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Impact of natural toxin spinetoram 12 SC w/v (11.7 w/w) against *Trichogramma chilonis* Ishii and *Chrysoperla zastrowi sillemi* (Esben - Petersen) under laboratory conditions

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Insecticides are unavoidable in pest management programs especially when the pest crosses Economic Threshold Level (ETL). Nevertheless, often the plant protection products kill the natural enemy population making the pest to resurge and thus demanding more sprays. Therefore, insecticides used in integrated pest management (IPM) programs should be selective enough to spare the beneficial. Laboratory experiments were conducted with spinetoram 12 SC at 36, 45, 54 and 108 g a.i./ha; and various standard chemicals were used to assess the toxicity of spinetoram 12 SC to the egg parasitoid, *Trichogramma chilonis* and predatory green lacewing, *Chrysoperla zastrowi sillemi* during January 2013. In the present study, spinetoram 12 SC did not show harmful effects on *T. chilonis*. The results of the safety test experiment for *T. chilonis* on adult emergence and percent parasitization revealed that spinetoram 12 SC at 36, 45, 54 and 108 g a.i./ha had little adverse effect when treated at egg, larval and pupal stages. Treatment of parasitized eggs with spinetoram did not cause any ill effects to the developing parasitoids, adult emergence and emerged adults. The lowest egg mortality and highest egg hatchability of *C. zastrowi sillemi* was recorded by spinetoram at 36 g a.i./ha which was on par with spinetoram at 45 g a.i/ha. Effect of spinetoram on adult longevity and fecundity of *C. zastrowi sillemi* revealed that the adult longevity was the longest and number of eggs laid per five female was also more in untreated check (14.70 days 366.40 eggs), while it was 11.37, 9.40, 8.27 and 7.67 days and 145.97, 133.40, 105.67 and 93.70 eggs in spinetoram at 36, 45, 54 and 108 g a.i./ha, respectively.

Key words: Spinetoram 12 SC, *Trichogramma chilonis, Chrysoperla zastrowi sillemi,* safety.

INTRODUCTION

Insecticides because of their promising attributes, such as immediate kill, ease in availability and use, occupy a prominent place in integrated pest management. Insecticides often interfere with the activity of parasitoids

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and predators in the cropping ecosystem. Destruction of natural enemies of the insect pests due to excess use of pesticides is a major concern for entomologists as well as ecologists. Indiscriminate use of persistent insecticides disrupted the natural balance of pests and their natural enemies leading to pest outbreaks and resurgence (Geethalaxmi and Chandrasekaran, 2000). So understanding the toxicity of insecticides to natural enemies is important and relevant to develop a sound pest management programme.

Trichogramma chilonis Ishii is one such parasitoid highly useful in pest management especially of lepidopteran insects which causes a severe damage almost in all crops. *C. zastrowi sillemi* is a predator which highly useful in pest management especially of aphids. The larva of *C. zastrowi sillemi* (aphid lion) has relatively a broad range of prey acceptance which includes aphids, whiteflies, eggs of moths and other soft-bodied insects. Due to the polyphagous and voracious nature and vast geographical distribution, ease of mass multiplication and tolerance to some pesticides it has received much attention of farmers as well as researchers as a potential biological pest control agent.

Effectiveness of *C. zastrowi sillemi* as biological control agent has been demonstrated in field crops, orchards and in green houses and reported to give about 100% lepidopteran pest control when used along with *Trichogramma* spp. (Rincon, 1999). Inspite of all these benefits, *C. zastrowi sillemi* with many other beneficials has almost been eliminated from fields due to frequent use of some non-selective agrochemicals (Nasreen et al., 2005).

