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Evaluation of the Different Control Methods for the Two-Spotted Spider Mites by Computer Software and Percentage Efficacy

Saied Alzoubi and Sultan Çobanoğlu
Department of Plant Protection, Faculty of Agriculture,
Ankara University, 06110 Dışkapı, Ankara, Turkey

Abstract: The trials were carried out, under greenhouse conditions in Ankara-Turkey to control the two spotted spider mite (TSSM) *Tetranychus urticae* Koch as part of a mite management program in 2007 season, on cucumber (*Cucumis sativus* L.). Three different control methods namely, chemical (by using hexythiazox, bifenthrin and dimethoate), biological (by releasing *Phytoseiulus persimilis* and *Amblyseius californicus*) and combination between chemical and biological control were applied and evaluated by two different methods. One of them, depended on measuring the feeding damage rate of TSSM by computer software (Compu Eye, leaf and Symptom Area). The other one is common in used and rely on calculation the percentage efficacy by mathematical formula (Henderson and Tilton formula). The ANOVA analysis of results of the tested evaluation methods could separate the mean of values of percentage efficacy and feeding damage rate and relatively assemble into counterpart groups and gave same decision in evaluation the effectiveness of the control methods. The results indicated that hexythiazox and dimethoate could not repress the TSSM population, which gave significant damage rate in its treatments and the efficacy of mention pesticides not provided well controlling, which was low to TSSM when compared with bifenthrin, predators and combination of chemical and predators. While, bifenthrin and hexythiazox combined with predators or bifenthrin alone could repress well the TSSM population so that, the damage rate was low, which its percentage efficacy was high. Feeding damage rate, which was assessed by computer software may be satisfactory recommend to evaluate the effectiveness of control methods against spider mites under IPM programs.

Key words: *Tetranychus urticae*, control methods, feeding damage rate, percentage efficacy, IPM

INTRODUCTION

The two-spotted spider mite (TSSM), *Tetranychus urticae* Koch (Acari: Tetranychidae) is common pests on many vegetables and ornamental plants, including tomatoes, cucumbers, peppers, strawberries, roses and many other host plant species. It feeds by puncturing cells and draining the contents, producing a characteristic yellow speckling of the leaf surface. They also produce silk webbing, which is clearly visible at high infestation levels (Alzoubi and Çobanoğlu, 2006). Logically, this reduces of plant's ability to build carbohydrates, which thereafter results reduction in total yield. Measuring damage is very important to identify economic threshold and set up a good integrated pest management program. Several methods for estimating *T. urticae* feeding damage have been proposed (Tomkiewicz *et al*., 1993; Iatrou *et al*., 1995; Nachman and Zemek, 2002). Recently, digital images and

Corresponding Author: Saied Alzoubi, Department of Plant Protection, Faculty of Agriculture, Ankara University, 06110 Dışkapı, Ankara, Turkey Tel: +90-312-596-1524 Fax: +90-312-318-7029

computers have been used to measure pest feeding (Alchanatis *et al*., 2000; O'Neal *et al*., 2002; Skaloudova *et al*., 2006). Compu Eye, leaf and Symptom Area software is one from the software programs to measuring the feeding damage of *T. urticae*. Bakr (2005) mentioned that Compu Eye, leaf and Symptom Area software was able to assess the symptom area of *T. urticae* accurately with no significant difference compared with manual measurement. This software is a simple and relatively inexpensive method because it does not require any special equipment beyond usual computer software and hardware. In addition, scanned images can be stored on digital media (e.g., on CD or USB) for later analysis and the software saves more time and effort than other mathematical methods, which require accounting the pest stages before and after application. There are many formulas available to calculate percentage efficacy against spider mites and insects. These formulas were used to evaluation the control methods for choosing in integrated pest management program, such as Abbott, Henderson and Tilton, Schneider-Orelli or Sun-Shepard formulas. The aim of this trial is evaluation and comparison between effectiveness of pesticides and predators as a percentage efficacy by using the Henderson and Tilton formula with the feeding damage of *T. urticae* as symptom area rate by Compu Eye, leaf and Symptom Area software.

MATERIALS AND METHODS

Source of Mites

Tetranychus urticae was reared on bean plants (*Phaseolus vulgaris* L.) at 25±1°C. Bean plants were grown under climate room condition (same regime) and the plants were added weekly to the spider mite culture. The predatory mites, *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) and *Amblyseius californicus* McGregor (Acari: Phytoseiidae) were reared at 25±1°C and 60±5% RH under 16 h light regime on bean plants, which infested with two-spotted spider mites. *P. persimilis* was obtained from Hatay Samandag Turkey. *A. californicus*, Spical® was obtained from Koppert.

