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Side Effects of Four Acaricides on the Predatory Mites of *Neoseiulus californicus* McGregor and *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae)

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Side effect

Abstract: In the present study determined the side effects of four acaricides of acequinocyl, etoxazole, bifenazate and milbemectin on the predator mites *Phytoseiulus persimilis* Athias-Henriot and *Neoseiulus californicus* McGregor. Acaricide concentrations were prepared as a two times the field application dose (2T), field application dose (T), and half of the field application dose (T/2) and were then applied on eggs, nymphs and adults of the *P. persimilis* and *N. californicus.* The side effects of the acaricidesapplied to the predator mites were determined three, five and seven days afterthe application. While all doses of acequinocyl and etoxazole showed a higher toxic effect on *N.californicus* eggs, it was found that bifenazate and milbemectin caused similar effects on both predator mite eggs. Furthermore, it was found that the toxic effects of acequinocyl, etoxazole, bifenazate and milbemectin on nymphs and adults of the predator miteswere high seventh day after the application. The results of the study showed that four acaracides frequently used against to pest mites, should be used more carefully in the agricultural areas.

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Neoseiulus californicus McGregor ve *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae) Avcı Türlerine Dört Farklı Akarisitin Yan Etkileri

Anahtar Kelimeler
Phytoseiidae,
Neoseiulus californicus,
Phytoseiulus persimilis,
Akarisit,
Yan etki

Özet: Bu çalışmada, acequinocyl, etaxozole, bifenazate ve milbemectin etkili maddeye sahip dört akarisitin, avcı akarlar *Phytoseiulus persimilis* Athias-Henriot ve *Neoseiulus californicus* McGregor'a karşı yan etkileri araştırılmıştır. Tarla uygulama dozunun iki katı (2T), tarla uygulama dozu (T) ve tarla uygulama dozunun yarısı (T/2) olacak şekilde hazırlanan akarisit konsantrasyonları *P. persimilis* ve *N. californicus'*un yumurta, nimf ve ergin dönemlerine uygulanmıştır. Akarisitlerin avcı akarlarayan etkileri uygulamadan 3, 5 ve 7 gün sonra belirlenmiştir. Acequinocyl ve etaxozole'ün, tüm dozları *N.californicus* yumurtalarında daha fazla toksik etki gösterirken, bifenazate ve milbemectinin ise her iki avcı akar yumurtalarında da benzer etkiye neden olmuştur. Acequinocyl, etaxozole, bifenazate ve milbemectin'in uygulamadan 7 gün sonra avcı akarların nimf ve erginleri üzerie toksik etkilerinin yüksek olduğu belirlenmiştir. Çalışma sonucunda, üretim alanları içerisinde zararlı kırmızıörümceklere karşı yaygın kullanılan dört akarisitin daha dikkatli bir şekilde kullanılması gerektiğini göstermiştir.

1. Introduction

Tetranychid phytophagous mites are a major arthropod pest that is found in greenhouses, orchards, vegetables and ornamentals, particularly during the warm season when populations can reach excessive levels in a short period of time [1, 2]. Owing to its high biotic potential, the pests can quickly inflict economic damage, causing great reductions in the quality and quantity of the plant [3]. Chemical control is the most common strategy for managing spider mite worldwide [4, 5].However, the use of pesticides for long periods and frequently causes resistance in pests as well as side effects in natural enemies [6, 7, 8]. As a result, procuders are evaluating the use of alternative management strategies for the spider mite that may avoid relying strictly on pesticides [9].

Alternative management strategies include the use of predator mites along with pesticides instead of using pesticides alone in production areas [10].To identify the most selective pesticides that could be used in combination with biological control strategies it is very important to know the side effects of these

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products on the most relevant natural enemies for each specific crop [11]. Phytoseid mites are important biological control agents for different kinds of pests on various greenhouse, fruit ranches, orchards and citrus groves[12]. According to the habitat and food spectrum, phytoseiid mites are classified as specialists (type I, II) and generalists (type III, IV) [13]. *Phytoseiulus persimilis* A.H. (Acari: Phytoseiidae) is considered a type I predator because it only feeds and is able to survive on *Tetranychus urticae* Koch (Acari: Tetranychidae). In contrast, *Neoseiulus californicus* McGregor (Acari: Phytoseiidae) is is a type II predator because it feeds and can survive on alternative prey and pollen in the absence of *T.urticae* [14]. Furthermore, the tolerance of *N. californicus* against low humidity and high temperature is higher than *P. persimilis*[15]. While a 60-80% humidity increase is required for the population to increase in *P. persimilis*, *N. californicus* can maintain its population continuity under low humidity conditions [16].