Spinetoram 12 SC is a new green insecticide fermented from microorganism, *Saccharapolyspora spinosa* and it belongs to the new chemical class of spinosyn compound. Spinetoram 12 SC has been reported as effective biological insecticide for the management of lepidopteran pests of chilli (Dharne and Bagde, 2011) and tomato (Visnupriya et al., 2013). However, hitherto research on natural enemies is limited. As a part of biointensive approach to the pest management, the safety of spinetoram in pest control needs to be evaluated. Considering the above aspects, present investigations were carried out to study the effect of spinetoram on parasitization and parasitoid emergence percentage of *T. chilonis* and effect of spinetoram on eggs, grubs and adults of *C. zastrowi sillemi* under laboratory conditions.

MATERIALS AND METHODS

Laboratory experiments were conducted with spinetoram 12 SC at 36, 45, 54 and 108 g a.i./ha; emamectin benzoate 5 SC 8.5 g a.i./ha; chlorpyriphos 20 EC 200 g a.i./ha; quinalphos 25 EC 200 g a.i./ha; indoxacarb 14.5 SC 75 g a.i./ha; novaluron 10 EC 75 g a.i./ha; and untreated control to assess the toxicity of spinetoram 12 SC to the egg parasitoid, *T. chilonis* and predatory green lacewing, *C. zastrowi sillemi*. For obtaining different doses, 0.6, 0.75, 0.9 and 1.8 ml of spinetoram 12 SC; 0.34 g of emamectin benzoate 5 SG; 2 ml of chlorpyripos 20 EC; 1.6 ml of quinalphos 25 EC; 1.04 ml of indoxacarb 14.5 SC; and 1.5 ml of novaluron 10 EC were dissolved in one litre of distilled water and these dilutions were used for toxicity experiments.

Impact of spinetoram 12 SC on immature stages of *T. chilonis*

The bioassay method described by Jalali and Singh (1997) was adopted with modifications. The eggs of *C. cephalonica* were pasted on paper cards of 21×30 cm size having thirty 7 × 2 cm rectangles. These egg cards were placed in plastic bags along with the nucleus card at 6:1 ratio for parasitization. The parasitized egg cards were cut into one centimeter square bits and for treating egg stage, two days old hundred percent parasitized eggs (eggs appearing black and plump) were sprayed with different concentrations of insecticides using an atomizer. For untreated check, distilled water was sprayed. The treated egg cards were shade dried for 10 min and then kept in a test tube of 10 × 1.5 cm size. In the same way larval (4 days old) and pupal (6 days old) stages of *T. chilonis* were treated. The number of parasitoids that emerged from each treatment was recorded after 24 and 48 h of treatment and percent emergence was worked out.

Fresh eggs were provided to these parasitoids at 6:1 ratio and the numbers of parasitized eggs were recorded after 24 and 48 h of treatment and the percent parasitization was worked out.

Impact of spinetoram 12 SC on *C. zastrowi sillemi*

Impact of spinetoram 12 SC on eggs of C. zastrowi sillemi

Laboratory studies were conducted to assess the effect of spinetoram on the eggs of *C. zastrowi sillemi*, as per the method described by Krishnamoorthy (1985). The eggs along with stalk collected on brown paper strips were sprayed with different insecticides viz., 0.6, 0.75, 0.9 and 1.8 ml of spinetoram 12 SC; 0.34 g of emamectin benzoate 5 SG; 2 ml of chlorpyripos 20 EC; 1.6 ml of quinalphos 25 EC; 1.04 ml of indoxacarb 14.5 SC; and 1.5 ml of novaluron 10 EC using an atomizer. Each treatment was replicated three times with 50 eggs per treatment. Untreated check was maintained by spraying distilled water. The number of grubs hatching from each treatment was recorded and percent hatchability was worked out.

Impact of spinetoram on grubs of *C. zastrowi sillemi*

Larval feeding method

Eggs of *C. cephalonica* were exposed to UV radiation of 15 W capacity for 15 min to kill the embryo and then sprayed with different concentrations of the insecticides with an atomizer. The treated eggs were shade dried for 15 min and then transferred to test tubes (one cc egg card/test tube of 2.0 × 15 cm size). In the control, the eggs were sprayed with distilled water. Second instar grubs of *C. zastrowi sillemi* were transferred to these test tubes at the rate of 10 per test tube. After complete feeding of the treated eggs, the grubs were provided with untreated *C. cephalonica* eggs until pupation. Observations were made on the grub mortality (12, 24 and 48 h after treatment), pupation and adult emergence (Suganyakanna, 2006).

