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ORIGINAL ARTICLE

Comparative evaluation of the toxicity of lambda cyhalothrin and spinosad on the insect pests and auxiliary fauna in an orange orchard of the central Mitidja (Blidean Atlas, Algeria)

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Allal-Benfekih L., Aoudia B., Mostefaoui H. & Belguendouz R: Comparative evaluation of the toxicity of lambda cyhalothrin and spinosad on the insect pests and auxiliary fauna in an orange orchard of the central Mitidja (Blidean Atlas, Algeria).

ABSTRACT

Impact of phytosanitary treatments on time variation in the abundance and diversity of the insect fauna was evaluated on an orange orchard in Central Mitidja. The ecotoxicity of Lambda-cyhalothrin and spinosad applied to the approved dose and half-dose were evaluated through the abundance and availability of pest populations and associated auxiliary procession after a period of 16 days exposure. Our results showed that Lambda-cyhalothrin has a toxic effect on the aphid residual population during 12 days after treatment, which is moderately toxic from the 13th to the 16th day, while spinosad has a neutral effect during the hole exposure period. Community of the insect fauna harvested during the 16 days of observation after treatment consists of 12 species of phytophagous, 11 parasits and 13 predators. Under the effect of the approved dose of Lambda-cyhalothrin, temporal fluctuation pest shows a slight increase in the first 12 days with a significant difference compared to control (23.30% in 12 days). The Aphididae, *Phyllocnistis citrella* and *Ceratitis capitata* are the most influenced unlike Coccidae, Aleurodidae and *Tetranychus* sp. The similarity analysis to one factor shows very highly significant differences between two types of treatments and between each treatment group and the controls. These differences may be due to variations in the relative abundance of different taxa or species composition of communities. Lowest contribution differences are recorded in parasitoïds and Chrysopidae.

Key words: pesticides, ecotoxicology, beneficial ennemis, pests, crops, auxiliary fauna assemblages.

Introduction

Progress in plant protection have contributed to the increase in yields and the regularity of production. Easy to access and use, relatively cheap, synthetic plant protection products have proved very effective and reliable in a significant number of cases, on large surfaces (Bellabas, 2010). But today, the systematic use of these products is called into question, with increasing risk awareness that they can generate for the biocoenosis (Fournier *et al*., 2002). Treatments for arthropod pests constitute the major market for insecticides. Side-effects against non-target species of beneficial ennemis are a potentially undesirable consequence of insecticide use. Owing to their importance as biological control agents in orchards and glasshouses, many studies have assessed the impact of insecticides on important beneficial, non-target species (Fournier *et al*., 2002, Morin, 2002, Sotherton et Self, 2000).

Bibliographic analysis of lethal and sublethal insecticides effects shows that insecticides may change the ecological balance, as they participate in environmental pollution (Ronzon, 2006). Auxiliary insects phytosanitary risks are assessed by mortality measured after exposure of the insects in the laboratory. However there is an offset significant exposure in natural conditions, where there is refuge areas and where the product can evolve rapidly. Polyphagous aphids are part of the major pest of many cultures in Algeria (Bellabas, 2010). With the increase of these Homopteran species resistance with regard to chemical applications, the choice of treatment and dose is essential to reduce aphid resistance on the one hand, and on the increase of the efficiency of plant protection on the other hand. In this work, an ecotoxicological aspect is highlighted by a comparative study of the active effect of Lambdacyhalothrin and spinosad on different trophic groups, as well as their biocenotic recovery after treatment in an orchard of citrus in the Central Mitidja. We will also try to answer the

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question of whether the dose of these two insecticides products has sufficient effects to regulate pest population and non-effect on the non target entomofauna referred, in order to better situate these treatments applications in IPM.