Planting of Host Plants

Cucumber, *Cucumis sativus* L., plants were used as the host plant species in greenhouse experiments. Cucumber seedlings were prepared for planting in gowning room and then transferred to the greenhouse. In greenhouse experiments the plants were separated from each other to prevent touching and movement of the mites by using cloth barricades. Thereafter, plants were infested with TSSM (30 females/plant) when became mature to the four real leaves phase.

Experiment of Chemical Control

Two insecticide-acaricides (bifenthrin and dimethoate) and a selective acaricide and mite growth regulator hexythiazox were used. The recommended field dose of bifenthrin (Talstar® 10 EC, Bayer), dimethoate (Poligor® 40 EC, Hekta°) and hexythiazox (Twister® 5 EC, Hekta°) which 0.06 g a.i. L^{-1} (60 ppm), 0.45 g a.i. L^{-1} (450 ppm) and 0.05 g a.i. L^{-1} (50 ppm), respectively. The experimental dose of the pesticides was one-third of the recommended field dose i.e., bifenthrin 0.02 g a.i. L^{-1} (20 ppm), dimethoate 0.15 g a.i. L^{-1} (150 ppm) and hexythiazox 0.0167 g a.i. L^{-1} (16.7 ppm). Pesticides were applied 17 days after infestation of TSSM by using hand sprayer. This experiment was consisted of three blocks, containing four plants in each block.

Experiment of Biological Control

The predatory mites, *P. persimilis* and *A. californicus* were released four females/plant, after 17 days of infestation. This experiment was consisted of two blocks, containing four plants in each block.

Experiment of Combination of Chemical and Biological Control

Predatory mites (*P. persimilis* and *A. californicus*) were released i.e., four predatory females per plant, after 17 days from infestation with TSSM. Thereafter, pesticides were applied with a hand sprayer after seven days of predators release. This experiment was consisted of six blocks, containing four plants in each block. In Addition, one block containing TSSM as control was used for all experiments.

Measuring of Damage Rate

The leaf samples were taken from experimental blocks as four leaves from each block after 38 days of infestation. Thereafter, each leaf was scanned individually, on a black background, with 150 DPI (dots per inch) resolutions. HP scan jet 2400 (Hewlett-Packard, Palo Alto, CO., USA) was used to in this purpose. Scanned leaf images were saved separately as bmp 24 bit-files. Compu Eye, leaf and Symptom Area software was used as Bakr (2005) described it. The software is available now at http://www.ehabsoft.com/CompuEye/LeafSArea. The principal idea of the software is to divide the image into small squares and assess the average colour of every square, where the area of these square units could be adjusted between 0.1 and 1.0 mm^2. After calibration, the standard-shape image files were opened and analysed by the software, the percentage of symptom area value was calculated for each leaf image. Data were analyzed with ANOVA using Cohort Software and means were separated according to Duncan's Multiple Range Test (DMRT).

Evaluation of Percentage Efficacy

The numbers of TSSM (egg, immature and adult stages) were counted on an area of 8 cm^2 of cucumber leaf in laboratory, using the stero-microscop. The corrected efficacy percentage was calculated according to Henderson and Tilton formula (Henderson and Tilton, 1955):

$$\text{Corrected (\%)} = (1 - \frac{\text{n in Co before treatment} \times \text{n in T after treatment}}{\text{n in Co after treatment} \times \text{n in T before treatment}} \times 100)$$

Where:

n = No. of TSSM population
T = Treated
Co = Control

The leaf samples were taken from experimental blocks in amount of four leaves from each block before and after 38 days of infestation.

RESULTS AND DISCUSSION

For chemical control treatments, according to ANOVA analysis, the results of feeding damage values of *T. urticae* were evaluated in different three groups (b, ef and c) and there were significant differences within used pesticides (Table 1). On the other hand, the efficacy rate of hexythiazox (42.05%) and dimethoate (37.96%) showed significant difference with the efficacy of bifenthrin (98.70%), result of pesticides efficacies were evaluated in two groups (d, a). According to the results of feeding damage rate, it is expected that there is significant difference ($p<0.05$) between hexythiazox and dimethoate efficacy, but hexythiazox is a growth regulator and exposed mite adults to residue may lay eggs that were not viable (Kenneth *et al*., 2002) which calculated in counting. However, in both evaluation methods indicated significant difference ($p<0.05$) between bifenthrin with other used pesticides.