Dry film method

The bioassay method described by McCutchen and Plapp (1988) was adopted with modifications. Glass vials of 20 ml capacity with 1 mm thickness were evenly coated with one milliliter of acetone

Table 1. Impact of spinetoram 12 SC on immature stages of egg parasitoid, *Trichogramma chilonis* Ishii on the adult emergence and parasitization.

Treatments	Doses (g a.i/ha)	Egg (2 days old egg)		Larval (4 days old egg)		Pupal (6 days old egg)	
		Adult emergence (%)	Parasitization (%)	Adult emergence (%)	Parasitization (%)	Adult emergence (%)	Parasitization (%)
Spinetoram 12 SC	36	86.9^{ab}	85.5^{ab}	90.1^{ab}	87.9^{ab}	88.9^{ab}	85.3^{ab}
Spinetoram 12 SC	45	84.9^{ab}	80.9^{b}	88.6^{b}	86.8^{ab}	86.2^{ab}	85.0^{ab}
Spinetoram 12 SC	54	77.6^{b}	73.4^{bc}	86.9^{b}	82.9^{b}	84.0^{b}	81.3^{b}
Spinetoram 12 SC	108	76.0^{bc}	71.4^{bc}	83.7^{bc}	81.3^{b}	80.1^{bc}	78.0^{bc}
Emamectin benzoate 5 SG	8.5	77.2^{b}	72.7^{bc}	86.9^{bc}	82.3^{b}	82.1^{b}	80.5^{b}
Chlorpyriphos 20 EC	200	66.6^{c}	63.3^{c}	73.4^{cd}	69.7^{c}	71.2^{c}	68.3^{c}
Quinalphos 25 EC	200	72.9^{bc}	66.5^{c}	79.5^{c}	75.0^{bc}	72.5^{c}	68.9^{c}
Indoxacarb 14.5 SC	75	62.6^{c}	60.1^{cd}	66.0^{d}	60.9^{cd}	63.3^{cd}	60.8^{cd}
Novaluron 10 EC	75	68.7^{c}	65.9^{c}	78.2^{c}	73.8^{bc}	73.1^{c}	70.3^{c}
Untreated control	-	91.4^{a}	91.7^{a}	96.0^{a}	91.6^{a}	91.8^{a}	90.3^{a}
CD (0.05%)	-	2.50	2.20	2.18	3.09	2.10	2.99
SEd	-	1.28	1.11	1.08	1.60	1.05	1.51

Data are mean values of three replications; In a column, means followed by a common letter are not significantly different by DMRT (P = 0.05); Values are arc sine $\sqrt{\text{percent}}$ transformed value.

solutions of insecticide formulations dried by rolling for few seconds. Second instar *C. zastrowi sillemi* grubs were released into the vials at 10 per vial, covered with muslin cloth and secured with a rubber band. For untreated check only acetone was used. Mortality observations were taken at 12, 24 and 48 h after treatment. After 24 h exposure of the grubs, 1 cc of *C. cephalonica* eggs were given as feed to the grubs. Percent mortality of the grubs was worked out and pupation (%) and adult emergence (%) were also worked out.

Impact of spinetoram 12 SC on adults of *C. zastrowi sillemi*

Five pairs of freshly emerged *C. zastrowi sillemi* adults were allowed in separate plastic containers. The adults were fed with 10 percent sucrose solution containing different concentrations of spinetoram formulation and other insecticides. In the untreated check, the adults were fed with 10 percent sucrose solution alone. The eggs laid in each treatment were collected daily by keeping a brown paper sheet of 21 × 6 cm size along the inner side of the plastic container. Observations were made on the adult longevity and fecundity at 12, 24 and 48 h after treatment (Suganyakanna, 2006).