Material and Methods

Situation and climate:

The study was conducted in 2010 in the Oued-El-Alleug citrus region located ten miles east of Blida, in the Central Mitidja. The studied orchard (14.76 m altitude, 36 ° 33' 19 1" latitude N, 2 ° 47 ' 25 E longitude) is located on the left side of the Oued El Alleug-Gomez road, 11 Km to the West of the municipality of Oued El Alleug, at the level of a private farm which extends over 10 ha of area. The Orchard is surrounded by windbreaks made of cypress (*Taxodium distichum*), bounded to the South by a small village, and citrus orchards in the North, East and West directions.The climate is Mediterranean with a continental trend (humid stage with cool winter). The precipitation, mostly observed in winter and spring, is characterized by a great inter-annual and inter-monthly irregularity.

Insecticides:

The experimental design used to quantify the extent of the activity of two insecticides against citrus pests and non-target insect and Aranean fauna was conducted over an orange orchard of washington Navel Variety. Lambda-cyhalothrin, a synthetic pyrethrinoid is a multipurpose insecticide formulated in liquid 50 g/l, the dosage is 60 ml/hl, the Spinosad is formulated in concentrated suspension (SC) of 480 g/l, the used dose is 0.2 l/ha. No cultural maintenance and plant protection work were conducted during our experiment.

Samplings and statistical analyses :

The sampling of entomofauna living on the unit areas defined by the orange trees began in September 20th until october 10th 2010, covering a 16 days period. Every 2 days, we carefully examined the aerial compartments of five randomly sampled orange trees (leaves and fruits) from each representativ 8 units : one water treated unit and the seven others treated respectively with the approved doses and half doses of lamdacyhalothrin and spinosad.

At the level of leaves of each sampled tree, 4 leaves were collected from both northern and southern cardinal direction each at approximatively 1.80 m above the ground. All the encountered specimens (insects, Acari and spiders) were recorded. Four yellow water traps were also placed per treated and control units and renewed every two days for counting. All the specimens collected were put into jars containing diluted ethanol at 70%, and then kept in the laboratory to be identified and quantified.

We tested the total similarities between the sites by an ANOSIM (Analysis Of SIMilarity), a nonparametric test of significant difference based on a distance measure (Clarke, 1993). The index of Bray-Curtis was selected here as a measure of similarity and the P-values were deduced from 10 000 permutations. The contribution of each insect species to the differences observed between assemblages was calculated with the program SIMPER (SIMilarity PERcentage), using again the index of Bray-Curtis, following the statistical processing mentionned in Moussi *et al.*, (2009).

Results:

Comparative evaluation of the two pesticides effectiveness on aphid populations :

The comparative study of the two products shows that Lambda-cyhalothrin has a toxic effect on the population as well as residual aphid during 12 days exposure, which became moderately toxic from the 13th to the 16th day (figure 1). Variance (GLM) analysis showed a non-significant difference in the abundances of the residual aphid populations under the effect of Lambda-cyhalothrin as the exposure time ($p = 0.104 > 5\%$), and a very highly significant difference according to the dose used ($p = 0. 000 < 1‰$) (figure 2). The dose of Lambda-cyhalothrin has a toxic effect, while the half dose has a moderately toxic effect. Spinosad has a neutral effect in improved dose and half dose on residual populations ($p = 0. 000 < 1‰$), regardless of the time of exposure to the treatment ($p = 0. 055 < 5\%$) (figure 1 & 2). The percentage of the residual populations of aphids is maintained between 8% and 100% during the 16 days of exposure (table 1).

