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Influence of Predator Density on the Efficiency of Spider Mite Predators against Two Spotted Spider Mite, *Tetranychus urticae* Koch (Acari: Tetranychidae)

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ABSTRACT
The two spotted spider mite, *Tetranychus urticae* Koch was reported as one of the important mite pests of vegetable crops and ornamentals in greenhouses and of several other agricultural outdoor crops. It is well adapted to various environmental conditions, causing loss of quality and yield or death of plants by sucking out the contents of leaf cells. Wide arrays of natural enemies were reported to feed on the spider mites. Among the natural enemies, predatory coccinellid of the genus *Stethorus*, staphylinid, *Oligota* sp. and phytoseiid mite, *Amblyseius longispinosus* (Evans) contribute the chief predatory fauna on spider mites. Hence, present investigations were carried out to study the influence of different predator prey densities on the efficacy of predators viz., the predatory coccinellid, *Stethorus pauperculus* Weise, staphylinid, *Oligota* sp. and phytoseiid mite, *Amblyseius longispinosus* (Evans) against *T. urticae* on okra. The results of the study revealed that the predator prey ratio of 5:150 was highly suitable for both *Stethorus pauperculus* and *Oligota* sp. Among the predators, *S. pauperculus* recorded the highest consumption of 18.00, 39.50, 117.25, 125.00 and 149.25 number of *T. urticae* adults per day against first, second, third, fourth instar grubs and adults, respectively at a predator prey ratio of 5:150. The predatory staphylinid, *Oligota* sp. grubs fed significantly more *T. urticae* (134.50 day^{-1}) than adults (49.25 day^{-1}). Similarly, maximum consumption was recorded in 5:50 ratio of *A. longispinosus* and *T. urticae* where nymph fed were 13.50 day^{-1} and adult fed were 16.54 day^{-1}.

Key words: *Tetranychus urticae*, *Stethorus pauperculus*, *Amblyseius longispinosus*, *Oligota* sp., predator density, predatory potential, okra

INTRODUCTION
Okra (Bhendi), *Abelmoschus esculentus* (L.) Moench is one of the most important vegetables widely cultivated as a summer crop in North India and also as winter crop in Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. Okra is highly valued for its tender delicious pods (fruits) in different parts of the country. Though, it is mainly used as a fresh vegetable, it is also consumed as canned, dehydrated or frozen forms. Besides insect pests, several species of mites belonging to the genus *Tetranychus* causes a loss of 7 to 48% in okra fruit yield (Srinivasa and Sugeetha, 1999; Kumaran *et al*., 2007). The two spotted spider mite, *Tetranychus urticae* Koch was reported as one of the important mite pests of vegetable crops and ornamentals in greenhouses and of

several other agricultural outdoor crops (Mondel and Ara, 2006). It is well adapted to various environmental conditions, causing loss of quality and yield or death of plants by sucking out the contents of leaf cells.

The high reproductive potential and extremely short life cycle, combined with frequent acaricide applications, facilitates resistance build-up (Stumpf and Nauen, 2002; Chiasson *et al*., 2004; Van Leeuwen *et al*., 2005). In this regard, natural enemies were an important component in a cropping system. They were believed to suppress spider mite populations and in many cases are effective in delaying population buildup (Schoenig and Wilson, 1992). Wide arrays of natural enemies were reported to feed on the spider mites. Among the natural enemies, the phytoseiid predatory mite, *Amblyseius longispinosus* (Evans) and predatory coccinellid of the genus *Stethorus* and staphylinid, *Oligota* sp. contribute the chief predatory fauna on spider mites. The genus *Stethorus* is unique among the coccinellids with specific preference for mites. *Stethorus* is also found in a variety of habitats, including many agricultural and forest ecosystems. All known species of the genus, *Stethorus* are predators of spider mites and are found to have high potential as biological control agents in agricultural crops (Biddinger *et al*., 2009).

However, very little study was carried out on the efficacy of spider mite predators against *T. urticae* on vegetables crops. Keeping this in view, the present investigations were carried out to study the effects of different predator prey densities on the efficacy of predators against *T. urticae* on okra.