RESULTS AND DISCUSSION

Impact of spinetoram 12 SC on immature stages of egg parasitoid, *T. chilonis* (Ishii) on adult emergence and parasitization

Treatment of spinetoram 12 SC at 36, 45, 54 and 108 g a.i./ha on 2 days old parasitized egg card (egg stage) of *T. chilonis* resulted in adult emergence of 86.9, 84.9, 77.6 and 76.0% (Table 1). The adult emergence however was 90.1, 88.6, 86.9 and 83.7% and 88.9, 86.2, 84.0 and 80.1% when 4 days old (larval stage) and 6 days old (pupal stage) parasitized egg card of *T. chilonis* was treated with spinetoram 12 SC at 36, 45, 54 and 108 g a.i./ha. Emamectin benzoate at 8.5 g a.i./ha recorded 77.2, 86.9 and 82.1% adult emergence, respectively when treated at egg, larval and pupal stages followed by quinalphos 200 g a.i/ha (72.9, 79.5 and 72.5% at egg, larval and pupal stage respectively) and novaluron (68.7, 78.2 and 73.1% at egg, larval and pupal stage respectively). Chlorpyriphos and indoxacarb treated eggs of *T. chilonis* however, achieved adult emergence of 66.6 and 73.4; 62.6 and 66.0; and 62.6 and 64.8% at egg, larval and pupal stages respectively. The untreated *T. chilonis* registered 91.4, 96.0 and 91.8% adult emergence from egg, larval and pupal stages, respectively.

The highest parasitization (from 90.3 to 91.7%) was recorded in the untreated check which was significantly superior to other treatments. This was

followed by spinetoram 12 SC at 36 g a.i./ha which recorded 85.3 to 88.0% parasitization. Spinetoram 12 SC at 45 g a.i./ha recorded 80.9, 86.8 and 85.0% parasitization when treated during egg, larval and pupal stages, respectively. Spinetoram 12 SC at 108 g a.i./ha recorded 71.4, 81.3 and 78.0% parasitization when treated during egg, larval and pupal stages, respectively and comparable with that of emamectin benzoate 5 SG at 8.5 g a.i/ha (72.7, 82.3 and 80.5% respectively).

The present investigation was in agreement with Hernandez et al. (2011) who reported that spinetoram 12 SC had no more toxic to the leaf miner parasitoid complex compared to other treatments and untreated control. In contrast, Hossain and Poehling (2006) found that spinetoram 12 SC negatively affects two endolarval leaf miner parasitoid immature stages. But Ruberson (2003) stated that spinosad had no negative effects on the development of *T. pretiosum* and appears to be entirely compatible with *T. pretiosum*. Elzen et al. (1998) who reported that spinosad at 75 g a.i./ha was safer to egg parasitoid *T. chilonis* than other insecticides (azinphos - methyl, imidacloprid, oxamyl, endosulfan and betacyfluthrin) and also Dhawan (2000) reported that spinosad was safe to predators (predatory bugs, spider and green lace wing) and parasitoids (*T. chilonis*) whereas conventional insecticides caused higher mortality. Spray droplets can cause harm to *Trichogramma* wasps and other parasitoids (Bret et al., 1997; Suh et al., 2000; Tillman and Mullrooney, 2000). However, once the deposits dry, they are generally safer for beneficial insects. Present study revealed that spinetoram 12 SC at lower doses (36 and 45 g a.i./ha) was less toxic to *T. chilonis.*