Broadly effective pesticides used in agricultural areas cause side effects on all natural enemies as well as predator mites. *P. persimilis* and *N. californicus,* in the Phytoseiidae family, are affected by pesticides used in agricultural areas and cannot maintain their natural population [17]. Identifying the effects of the pesticides to be used on natural enemies is of importance for developing integrated control methods. Therefore, it is necessary to choose the pesticides used for diseases and pests that have the lowest effect on the beneficial insects in integrated control programs. Studies conducted regularly on pesticides and mites with the aim of identifying the side effects are of particular importance in order to develop integrated control programs and determine the compounds to be used in these control programs [18]. At the end of the studies, it is possible to use the pesticides identified as harmless and not very harmful for predator mites in production areas. It is also thought that the development of resistance in pests will reduce based on the decrease in pesticide use.

The study aimed to determine the side effects of four acaricides in different life periods of predator mites, *P. persimilis* and *N. californicus.* Additionally, the effects of acaracides used in the study on egg hatching of *P. persimilis* and *N. californicus* were identified.

2. Material and Method

2.1. Origin and rearing of predatory mites

In the study, eggs, nymphs and adults of two predator mites, *P. persimilis* and *N. californicus* were used. In Turkey, the *P. persimilis* was first collected from vegetable fields in Hatay province in 1993 [19]; the *N. californicus* was first collected in Isparta from an organic apple garden in 2008 [20]. Both of the predator mites, so far, were rearedin laboratory and were newer exposed to a pesticide. The predator mites was reared in a climatically controlled chamber on the *Phaseolus vulgaris* L. var. Barbunia plant on which there is *T. urticae. P. persimilis* and *N.californicus* populations were reared at 26±2°C temperature and 60±5% relative humidity in climatically controlled chambers lighted for 16 hours.

2.2. Acaricides

Three different doses of acaricides that included a field application dose (T), double the field application dose (2T) and half of the field application dose (T/2) were applied on the eggs, nymph and adults of *P. persimilis* and *N. californicus*. The general features and application doses of the acaracides used in the study are given in Table 1.These acaricides have been chosen because they are widely used in the study.

2.3. Obtaining some periods predator mites

A spray tower-leaf disk method was used to determine the side effects of acaricides on *P. persimilis* and *N. californicus*. In the preparation of leaf discs, leaves removed from bean plants (*Phaseolus vulgaris* L. var. Barbunia) were placed on moist cotton in 90 mm diameter plastic Petri dishes. To prevent predatory mites from escaping, the leaf discs were made using approximately 3 cm diameter rings with Tangle-Trap adhesive material. The study used eggs, nymphs and adults of *N. californicus* and *P. persimilis*. To ensure that all individuals used in the study were at the same age and developmental stage, female individuals taken from the population were transferred to leaf discs to lay eggs and the eggs taken from these females were used in the study. For nymph and adult experiments, the researchers waited until the eggs hatched and then nymphs and adults of the same age were used.

2.4. Application to acaricides on predatory mite eggs

In the study, the Kim & Yoo's [21] method was adopted and used with the purpose of determining the effects of acaricides on *P. persimilis* and *N. californicus* eggs hatching. *N. californicus* and *P. persimilis* eggs were transferred onto leaf discs in the petri dishes and it was confirmed that each leaf disc had 10 individuals. Three doses of acaricides were applied four replications. Only distilled water was applied on predator mite eggs in the control group. The doses prepared acaricides were sprayed on leaf surfaces at 1 bar pressure and 1.7 mg cm^{-2}[22] acaricides at every application by spray tower. In daily controls the individuals that hatched and did not hatch from the eggs were determined by using the control group as a reference. Counting procedure continued until all the eggs in the control group were hatched.

Table 1. General features and application doses of the acaracides used in the study.