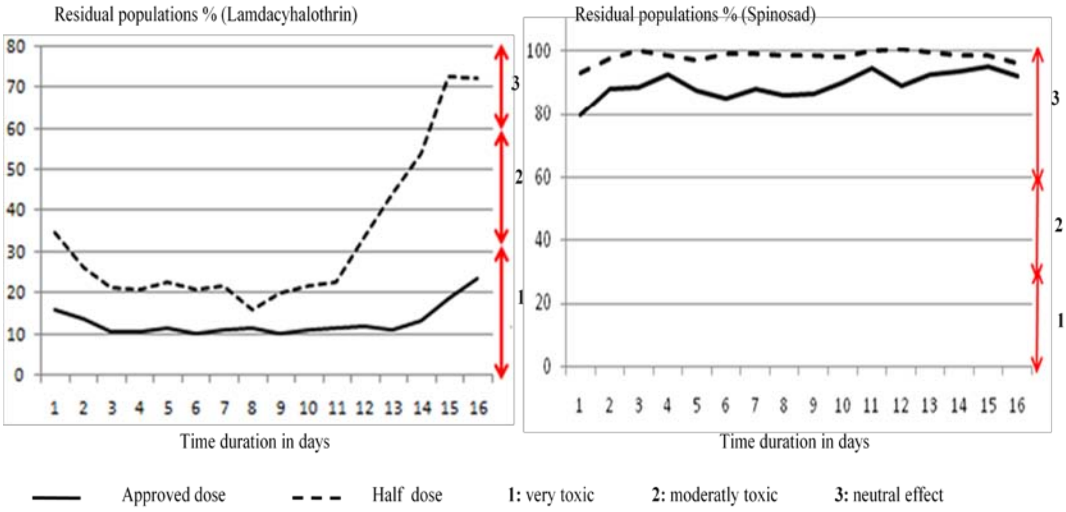

Fig. 1: Evolution of the residual aphid populations in relation to duration of exposure to Lamdacyhalothrin and Spinosad.

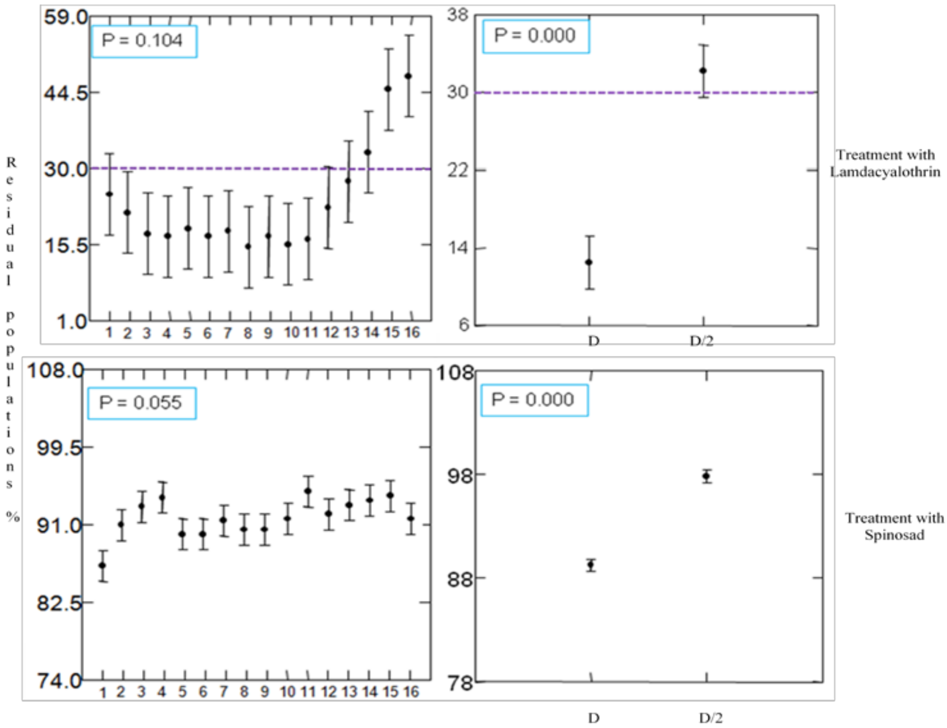

Fig. 2: GLM (Anova, SPSS) analysis and associated probabilities of the comparision between treatment effects.

Comparative composition of the entomofauna abundances exposed to doses and tested treatments :

During the period of treatment exposure (16 days), we surveyed a total of 48 species grouped into four trophic groups: the phytophagous (12 species), parasits (11especes), predators (13 species), and the the polyphagous group including 12 species. Two way ANOSIM similarity analysis between the two categories of treatments taken two by two, shows a highly significant difference between active substances ($R = 0.75$, $p < 0.0001$), and between doses ($R = 0.50$, $p < 0.0001$). Overall, during the two weeks of exposure, the two treatments have a different degree of toxicity on the taxa of the entomofauna depending on each dose of application. The contribution of each taxa to the differences in composition of each respective treatment groups type was calculated using the SIMPER (SIMilarity PERcentage) according to the programms procedure in software (Past, 2001).