MATERIALS AND METHODS

Laboratory rearing of prey and predators

Culturing of *T. urticae*: The two spotted spider mites, *T. urticae* were collected from okra fields, mass reared and maintained in the glass house following the method developed by Krishnamoorthy (1988). Okra plants were raised in pots once in a week for culturing *T. urticae*. The plants after thirty days were inoculated with *T. urticae* with the help of camel hair brush or by keeping the already infested leaves on fresh plants in order to transfer the mites. Then freshly potted plants were transferred besides the older plants at periodic intervals to transfer the mites from older one to fresh so as to maintain the continuous culture of *T. urticae*. The mites from the culture were used for various experiments.

Culturing of *S. pauperculus*: Mass culturing was carried out by using the prey mites, *T. urticae* as per the method developed by Perumalsamy *et al*. (2008). Two spotted spider mite infested leaves were collected along with different stages of the predator, *S. pauperculus* from okra field and was maintained in the laboratory at room temperature. Newly emerged male and female beetles were collected and introduced into the glass container (15×20×8 cm) having mite infested okra leaves with moist cotton at the bottom for copulation. Top of the container was covered with white muslin cloth and fastened with rubber band.

After mating females were transferred to separate containers for egg laying. The females were allowed to lay the eggs on the surface of mite infested leaves. The egg laden leaves were removed periodically and placed on the moist cotton kept in other glass container for hatching. After hatching the larval instars were provided with mite infested okra leaves for feeding on alternate days. The pupae were collected from the containers and kept separately for adult emergence and the cycle was repeated. Fine tipped camel hair brush was used to collect and handle all the developmental stages of the beetles.

Culturing of predatory staphylinid, *Oligota* sp.: The staphylinid predator, *Oligota* sp. were not amenable for mass culturing and hence the grub and the adult stages collected from the okra fields were used for the studies.

Culturing of predatory mite, *A. longispinosus*: The predators were cultured by following the method developed by Mallik *et al.* (1999). *T. urticae* was used as the prey mite for culturing the predatory mite *A. longispinosus*. French bean (*Phaseolus vulgaris* L.) plants were raised in earthen pots and the canopy development of these plants was monitored by periodically recording the number of leaflets on the plants. The spider mites were released on these plants when they had three compound leaves. Nine days after the release of spider mites, the predators were released at the rate of ten per plant. After twelve days, the predators were harvested and used for further experiments. The cycle was thus repeated to maintain the culture continuously.

Influence of predator density on the predatory efficiency: Experiments were carried out to know the effects of different predator prey densities on the efficacy of predators during 2010-11. The *T. urticae* adults cultured on okra was offered separately to the most voracious stages viz., third, fourth instar grubs and adults of *S. pauperculus* at a ratio of 1:150, 2:150, 3:150, 4:150 and 5:150. The experiment was conducted on okra leaf disc kept over a petri dish (10 cm diameter) lined with moist cotton wool with four replications in Completely Randomized Design (CRD). Observations on the number of prey consumed were worked out after 24 h.

The study was also conducted using the third instar grubs and adults of predatory staphylinid, *Oligota* sp. at the predator prey ratio similar to that of *S. pauperculus* and with the predatory mite, *A. longispinosus* against *T. urticae* cultured on okra at a predator prey ratio of 1:50, 2:50, 3:50, 4:50 and 5:50 with four replications.

Statistical analysis: The data obtained from different laboratory experiments were subjected to analysis of variance using AGRES ver. 7.01, Pascal International software solutions and the means were separated by LSD available in the package (Gomez and Gomez, 1994).

RESULTS AND DISCUSSION

Influence of predator density on the predatory efficiency: The studies showed that there was a significant difference in predation, between different predator prey ratios. Among the different densities tested for the *S. pauperculus*, the predator prey ratio of 5:150 was found to be highly significant which recorded maximum consumption of 18.00, 39.50, 117.25, 125.00 and 149.25 number of *T. urticae* per day for first, second, third, fourth instar grubs and adults, respectively (Table 1). The rate of predation increased with the increase in predator density. Similar results were also reported by Arbabi and Singh (2008) on *Stethorus punctillum* against *Tetranychus ludeni*. Prey consumption by the predatory staphylinid, *Oligota* sp. was also significantly high at a predator prey ratio of 5:150.