Active substance name	Commercial name	Half of field application dose (ml/100 L water)	Field application dose (ml/100 L water)	Two fold of field application dose (ml/100 Lwater)
Acequinocly	Kanemite SC g/l	62.5	125	250
Etoxazole	Zoom 10SC g/l	12.5	25	50
Milbemectin	Milbeknock EC g/l	50	100	200
Bifenazate	Floramite SC 240 g/l	30	60	120

Table 2. Mean egg not hatching rate (%±SE) ofpredatory mites when exposed to acaricides.

Acaricides	Doses		
	Neoseiulus californicus		
	T/2	T	2T
Acequinocly	49.99±8.61bcB	64.99±3.33bcA	76.66±6.66bcA
Etoxazole	68.33±6.38aB	83.33±3.85aA	91.66±6.38aA
Bifenazate	61.66±3.33abC	74.99±3.33abB	89.99±3.85abA
Milbemectin	44.99±3.33cdC	69.99±3.85abcB	84.99±3.33abcA
	Phytoseiulus persimilis		
Acaricides	Doses		
	T/2	T	2T
Acequinocly	23.33±3.85eC	34.99±3.33eB	46.66±5.44dA
Etoxazole	30.48±13.21deB	56.04±15.14cdA	78.82±9.03abcA
Bifenazate	61.30±4.91abC	77.14±3.86abB	91.44±3.16aA
Milbemectin	48.33±1.92bcC	63.81±2.77bcdB	77.61±2.93abcA

* Lower cases show difference among average of pesticide effect in the same column, upper cases show difference among effect of dose of each pesticide in the same day. $p<0.05$

2.5. Application to acaricides on thenymphs and adultsof predatory mites

Kaplan et al's [23] and Bernardi et al's [22] methods were used in the study with the aim of determining the effects of acaricides on nymphs and adults of *P. persimilis* and *N. californucus.* Predator mite nymphs or adults at the same period were transferred onto leaf discs; each petri dish had 15 individuals and was sprayed by spraying tower. The spray tower was worked under 1 bar pressure and 1.7 mg cm^{-2} acaricides containing compounds were sprayed on the leaf surface. Distilled waterwereapplied on the nymphs and adults of predator mites in the control groups. In the study, three doses of each acaricides(application dose, half of the application dose and double the application dose) were applied four replications. All periods of *T. urticae* individuals were given to hunt in the petri during the counting in order to feed predator mite nymphs or adults.Counting was performed on the first, third, fifth and seventh days and the effects of the acaricides on the nymphs or adults of *N. californicus* and *P. persimilis were* assessed.

2.6. Statistical analysis

The mortality rate (M) for the predator mites, as a result of the use of acaricides, was calculated according to Abbott [24]. Therefore, the mortality in the control groupswerenot given. When the deaths in the control groups were more than 10%, the study was repeated in an experiment. All experiments were conducted in a climatically controlled chamber at 26±2◦C, 60±5% relative humidity and 16: 8 hours light: dark photoperiod.

$$Mortality\ (M) = \frac{CL - DL}{CL} X100 \qquad (1)$$

Where; CL is the number of living individuals in the control group (%) and DL is the number of the living individuals in the disinfected groups (%)

Pesticides are separated into four groups by the International Organization for Biological Control "Pesticides and Beneficial Organisms" study group as follows: If the mortality rate is <30%, it is accepted as harmless[1], if it is between 30-79%, it is accepted as a little harmful [2], if it is between80-99% it is as moderately harmful [3] and if it is >99% it is accepted as harmful [4, 25].In the statistical evaluation of the results, one-way analysis of variance technique (One-Way ANOWA) was applied on the data obtained and the Tukey test was used to determine the difference between the averages [26].

3. Results

3.1. Effect of acaricides on predatory mites eggs

The effects of acaricides on *N. californicus* and P. *persimilis* egg hatching are given in Table 2. They were foundat the highest level of effect at T/2 dose acaricides ofetoxazole and bifenazate on *N. californicus* and bifenazate on *P. persimilis.* The highest effect values for of acaricides on eggs hatching at T dose were found in *N. californicus* with etoxazole, bifenazate and milbemectin and in *P. persimilis* with bifenazate. The highest toxic effect of acaricides on eggs hatching at 2T dose was found with etoxazole on *N. californicus* with 91.66%, with bifenazate on *P. persimilis* with 91.44%. The highest effect of acaricides on eggs hatching in both predator mites at 2T dose was found in etoxazole, bifenazate and milbemectin. In Table 2, the effects of T dose of all acaricides on *N. californicus* and *P. persimilis* were not found statistically different from each other.