Species that show a difference of contribution between Assemblage of the approved dose and the half dose of Spinosad are Aleurodidae, Aphidoidea, *Phyllocnistis citrella*, *Ceratitis capitata* and *Cataglyphis bicolor* (4.80% to 0.97%, table 2).

These are species that have a low sensitivity to dose but not to the half dose of Spinosad. Species that have a low difference of contribution are (Aranea and Coccinellidae), predators and pests (*Tetranychus sp* and the Coccidae)), which have a resistance to both tested doses, unlike parasites. The Aleurodidae, *Phyllocnistis citrella*, and the Aphididae (7.19% to 3,18%), followed by *Cataglyphis bicolor* (2.17%), the Aranea and *Tetranychus sp*, show a higher difference in contribution between Assemblage of the approuved dose and the half dose of Lambda-cyhalothrin. These species are more sensitive to the dose compared to the half dose of the active substances. The Coccidae showed resistance to Lambda-cyhalothrin in dose and half dose, unlike other pests species (*Ceratitis capitata)* and the Coccinellidae) that show sensitivity to Lambda-cyhalothrin regardless of the dose.

Table 1: Contributions of the insect fauna to differences in composition between different assemblages of chemical and biological treatments (l: Lambda-cyhalothrin, t: Spinosad, d: dose, d/2: half dose).

Trophic Group	Taxa	dl-d/2l	ds-d/2s	Trophic Group	Taxa	dl-d/2l	ds-d/2s
Predator	*Adalia bipunctata (Coccinellidae)*	0,16	0,41	Pest	*Icerya purchasi (Monophlebidae)*	0,60	0,22
Pest	*Aphis spiraecola (Aphididae)*	3,47	1,40	Pest	*Lepidosaphes beckii (Coccidae)*	0,84	0,20
Predator	*Adonia variegata (Coccinellidae)*	0,04	0,09	Predator	*Lepthyphantes sp (Aranea)*	1,61	0,35
Pest	*Aleurothrixus floccosus (Aleurodidae)*	6,91	4,57	Predator	*Lycosidae 1 (Aranea)*	0,70	0,27
Pest	*Aphis gossypii (Aphididae)*	3,18	2,04	Predator	*Lycosidae 2 (Aranea)*	1,73	0,18
Parasit	*Bethylidae (Hymenoptera)*	0,04	0,45	Pest	*Planococus citri (Pseudococcidae)*	0,90	0,22
Parasit	*Braconidae 1 (Hymenoptera)*	0,04	0,36	Pest	*Phyllocnistis citrella*	5,55	1,14
Parasit	*Braconidae 2 (Hymenoptera)*	0,19	0,14	Pest	*Parlatoria zizyphi (Coccidae)*	0,80	0,21
Parasit	*Braconidae 3 (Hymenoptera)*	0,25	0,23	Predator	*Salticidae (Aranea)*	1,83	0,31
Predator	*Cataglyphis bicolor (Formicidae)*	2,17	2,08	Parasit	*Tachinidae 1 (Diptera)*	0,09	0,14
Predator	*Chilocorus bipustulatus (Coccinellidae)*	0,23	0,49	Parasit	*Tachinidae 2 (Diptera)*	0,22	0,58
Pest	*Ceratitis capitata (Diptera, Tephritidae)*	0,95	0,79	Pest	*Toxoptera aurantii (Aphididae)*	4,01	1,03
Parasit	*Chalcidae sp1(Hymenoptera)*	0,35	0,87	Pest	*Tetranychus urticae (Tetranychidae)*	1,43	0,33
Parasit	*Chalcidae 2 (Hymenoptera)*	0,39	0,36	Predator	*Thomisidae sp (Aranea)*	1,67	0,23
Predator	*Chrysopidae 1(Neuroptera)*	0,14	0,18	Parasit	*Trichogramatidae (Hymenoptera)*	0	0,11
Predator	*Chrysopidae 2 (Neuroptera)*	0,35	0,07	Predator	*Coccinella algerica (Coccinellidae)*	0,22	0,55
Pest	*Dialeurodes citri (Aleurodidae)*	7,19	4,80	Predator	*Gnaphosidae (Aranea)*	0,08	0,36
Parasit	*Ichneumonidae 2 (Hymenoptera)*	0	0,28	Parasit	*Ichneumonidae 1 (Hymenoptera)*	0,04	0,59