Table 1: Mean of percentage feeding damage rate and corrected efficacy (±SE) for treatments of greenhouse experiments

Control method	Treatment	Damage rate %±SE	Efficacy %±SE
Chemical control	Dimethoate	59.85±5.30^{b}	37.96±3.46^{d}
	Bifenthrin	16.50±0.64^{ef}	98.70±0.27^{a}
	Hexythiazox	36.50±2.41^{c}	42.05±2.15^{d}
Biological control	*P. persimilis*	25.00±2.16^{de}	84.99±0.84^{c}
	A. californicus	24.12±2.94^{de}	87.34±0.62^{c}
Combination of chemical and biological control	Dimethoate+ *P. persimilis*	29.42±3.38^{d}	85.30±0.79^{c}
	Dimethoate + *A. californicus*	21.37±4.36^{de}	90.49±0.61^{b}
	Bifenthrin+ *P. persimilis*	14.50±3.03^{ef}	99.62±0.21^{a}
	Bifenthrin+ *A. californicus*	11.80±3.03^{ef}	99.48±0.17^{a}
	Hexythiazox + *P. persimilis*	18.00±1.95^{ef}	99.62±0.21^{a}
	Hexythiazox + *A. californicus*	10.90±1.60^{f}	99.31±0.00^{a}
	Control (water)	79.53±4.09^{a}	0.00^{g}

Split-Plot, Duncan's test; p = 0.05; r = -0.93 Slope = 0.0074, Means with different letter(s) within a column were significant different (p = 0.05. Duncan's Test)

Results of biological control treatments, the results were evaluated in one group in both evaluation methods. There was no significant difference ($p<0.05$) between treatments of predatory mites (*P. persimilis* and *A. californicus*) in both evaluation methods.

For treatments of combination of chemical and biological control, the damage rate results of *T. urticae* indicated no significant difference between hexythiazox+ predators (*P. persimilis* and *A. californicus*) and bifenthrin+ predators; it was evaluated in one group (ef). This assessment of results similar with percentage efficacy evaluation and its results were evaluated in one group (a).

For comparison between control methods, the results of percentage efficacy showed no significant difference between predators treatments and dimethoate+ *P. persimilis*, these results were evaluated in one group (c). This assessment of results similar with the damage rate evaluation and its results were evaluated in one group (de) (Table 1).

This is concluded from used evaluation methods that, hexythiazox and dimethoate could not repress the TSSM population, which gave significant damage rate in its treatments and the efficacy of mention pesticides which was low, not provided well controlling to TSSM when compared with bifenthrin and combination between chemical and predators. In addition, bifenthrin and hexythiazox combined with predators or bifenthrin alone could repress well the TSSM population so that, the damage rate was low, while its percentage efficacy was high. Therefore, the data of experiments clearly showed negative relationship between feeding damage rate and percentage efficacy values (Correlation Coefficient; r = -0.93). Whenever, the feeding damage rate has a high value, the percentage efficacy has a low rate.

The satisfactory methods to controlling TSSM population according to the damage rate were bifenthrin, hexythiazox combined with predators and bifenthrin alone followed by predators and dimethoate combined with predators. This assessment has same arrangement to percentage efficacy to controlling TSSM population.

Therefore, the ANOVA analysis of the results of the tested evaluation methods could separate the mean values of percentage efficacy and feeding damage rate and relatively assemble into counterpart groups and gave same decision in evaluation the effectiveness of control methods. Thus, the computer software (Compu Eye, leaf and Symptom Area) may be satisfactory recommended for the evaluation of effectiveness of control methods.

Verkerk (2001) reported that the effects of pesticides on natural enemies were often negative; pesticides can sometimes enhance natural enemy function particularly, if they are selective against the pests or are used at low dosages. Wilson *et al*. (1999) reported that dimethoate had very low acaricidal activity on TSSM. Kenneth *et al*. (2002) reported that hexythiazox had ovicidal action and provide poor control of *T. urticae* adults; mortality of *T. urticae* from hexythiazox and spinosad residues was not significantly greater than the tested control. Kim (2001) reported that chemical application could

be successfully integrated with biological control. If there is, a high population density of TSSM the release of *P. persimilis* is more effective if a chemical spray initially reduces TSSM density.

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