3.2. Effect of acaricides on predatory mite nymphs

The different doses of acaricides on *N. californicus* and *P. persimilis* nymphs are given in Table 3. It was detected that the effects of the different doses of acaricides applied on predator mite nymphs increased according to which acaracides was applied and counting the days (Table 3). The results revealed that the acaricides used in the study caused remarkable side effects on predator mite nymphs. In the observations performed seventh day after the application, it was seen that 2T dose caused high side effects at high rate in both predator mite nymphs and acaricidial effects persisted in the same group statistically *(p*<0.05).At 2T dose, aceguinocly showed 100 % effect on *N. californicus* nymphs; acequinocly, etoxazole and bifenazate showed 100% effect on *P. persimilis* nymphs. According to Hassan [25], since the seventh day results showed that aceguinocly had more than 99% effect on *N.californicus* nymphs and acequinocly, etoxazole and bifenazate showed more than 99% effect on *P. persimilis* nymphs at 2T dose, they were included in the harmful group. At the 2T dose, for milbemectin<bifenazate<etoxazole effect was between 80-90% on *N.californicus* nymphs and milbemectin showed effect between 80-90% on *P. persimilis* nymphs, they were classified as moderately harmful. In the observations were made seventh days after the application, at T dose of acenequinocly, etoxazole on *N. californicus* nymphs and acequinocly, etoxazole and bifenazate in *P. persimilis* nymphs, were classified in the same group *(p*<0.05).Bifenazate showed less effect against *N. californicus* nymphs and milbemectin showed less effect against to*P. persimilis* predator mite nymphs than the others. Nonetheless, they were not found statistically different from each other *(p*<0.05). According to Hassan [25],for the results of the seventh day, for etoxazole and bifenazate showed 100% effect on *P.persimilis* nymphs at level of T dose, they were in the harmful group.

Foracequinocly < etoxazole < bifenazate showed between 80-90% effect on *N.californicus* nymphs and acequinocly<milbemectin showed between 80-90% effect in *P. persimilis* nymphs at T dose, they were classified as moderately harmful. At T dose, since milbemectin showed between 30-79% effect in *N.californicus* nymphs. It was the only one no placed in very harmful group. In the observations performed seventh days after the application, at T/2 dose, since etoxazole showed 80-90% effect on *N.californicus* nymphs and acequinocly<bifenazate<etoxazole showed between 80-90% effect on *P. persimilis* nymphs, they were not in very harmful group. At T/2 dose, since bifenazate<milbemectin<aceqinocly on *N.californicus* nymphs and milbemectin on *P. persimilis* nymphs showed 30-79% effect, they were classified as a little harmful.

3.3. Effect of acaricides on predatory mite adults

The effects of the different acaricides doses used in the study on *N. californicus* and *P. persimilis* adults are given in Table 4.It was as certained that effects of the different acaricides doses applied on predator mite adults increased according to the acaricides and counting daily (Table 4). It was also found that the acaricides used in the study had significant side effects on predator mite adults, particularly at the end of seventhday. In the observations performed seventh days after the application, it was found that allof the acaricides were in the same group statistically in terms of the effect values identified in both predators at 2T dose of the acaricides (*p*<0.05).

According to Hassan [25], at the seventhday results at 2T dose, for aceguinocly and bifenazate showed 100% effect on *P. persimilis* adults, were in the harmful group. At 2T dose, for acequinocly< etoxazole<milbemectin<bifenazate showed 80-99% effect on *N. californicus* adults and also etoxazole<milbemectin showed between 80-99% effect on *P. persimilis* adults, they were classified as moderately harmful. In the observations performed seventh days after the application, for T dose of the acaricides, the effect values of bifenazate and etoxazole identified on *P. persimilis* adults were found statistically similar (*p*<0.05). All acaricides applied on *N. californicus* at T dose and the effect values identified in acequinocly and milbemectin were found similar and the same group statistically *(p*<0.05). At T dose, for bifenazate showed 100% effect on *P. persimilis*, they were in the harmful group. According to Hassan [25], at the end of the results of seventhday at T dose, for etoxazole showed between80-99% effect on *N. californicus* adults and etoxazole<acequinocly<milbemectin showed between 80-99% effect on *P. persimilis* adults, they were in the moderately harmful group. For acequinocly<milbemectin<bifenazate showed between30-79% effect on *N. californicus* adults at T dose, it was found that they were as little harmful group.