Impact of spinetoram 12 SC against *C. zastrowi sillemi*

Impact on egg hatchability and mortality

The results on the effect of spinetoram on *C. zastrowi sillemi* eggs are presented in Table 2. The lowest egg mortality was recorded by spinetoram at 36 g a.i./ha (4.2%) and 45 g a.i/ha (9.5%) which was followed by spinetoram at 54 g a.i/ha (13.2%), emamectin benzoate 5 SG at 8.5 g a.i/ha (13.8%) and spinetoram 108 g a.i/ha (18.4%). The next best treatments which registered moderate level of egg mortality were novaluron 10 EC at 75 g a.i/ha (24.0%), quinalphos 25 EC at 200 g a.i/ha (37.7%) and chlorpyriphos 20 EC at 200 g a.i/ha (38.4%). Indoxacarb 14.5 SC at 75 g a.i/ha (40.3%) was recorded highest egg mortality and the lowest egg mortality was in untreated check (2.9%).

The highest egg hatchability was recorded by spinetoram at 36 g a.i./ha (95.2%) and 45 g a.i/ha (90.1%) which was followed by spinetoram at 54 g a.i/ha (86.3%), emamectin benzoate 5 SG at 8.5 g a.i/ha (86.0%) and spinetoram 108 g a.i/ha (81.6%). The next best treatments which registered moderate level of egg hatchability were novaluron 10 EC at 75 g a.i/ha (76.0%), quinalphos 25 EC at 200 g a.i/ha (62.3%) and chlorpyriphos 20 EC at 200 g a.i/ha (60.4%). Indoxacarb 14.5 SC at 75 g a.i/ha (59.7%) was recorded lowest egg hatchability and the highest egg hatchability was in untreated check (97.1%).

Results are comparable with the findings of Elbarky et al. (2008) who found that spinetoram 12 SC (radiant) does not have harmful effect on population of lady beetles *Coccinella* spp., aphid lion, *Chrysoperla* spp. and rove beetle, *Paederus* spp.

Impact on adult longevity and fecundity of C. zastrowi sillemi

The studies conducted on effect of spinetoram 12 SC on adult longevity and fecundity of *C. zastrowi sillemi* revealed that the adult longevity was the longest in untreated check (14.7 days) and it was followed by 11.4, 9.4, 8.7, 8.3 and 7.7 days in spinetoram at 36, 45 g a.i/ha, emamectin benzoate 5 SG at 8.5 g a.i/ha, spinetoram 54 and 108 g a.i./ha respectively. Moderate level of adult longevity was recorded in novaluron 10 EC at 75 g a.i/ha (6.9 days), quinalphos 25 EC at 200 g a.i/ha (5.8 days) and chlorpyriphos 20 EC at 200 g a.i/ha (5.8 days). Adult longevity was shortest in indoxacarb 14.5 SC at 75 g a.i/ha (4.0 days) (Table 2).

The number of eggs laid per five female was also more in untreated check (366.4 eggs) and it was followed by spinetoram 36 g (146.0 eggs), 45 g (133.4 eggs), emamectin benzoate 5 SG at 8.5 g a.i/ha (106.1 eggs), spinetoram 54 g (105.7 eggs) and 108 g (93.7 eggs). Our results are in line with Medina et al. (2003) who investigated that spinosad at the highest concentration tested cause slight significant reduction in the adult life span and fecundity.

Impact on the grubs of C. zastrowi sillemi - Larval feeding method

C. zastrowi sillemi larval feeding method study revealed from 0.4 to 4.0 and from 3.2 to 9.5% mortality in spinetoram treatments at 12 and 24 HAT respectively (Table 3). At 48 HAT, the lowest mortality was recorded in spinetoram at 36 g a.i./ha (10.8%), while spinetoram at 45 g a.i./ha (16.2%) was followed by spinetoram at 54 g a.i./ha (19.2%). The next best treatments were emamectin benzoate 5 SG at 8.5 g a.i/ha (20.1%) and spinetoram at 108 g a.i/ha (22.3%). The standard check insecticides *viz.,* quinalphos 25 EC at 200 g a.i/ha, chlorpyriphos 20 EC at 200 g a.i/ha, indoxacarb 14.5 SC at 75 g a.i/ha and novaluron 10 EC at 75 g a.i/ha recorded > 30.00% mortality at 48 HAT.