The grubs fed significantly more *T. urticae* (134.50 day^{-1}) than adults (49.25 day^{-1}) (Table 2). Similarly, the third instar larvae of *O. kashmirica benefica* was reported to have much higher prey consumption than the adults (Shimoda *et al.*, 1997). Kishimoto and Adachi (2008) reported that the *Oligota kashmirica benefica* consumed more prey and laid more eggs in *T. urticae* egg patches, particularly at high prey density. However, predation and oviposition by *O. kashmirica benefica* increased greatly with increasing prey density, indicating that prey density was the most important factor in predation and oviposition.

Table 1: Predatory potential of *S. pauperculus* at different predator prey ratio against *T. urticae* adults in okra

	Stages of predator				
Predator:Prey ratio	I Instar	II Instar	III Instar	IV Instar	Adult
1:150	4.75 (2.29)[a]	9.25 (3.12)[a]	44.25 (6.60)[d]	63.25 (7.90)[c]	100.75 (9.97)[b]
2:150	8.25 (2.96)[b]	18.25 (4.33)[b]	78.50 (8.82)[c]	76.75 (8.70)[bc]	130.25(11.35)[a]
3:150	12.00 (3.54)[c]	25.25 (5.07)[c]	86.75 (9.25)[bc]	87.00 (9.25)[b]	139.75(11.77)[a]
4:150	15.25 (3.97)[d]	33.25 (5.81)[d]	100.75 (9.97)[ab]	112.50 (10.65)[a]	140.50(12.08)[a]
5:150	18.00 (4.30)[e]	39.50 (6.32)[e]	117.25 (10.75)[a]	125.00 (11.07)[a]	149.25(12.51)[a]
CD	0.2274	0.2073	0.9441	1.0582	0.8163
SEM	0.1067	0.0972	5.6908	6.3383	5.90602

Values are mean of four replications, Values in parentheses are √(x+0.5) transformed values, In a column, means followed by a common letter(s) are not significantly different by LSD (p = 0.05)

Table 2: Predatory potential of *Oligota* sp. at different predator prey ratio against *T. urticae* adults in okra

	Stage of predator	
Predator:Prey ratio	Grub	Adult
1:150	65.50 (8.02)[d]	19.25 (4.30)[d]
2:150	79.25 (8.85)[c]	29.25 (5.37)[c]
3:150	112.75 (10.55)[b]	33.75(5.75)[bc]
4:150	123.25 (11.05)[ab]	38.25 (6.10)[b]
5:150	134.50 (11.55)[a]	49.25 (6.95)[a]
CD	0.4927	0.7597
SEM	2.61827	3.01428

Values are mean of four replications, Values in parentheses are √(x+0.5) transformed values, In a column, means followed by a common letter(s) are not significantly different by LSD (p = 0.05)

Table 3: Predatory potential of *A. longispinosus* at different predator prey ratio against *T. urticae* on okra

	Stages of predator	
Predator:Prey ratio	Nymph	Adult
1:50	3.75 (1.90)[d]	4.25 (2.02)[d]
2:50	5.25 (2.25)[c]	7.75 (2.72)[c]
3:50	9.25 (3.00)[b]	11.25(3.30)[b]
4:50	11.50 (3.35)[a]	14.75(3.80)[a]
5:50	13.50 (3.55)[a]	16.54(4.00)[a]
CD	0.5429	0.4140
SEM	0.88291	0.74692

Values are mean of four replications, Values in parentheses are √(x+0.5) transformed values, In a column, means followed by a common letter(s) are not significantly different by LSD (p = 0.05)

In case of predatory mite, maximum consumption was recorded in 5:50 ratio of *A. longispinosus* and *T. urticae* where nymph fed 13.50 nos. per day and adult fed 16.54 day^{-1} (Table 3). However, the ratio of 4:50 was also found to be on par with 5:50. Hamlen and Lindquist (1981) and Opit *et al*. (2005) reported that the predator prey ratio of 1:20 was very effective and for greatest reliability, the ratio should be maintained at 1:4 for *P. persimilis* and *T. urticae*. Similarly Canlas *et al*. (2006) reported that consumption of *T. urticae* by the *Neoseiulus californicus* (McGregor) increased with the increase in the prey density. This is in close agreement with our findings.

CONCLUSION

Earlier studies related to spider mite predators viz., Stethorus spp. and predatory mites were targeted mostly against greenhouse grown crops and orchard ecosystem. The present investigation wide opened the scope of spider mite predators on vegetables like okra. Further, developing mass production strategies at cheaper cost coupled with large scale field studies may give long term benefits in the bio-suppression of *T. urticae* on okra.

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