In view of the counting results of seventhday, in acaricide applications at T/2 dose, the highest effect was identified in bifenazate with 89.52% in *P. persimilis* adults and was not found statistically different from the others (*p*<0.05). At T/2 dose of the acaricides the effects of etoxazole on *N. californicus* adults and the effects acequinocly, etoxazole and milbemectin on *P. persimilis* adults were found similar (*p*<0.05). At T/2 dose, the effect values of aceguinocly, bifenazate, milbemectin on *N. californicus* adults were in the same group.

Table 3. Percentage mortality (±SE) of *Neoseiulus californicus* and *Phytoseiulus persimilis*nymphs exposed to acaricides.

		Doses	Day 1	Day 3	Day 5	Day 7
Neoseiulus californicus		T/2	50.00±2.71^{cdeC}	60.00±6.70dC	76.32±1.55bcC	78.74±2.89bcB
	Acequinocly	T	68.33±3.33^{bcB}	79.40±5.08cdB	91.31±3.09aB	96.43±4.12abA
		2T	83.33±8.61^{bcA}	98.22±3.57abA	100.00±0.0aA	100.00±0.0aA
		T/2	52.49±10.32^{bcdeB}	70.71±8.21bcdA	77.73±9.92abcA	82.57±9.16abB
	Etoxazole	T	64.16±5.00^{bcdAB}	75.23±7.50cdeA	77.61±6.52bcA	88.96±8.75abcAB
		2T	69.25±3.22^{dA}	83.33±3.74cdA	91.24±6.18abcA	98.21±3.57aA
		T/2	44.99±6.38cdeB	56.66±3.85deC	67.26±2.99cdB	68.45±3.57cC
	Bifenazate	T	63.33±3.84bcdA	69.99±3.85defB	75.71±4.94cA	80.59±4.04cdB
		2T	71.66±3.33cdA	78.33±3.33dA	82.85±3.29cdA	91.19±3.66bcA
		T/2	37.38±7.27eC	44.75±6.23eC	56.78±4.71dC	70.23±2.38cC
	Milbemectin	T	55.83±7.38cdB	60.35±2.94fB	68.93±4.17cB	77.14±3.86dB
		2T	74.64±2.62cdA	77.61±2.93dA	81.07±3.16dA	85.95±0.47cA
Phytoseiulus persimilis		T/2	68.81±9.53abA	75.48±9.01bcA	77.26±6.39bcB	87.14±1.65abB
	Acequinocly	T	63.81±10.05bcdA	85.95±5.85bcA	91.19±9.02aA	94.64±6.84abA
		2T	77.37±7.98cdA	87.62±3.81cA	100.00±0.0aA	100.00±0.0aA
		T/2	78.13±9.80aA	91.43±3.18aB	90.94±3.49aB	92.72±5.84aB
	Etoxazole	T	91.18±6.88aA	98.22±3.57aA	100.00±0.0aA	100.00±0.0aA
		2T	92.97±5.83abA	100.00±0.0aA	100.00±0.0aA	100.00±0.0aA
		T/2	78.93±5.87aB	80.36±3.57abB	83.93±3.57abB	89.28±4.12abB
	Bifenazate	T	92.86±5.83aA	96.43±4.12abA	100.00±0.0aA	100.00±0.0aA
		2T	100.00±0.0aA	100.00±0.0aA	100.00±0.0aA	100.00±0.0aA
		T/2	59.16±6.86bcB	62.61±4.81cdB	68.93±4.17cdB	78.92±0.71bcC
	Milbemectin	T	71.07±4.52bcA	72.86±0.95deA	77.50±4.10cA	85.95±0.48bcdB
		2T	77.00±3.43cdA	77.85±4.25dA	82.74±4.04cdA	91.31±3.10bcA

* Lower cases show difference among average of acaricides effectin the same column; upper cases show difference among effect of dose of each pesticide in the same day (p<0.05).