Spinetoram 12 SC at 36 g (88.8%), 45 g (83.2%) and 54 g (79.8%) were recorded the highest pupation percentage followed by emamectin benzoate 5 SG at 8.5 g a.i/ha (79.5%), spinetoram 108 g (77.6%) and novaluron 10 EC at

Table 2. Impact of spinetoram 12 SC on the eggs and adults of *Chrysoperla zastrowi sillemi* (Esben - Petersen).

Treatments	Dose (g a.i/ha)	Eggs*		Adults**	
		Egg hatchability (%)	Egg mortality (%)	Adult longevity (days)	No. of eggs laid per 5 female
Spinetoram 12 SC	36	95.2^{ab}	4.2^{ab}	11.4^{b}	146.0^{b}
Spinetoram 12 SC	45	90.1^{b}	9.5^{b}	9.4^{c}	133.4^{c}
Spinetoram 12 SC	54	86.3^{c}	13.2^{c}	8.3^{d}	105.7^{d}
Spinetoram 12 SC	108	81.6^{d}	18.4^{d}	7.7^{e}	93.7^{e}
Emamectin benzoate 5 SG	8.5	86.0^{c}	13.8^{c}	8.7^{d}	106.1^{d}
Chlorpyriphos 20 EC	200	60.4^{f}	38.4^{f}	5.8^{g}	48.1^{g}
Quinalphos 25 EC	200	62.3^{f}	37.7^{f}	5.8^{g}	48.5^{g}
Indoxacarb 14.5 SC	75	59.7^{f}	40.3^{f}	4.0^{h}	45.6^{g}
Novaluron 10 EC	75	76.0^{e}	24.0^{e}	6.9^{f}	72.0^{f}
Untreated control	-	97.1^{a}	2.9^{a}	14.7^{a}	366.4^{a}
CD (0.05%)	-	1.18	2.20	2.52	3.00
SEd	-	0.71	1.10	1.30	1.53

In a column, means followed by a common letter are not significantly different by DMRT (P = 0.05); *Values are arc sine $\sqrt{\text{per cent}}$ transformed values; ** Values are $\sqrt{X+0.5}$ transformed values.

Table 3. Effect of Spinetoram 12 SC on the grubs of *C. zastrowi sillemi* by larval feeding method.

Treatments	Dose (g a.i/ha)	Larval feeding method*				
		Mortality (%)			Pupation (%)	Adult emergence (%)
		Hours after treatment (HAT)				
		12	24	48		
Spinetoram 12 SC	36	0.4^{a}	3.2^{b}	10.8^{b}	88.8^{b}	88.8^{b}
Spinetoram 12 SC	45	1.0^{ab}	4.3^{c}	16.2^{c}	83.2^{c}	83.2^{c}
Spinetoram 12 SC	54	2.1^{b}	7.3^{d}	19.2^{d}	79.8^{cd}	79.8^{cd}
Spinetoram 12 SC	108	4.0^{c}	9.5^{e}	22.3^{e}	77.6^{cd}	77.6^{cd}
Emamectin benzoate 5 SG	8.5	2.3^{b}	7.8^{d}	20.1^{d}	79.5^{cd}	79.0^{cd}
Chlorpyriphos 20 EC	200	7.1^{f}	13.6^{g}	38.8^{g}	61.2^{f}	59.0^{f}
Quinalphos 25 EC	200	6.2^{e}	11.2^{f}	30.7^{f}	69.3^{e}	69.3^{e}
Indoxacarb 14.5 SC	75	8.0^{g}	15.7^{h}	47.2^{h}	52.8^{g}	50.3^{g}
Novaluron 10 EC	75	5.2^{d}	10.0^{e}	24.1^{e}	75.0^{d}	73.0^{d}
Untreated control	-	0.4^{a}	0.4^{a}	4.7^{a}	94.0^{a}	94.0^{a}
CD (0.05%)	-	0.01	0.20	1.32	2.20	2.21
SEd	-	0.005	0.10	0.71	1.11	1.12

HAT - Hours after treatment; * Mean of three replications; in a column, means followed by a common letter are not significantly different by DMRT (P = 0.05); Values are arc sine $\sqrt{\text{per cent}}$ transformed values.

