.39^{a}	14.5±0.65^{a}
Brinjal	2.5±0.07^{b}	1.3±0.03^{b}	1.4±0.01^{b}	1.4±0.01^{b}	9.4±0.07^{a}	14.9±0.34^{ab}
Tapioca	3.6±0.13^{d}	1.8±0.05^{c}	2.2±0.05^{e}	2.3±0.07^{e}	13.2±0.23^{c}	16.8±0.81^{de}
Pumpkin	4.0±0.13^{e}	2.1±0.05^{d}	2.5±0.04^{f}	2.5±0.05^{f}	14.0±0.53^{d}	17.5±0.11^{ef}
French bean	2.6±0.08^{b}	1.4±0.02^{b}	1.7±0.05^{c}	1.5±0.06^{c}	10.2±0.34^{b}	15.4±0.20^{bc}
Tomato	3.1±0.08^{c}	1.7±0.06^{c}	1.9±0.01^{d}	1.9±0.06^{d}	10.3±0.18^{b}	16.1±0.13^{cd}
Mulberry	4.4±0.17^{f}	2.7±0.09^{e}	3.2±0.05^{g}	3.3±0.07^{g}	14.5±0.10^{d}	17.8±0.73^{f}
SEd	0.0633	0.0270	0.0396	0.0308	0.2370	0.3807
CD(.05)	0.1359	0.0578	0.0848	0.0660	0.5083	0.8166

*Mean of four replications; Abbreviations; ♂- Male; ♀- Female
In a column, mean±S.D. followed by common superscript(s) are at par by LSD (P= 0.05)

Nevertheless the preoviposition period is remarkably shorter on okra (1.1 days) followed by egg plant (1.3 days), french bean (1.4 days), tomato (1.4 days), tapioca (1.5 days), pumpkin (1.8 days) and relatively the longest on mulberry (1.9 days). Oviposition period was significantely longer on okra (18.5 days) followed by egg plant (17.2 days), french bean (15.3 days), tomato (15.1 days), tapioca (14.5

days), pumpkin (12.5 days) and shorter on mulberry (11.5 days). The post-oviposition period was the least on okra (0.9 days) followed by egg plant (1.1 days), french bean (1.2 days), tomato (1.2 days), tapioca (1.4 days), pumpkin (1.4 days) and slow on mulberry (1.5 days) comparatively. The fecundity rate was also the highest on okra (133 eggs/♀) followed by egg plant (124 eggs/♀), french bean (122 eggs/♀), tomato (115 eggs/♀), tapioca (110 eggs/♀), pumpkin (84 eggs/♀) and the least on mulberry (65 eggs/♀). Hatching percentage was also maximum on okra (81.95%) followed by egg plant (79.03%), french bean (78.69%), tomato (78.26%), tapioca (76.36%), pumpkin (76.19%) and low on mulberry (75.38%).

Sex ratio (♂:♀) was more on okra (1:4.00) followed by egg plant (1:3.94), french bean (1:3.90), tomato (1:3.80), tapioca (1:2.89), pumpkin (1:3.45) and less on mulberry (1:2.76). Webbing intensity was severe on okra leaves followed by egg plant, french bean, tomato, tapioca, pumpkin and low webbing activities could be observed in case of mulberry leaves, eventhough mite feeding was there. The pre-oviposition and oviposition periods were shorter on okra 1.1 days and 18.5 days, followed by egg plant 1.3 days and 17.2 days, respectively. Similar finding was reported by Vinoth Kumar *et al.* (2013), who confirmed that the pre-oviposition and oviposition periods of *T. urticae* ranged from 1.6 to 2.4 days and 11.9 to 13.4 days, respectively on egg plant. The fecundity of female mite ranged from 162 to 174 eggs. Vinoth Kumar *et al.* (2013) have also obtained similar results stating that each female laid about (135 eggs / ♀) on okra followed by egg plant (124 eggs / ♀). The fecundity was the lowest on mulberry (65 eggs / ♀) compared to rest of the host plants. Thus all the biological parameters were favourable on okra indicating that okra was the most preferred host plant, serving as the most suitable host to support *T. urticae* population, in contrary pumpkin and mulberry were the least preferred hosts despite mite colonization and feeding activity were noticed.

Table 2. Impact of host plants on the adult characteristics of TSSM.

Host plants	Duration in days (Mean* ±S.D.)			Fecundity (No.of eggs/♀), (Mean*±S.D.)	Hatching %	Sex ratio (♂:♀)	Webbing intensity
	Pre-oviposition	Oviposition	Post-oviposition				
Bhendi	1.1±0.07^{a}	18.5±0.67^{a}	0.9±0.06^{a}	133±4.37^{a}	81.95	1:4.00	S
Brinjal	1.3±0.06^{b}	17.2±0.60^{b}	1.1±0.03^{b}	124±5.84^{b}	79.03	1:3.94	S
Tapioca	1.5±0.04^{d}	14.5±0.07^{e}	1.4±0.10^{d}	110±4.56^{c}	76.36	1:3.45	S
Pumpkin	1.8±0.40^{e}	12.5±0.04f	1.4±0.06^{d}	84±0.61^{d}	76.19	1:2.89	S
French bean	1.4±0.01^{c}	15.3±0.46^{c}	1.2±0.07^{c}	122±0.43^{b}	78.69	1:3.94	S
Tomato	1.4±0.07^{c}	15.1±0.25^{cd}	1.2±0.04^{c}	115±4.77^{c}	78.26	1:3.80	S
Mulberry	1.9.±0.21^{f}	11.5±0.35^{g}	1.5±0.01^{e}	65±0.23^{e}	75.38	1:2.76	L
SEd	0.0289	0.3095	0.0281	2.7546	-	-	-
CD(.05)	0.0619	0.6639	0.0604	5.9086	-	-	-

*Mean of four replications; Abbreviations; ♂- Male; ♀- Female

In a column, mean±S.D. followed by common superscript(s) are at par by LSD (P= 0.05)

Grade 1: Low webbing (L) - webbing on few leaves

Grade 2: Moderate webbing (M) - webbing on >3 leaves.