Table 4. Mortality percentage (±SE) of *Neoseiulus californicus* and *Phytoseiulus persimilis*adults exposed to acaricides

		Doses	Day 1	Day 3	Day 5	Day 7
Neoseiulus californicus		T/2	6.9±0.27fC	28.80±3.14eB	35.46±0.47eC	42.08±5.16dC
	Acequinocly	T	21.66±3.33eB	38.93±5.85fB	52.73±12.97dB	70.11±7.16dB
		2T	34.16±0.96eA	55.35±7.66fA	81.43±6.15cdeA	94.88±3.42aA
		T/2	40.83±1.66cdB	48.16±3.46cdC	79.64±0.71abA	81.95±1.94abB
	Etoxazole	T	44.16±3.18cdB	62.83±6.33cdB	80.77±6.84bcA	85.11±2.61bcB
		2T	59.91±8.95cdA	75.83±3.19cdA	86.31±6.04bcdA	94.76±3.49aA
		T/2	29.28±6.48cdeC	39.64±2.95deC	52.62±3.39cdB	59.64±3.37cC
	Bifenazate	T	46.54±2.91cdB	58.69±4.62defB	68.45±3.57cdA	73.69±3.37dB
		2T	58.69±4.62cdA	67.26±2.99defA	75.36±4.57deA	84.16±3.75bA
		T/2	26.66±6.48deC	34.99±2.95deC	43.09±6.44deC	54.40±3.44cC
	Milbemectin	T	43.33±3.84cdB	51.66±3.33defB	62.02±4.26dB	70.23±6.29dB
		2T	61.66±3.33cA	66.66±0.0defA	74.17±3.07deA	82.49±3.76bA
Phytoseiulus persimilis		T/2	61.20±5.63bB	78.16±0.82aB	80.06±5.80aB	86.58±0.95abB
	Acequinocly	T	70.16±2.87bAB	85.59±1.57abA	89.01±4.46abB	92.83±8.32abB
		2T	82.08±9.79bA	89.59±4.02abA	98.33±3.33abA	100.00±0.0aA
		T/2	39.05±8.69cdB	48.33±13.67cdB	72.26±11.71abB	79.76±5.79bB
	Etoxazole	T	48.33±6.14cAB	68.81±5.22cdA	89.64±8.68abA	98.07±3.85aA
		2T	63.33±11.55cA	73.92±9.36cdA	91.19±3.66abcA	98.08±3.84aA
		T/2	82.97±4.29aB	82.62±4.67aB	84.40±3.92aB	89.52±3.87aA
	Bifenazate	T	96.66±3.85aA	98.33±3.33aA	100.00±0.0aA	100.00±0.0aA
		2T	100.0±0.00aA	100.00±0.0aA	100.00±0.0aA	100.00±0.0aA
		T/2	41.43±11.77cB	58.09±5.62bcC	65.83±5.13bcB	80.66±3.66abB
	Milbemectin	T	63.81±2.77bA	70.71±0.82bcB	82.62±4.67abcA	85.92±0.97bcB
		2T	72.26±6.46bcA	82.61±4.67bcA	87.85±3.67abcA	91.29±3.11abA

* Lower cases show difference amongaverage of acaricideseffect in the same column, upper cases show difference among effect of dose of each pesticide in the same day (p<0.05).

However, according to Hassan [25],at the end of the counting results of seventhday, at T/2 dose, for etoxazole showed between80-99% effect on *N. californicus* adults and bifenazate<acequinocly<milbemetin showed between80-99% effect on *P. persimilis* adults they were classified as moderately harmful. At T/2 dose, forbifenazate<milbemectin<acequinocly showed between30-79% effect on *N. californicus* adults and etoxazole showed between30-79% on *P. persimilis* adults, they were in the little harmful group.