75 g a.i/ha (75.0%). The same trend was observed in adult emergence also. Sansone and Minzenmayer (2000) also reported that spinosad had the least impact on spiders as compared to indoxacarb and emamectin benzoate.

Dry film method

Experiment by dry film method revealed that, the lowest mortality of grubs (0.5, 4.7 and 9.1%) was recorded in lower dose of spinetoram at 36 g a.i./ha followed by spinetoram at 45 g a.i./ ha (2.2, 11.4 and 15.3%), spinetoram at 54 g a.i./ha (5.6, 16.5 and 22.7%) and emamectin benzoate 5 SG at 8.5 g a.i/ha (5.7, 16.9 and 22.7%) at 12, 24 and 48 HAT respectively (Table 4).

The pupation per cent was higher in untreated check (94.1%) while spinetoram at 36, 45, 54 and 108 g a.i./ ha recorded 90.9 to 72.0% pupation and other standard checks recorded 77.3 to 49.8% pupation. The same trend was also followed in adult emergence percentage. These findings are in conformity with the results of Gamal El-Kady et al.

Table 4. Effect of spinetoram 12 SC on the grubs of *C. zastrowi sillemi* by dry film method.

Treatments	Dose (g a.i/ha)	Dry film method*				
		Mortality (%)			Pupation (%)	Adult emergence (%)
		Hours after treatment (HAT)				
		12	24	48		
Spinetoram 12 SC	36	0.5[a]	4.7[b]	9.1[b]	90.9[b]	90.9[b]
Spinetoram 12 SC	45	2.2[b]	11.4[c]	15.3[c]	84.7[c]	84.7[c]
Spinetoram 12 SC	54	5.6[c]	16.5[d]	22.7[d]	77.3[d]	77.3[d]
Spinetoram 12 SC	108	11.3[d]	20.1[e]	28.0[e]	72.0[e]	72.0[e]
Emamectin benzoate 5 SG	8.5	5.7[c]	16.9[d]	22.7[d]	77.3[d]	77.3[d]
Chlorpyriphos 20 EC	200	15.8[f]	29.7[g]	42.4[g]	57.6[g]	56.0[g]
Quinalphos 25 EC	200	14.5[f]	25.9[f]	38.7[f]	61.0[f]	60.2[f]
Indoxacarb 14.5 SC	75	17.5[g]	34.3[h]	50.2[h]	49.8[h]	49.8[h]
Novaluron 10 EC	75	12.8[e]	22.3[e]	31.1[e]	68.9[e]	68.9[e]
Untreated control	-	0.5[a]	1.5[a]	5.9[a]	94.1[a]	94.1[a]
CD (0.05%)	-	0.03	0.22	1.61	1.90	2.01
SEd	-	0.015	0.12	0.83	0.92	1.00

HAT - Hours after treatment; * Mean of three replications; in a column, means followed by a common letter are not significantly different by DMRT (P = 0.05); Values are arc sine $\sqrt{\text{percent}}$ transformed values.

(2007) and Mahmoud and Osman (2007) who found that spinetoram 12 SC when applied at low rates (10 µg/ml) had low impact on most beneficial insects such as ladybirds, lacewings, big-eyed bugs or minute pirate bugs.

In conclusion, spinetoram 12 SC did not show any harmful effects on parasitization and parasitoid emergence of *T. chilonis* and spinetoram 12 SC was recorded lowest egg and grub mortality, highest egg hatchability and highest adult longevity of *C. zastrowi sillemi.*

Conflict of Interests

The authors have not declared any conflict of interests.

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