Grade 3: Severe webbing (S) - covering all the leaves/ plant.

Impact of biochemical and physical factors on the incidence of T. urticae on different host plants

Biochemical constituents *viz.,* total chlorophyll, proteins, total sugars, total phenols, silica content and physical factors *viz.,* wax content were estimated in matured leaf samples of various host plants revealed that the (Table 3) total chlorophyll content was the highest in okra (2.60 mg/g) which was on par with egg plant (2.56 mg/g) statistically followed by french bean (1.61 mg/g), tomato (1.55 mg/g), tapioca (0.65 mg/g), pumpkin (0.56 mg/g) and very low concentration in mulberry (0.51 mg/g) proving that more the chlorophyll contents, more the feeding preference and other biological parameters (directly proportional). The protein content was the highest in okra (4.05 mg/g) followed by egg plant (3.66 mg/g), french bean (3.45 mg/g) and on par with tomato (3.43mg/g), tapioca (2.80 mg/g), pumpkin (2.63 mg/g) and the least in mulberry (1.40 mg/g). As for as total sugars are concerned, was the highest in okra (8.52 mg/g) followed by egg plant (7.50 mg/g), french bean (7.05 mg/g), tomato (6.04 mg/g), tapioca (4.53 mg/g) and on par with pumpkin (4.32 mg/g) and the least concentration in mulberry (2.58 mg/g).

Nevertheless the total phenol content in leaf tissues (Table 3) was the highest in mulberry (7.80 mg/g) followed by tapioca (7.76 mg/g), pumpkin (5.65 mg/g), french bean (5.33mg/g), tomato (4.58 mg/g), and the least was in egg plant (4.42 mg/g) which is statistically on par with okra (4.11 mg/g). Leaf silica content was more in mulberry leaves (0.79 mg/100g) followed by pumpkin (0.65 mg/100g) on par with tapioca (0.64 mg/100g), tomato (0.45 mg/100g), french bean (0.41mg/100g), egg plant

(0.38 mg/100g) and the least was in okra (0.34 mg/100g) revealing that more the silica content on leaves there was a reduced feeding preference and biological parameters. Leaf wax content was found to be the highest in mulberry (0.096 mg/100g) followed by tapioca (0.082 mg/100g), pumpkin (0.076 mg/100g), tomato (0.066 mg/100g), french bean (0.057mg/100g), egg plant (0.033 mg/100g) and the least in okra (0.029 mg/100g) showing an inverse relationship between the leaf wax content and the suitability of the host/ feeding preference.

Table 3. Impact of biochemical and physical factors of various host plants on biology of TSSM.

Host plants	Biochemical factors					Physical factor
	Total chlorophyll (mg/g)	Proteins (mg/g)	Total Phenols (mg/g)	Total sugars (mg/g)	Leaf silica content (mg/100g)	Leaf wax content (mg/100g)
Okra	2.60^{a}	4.05^{a}	4.11^{a}	8.52^{a}	0.34^{a}	0.029^{a}
Egg plant	2.56^{a}	3.66^{b}	4.42^{a}	7.50^{b}	0.38^{b}	0.033^{b}
Tapioca	0.65^{d}	2.80^{d}	7.76^{bd}	4.53^{e}	0.64^{e}	0.082^{f}
Pumpkin	0.56^{e}	2.63^{e}	5.65^{c}	4.32^{e}	0.65^{e}	0.076^{e}
French bean	1.61^{b}	3.45^{c}	5.35^{c}	7.05^{c}	0.41^{c}	0.057^{c}
Tomato	1.55^{c}	3.43^{c}	4.58^{b}	6.04^{d}	0.45^{d}	0.066^{d}
Mulberry	0.51^{e}	1.40^{f}	7.80^{d}	2.58^{f}	0.79^{f}	0.096^{g}
SEd	0.0418	0.0499	0.1673	0.1461	0.0079	0.0016
CD(P=0.05)	0.0896	0.1071	0.3588	0.3133	0.0170	0.0035

*Mean of four replications

In a column, mean ± S.D. followed by common superscript(s) are at par by LSD at (P= 0.05)

The high feeding preference of *T. urticae* showed on okra might be attributed to the presence of more total chlorophyll (2.60 mg / g), protein (3.66 mg / g), total sugars (8.52 mg / g) and lesser wax content (0.029 mg/g), phenol (4.11mg/g), silica (0.34 mg / g) compared to other shorter preferred host plants. The slow growth rate of mite on mulberry might be attributed to reduced amount of total chlorophyll (0.51 mg/g), total sugars (2.58 mg/g), protein (1.40 mg/g) apart from presence of more wax content (0.096 mg/g), increased concentration phenol (7.80 mg/g) and silica (0.79 mg/g) which probably discouraged feeding rate, besides suppressing overall growth and development. Host plant preference of TSSM differs based on the degree of suitability for feeding which either depends on the level of primary plant metabolites, or on the quantity and nature of secondary plant metabolites (Gulati, 2004). Many secondary plant metabolites found in host plants have a responsibility in defense mechanisms against herbivores, pests and pathogens. These compounds can perform as toxins, feeding deterrents, digestibility reducers or act as precursors to physical defense systems.

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