At the end of the study, the aim was to determine the side effects of selected acaricides on both predator mites bythe same method. It was found that all of the acaricides used in the study showed high levels of toxic effect on *N. californicus* and *P. persimilis* nymphs and adults at the end of seventhday. However, in relation to the effects of the acaricides on eggs hatching,the toxic effect of acaricides, except for bifenazate and milbemectin, werefound to be higher for *N. californicus*. Bifenazate and milbemectin showed similar effects on eggs hatching onboth predator mites. Some studies that investigated the side effects of some pesticides on some predator mites in the Phytoseiidae family are available. Oomen et al. [28], revealed that 51 insecticides/acaricides, 33 fungicides, 12 herbicides and four growing regulators had side effects on *P. persimilis.* James [29]determined that application dose of bifenazate is moderately harmful on *Galendromus occidentalis* (Nesbitt)(Acari: Phytoseiidae). Kim and Seo [30], found that bifenazate showed even toxic effect after 168 hours of application on *P. persimilis*. Kim and Yoo [21],determined that bifenazate, acequinocyl, chlorfenapyr, flufenoxuron and fenbutatin oxide were very toxic against to *P. persimilis* adults and milbemectin and fenazaquin werevery toxic against to this predator's adults and nymphs. Similarly, in our study, bifenazate, acequinocyl and milbemectin were foundharmful for *P. persimilis*nymphs and adults. A study by Sterk et al. [31]performed under laboratory and semi-field conditions found that thiamethoxam was moderately harmful on adults of *P. persimilis.* It was also found that imidacloprid was harmful. Castognoli et al. [32] reported that rotenone showed high levels of toxic effect on *N.californicus,* pyrethrins and imidacloprid reduced fertility rate, *Beauveria bassiana* showedhigh level of mortality on the generations of the predator and azadirachtin and pymetrozine showed a little toxic effect. Ahn et al. [33], determined that abamectin caused toxic effect on *P. persimilis* eggs. Abamectin and milbemectin are the acaricides that are in the same group having the same effect mechanism. Similarly, our study illustrated that milbemectin reduced eggs hatching rates of *P. persimilis* and *N. californicus*. Kim et al. [34] identified that abamectin showed even toxic effect 168 hours after applying on *Amblyseius cucumeris* (Oudemans) (Acari: Phytoseiidae) and reduced egg efficiency. Similarly, it was also found that seventh day after the application, milbemectin was highly toxic on *P. persimilis* and *N. californicus*. A study by Bostanian and Akalach [35] conducted on *P. persimilis,Amblyseius fallacies*Schicha (Acari: Phytoseiidae) and *Orius insidiosus*(Say) (Hemiptera: Anthocoridae) revealed that indoxacarb did not show toxic effects on the individuals but reduced fertility rate for *P. persimilis* with the rate of 26.7%, S-kinoprene and endosulfan had effect on one predator species at least, and dimethoate, abamectin and insecticidal soap have the highest toxicity levels in three beneficial organisms. Cloyd et al. [10] found that chlorfenapyr, spiromesifen and bifenazate are more toxic on *P. persimilis* compared to *N. californicus*. Similarly, our study revealed that bifenazate is more harmful on the *P. persimilis* nymphs and adults compared to the nymphs and adults of *N. californicus*. Irigaray and Zalom [36] determined that fenpyroximate application reduced the life span of female adults of *G. occidentalis* andspiromesifen and acequinocly application reduced the life span of female adults to four days. Furthermore, as the reproduction and fertility rates decreased, etoxazole and bifenazate application did not decrease the life span of female adults; however, these female adults were not able to reproduce.

Irıgaray et al. [37] found that 100% mortality rate was observed following the application of fenpyroximate and etoxazole on *P. persimilis*, abamectin increased the mortality rates of female adults after six days and acequinocyl increased mortality rates of the female adults after three days. Our study similarly determined that etoxazole showed 100% and 98.08% effect on *P. persimilis* nymphs and adults of after seven days. A study by Alzoubi and Cobanoglu [38] that investigated the effects of some pesticides on *T. urticae* andpredators *P. persimilis* and *Amblyseius californicus* identified that hexythiazox was harmless after 24 hours but harmful on predator mites after 72 hours. Nadimi et al. [39]found that hexythiazox was not harmful for *P. persimilis* with the low effect of all application doses and found that all doses of fenpyroximate and field application dose of abamectin were toxic against predator mites.

The results of the study revealed that acequinocly, etoxazole, bifenazate and milbemectin acaricides showed high levels of toxicity on the nymphs and adults of *P. persimilis* and *N. californicus*at seventh days after applying. Additionally, it was seen that acequinocly, etoxazole, bifenazate and milbemectin reduced egg hatching forboth predator mites. According to the results of the study, four acaricides that are used frequently against to the pest spider mites should be used more carefully in agricultural areas. The use of the results regarding side effect studies conducted with predator mites in the pesticide lists to be updated in the future will make contribution to the practice. The identification of the side effects of the pesticides used will enable the use of preparations that are harmless or a little harmful to natural enemies. Thus, the feasibility of biological control will be facilitated, the use of excessive pesticide doses will be prevented, and the environment and the health of living individuals will be protected.

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