Discussion:

Our results highlighted that Lambda-cyhalothrin as active chemical, has a toxic effect of the approved dose on residual aphid populations, and a moderately toxic effect to the halfdose, unlike the biological insecticide Spinosad including who show a neutral effect according to the two tested doses. The residual time effect of Lambda-cyhalothrin is clearly visible during the first week following the application of the treatment. This toxicity is gradually reduced during the second week.

Bourgeois and Mathieu (2007) explained that a lambda-cyhalothrin application can reduce to 95% the aphid populations infesting soybeans, and that an increase of 7.3% in the yield was observed. Nevertheless, Schellhorn and Andow, (1999) found a high abundance after application of Spinosad on maize plants as well as aphid infestation. Salgado (1998), Sagado *et al*., (1998) report in turn that Spinosad was relatively ineffective to protect plants against aphids. The gradient of the synthetic pyrethroid toxicity is in relation to the rate of application (Pope *et al.* 2005). The half dose of lambda-cyhalothrin has a significant effect on aphids in the first week. The fall of the biotic potential of aphid populations is the knock-down Lambda-cyhalothrin effect on the cerebral ganglia of the insects followed by a phase of hyperexcitation culminating in the insect death (Narahashi, 2000; Nauen, 2006). The recolonization of the pests at the end of the second week could be due to the fact that the insecticide is likely to select potentially resistant individuals within the treated population. The spraying of synthetic pyrethroids at sublethal doses also cause a rapid increase in the number of resistant individuals on aphids (Harrington *et al*., 2007; Nandihalli *et al.*, 1992).

The Coccinellidae are the leading group of predators in the control of the Aphididae. They are likely to play a role in the protection of crops against some of their pests (aphids, mealy bugs, mites), the aphidiphaggous categories being the most represented, but phytosanitary treatments influence their activity (Saharaoui *et al*., 2001).

Spinosad has presented a neutral effect on the Coccinellidae populations The temporal study of Spinosad toxicity on Coccinellidae highlighted a moderately toxic effect of the dose during the first week and a neutral effect in the second week after application. Such as ladybirds, *Hippodamia convergens* and *Coccinella septempunctata* were found to have been tolerant of Spinosad, (Singh *et al*., 2004). However, in controled conditions, sublethal doses of Spinosad 2SC led to a decrease in the survival of the larvae of *Harmonia axyridis*, a prolongation of the larval durations, and a decrease in the fertility of females. Climatic parameters variations also affect the phenological development of the plant as well as on the insects biology but also on the toxicity of the active substance. Studies have shown that the toxicity of the pyrethroid varies depending on the temperature. Other factors may influence the product toxicity, including the mode of implementation, conditions and experimental parameters (Pennetier, 2008 ; Vlasenko and Shtundyuk, 1994).

Several hypotheses can explain the increase in the phytophagous species populations following the application of a chemical. Natural enemy populations are reduced, behaviour and the predators lifecycle are affected and competing non-target species are eliminated (Dennis *et al.*, 1993, Longley *et al*., 1997) the use of broad spectrum pesticides causes instabilities in the predators populations which has the effect of increasing the phytophagous populations (Ronzon, 2006; Gibbs, 2009). The predators group showed a high sensitivity to the lambda-cyhalothrin compared to spinosad. Recolonization is made after the relocation of their prey. The use of lambda-cyhalothrin affect mortality of intraguild predators that can be explained by a second exposure to the chemical caused by prey.consumption. The consumption of prey contaminated with a chemical product can generate different levels of mortality of the predator depending on the product used toxicity, the applied dose and duration of exposure. Thus, a first exposure to a sublethal dose does not cause the death of intraguild predator, but when he devours his prey, he is exposed to a second dose of lambda-cyhalothrin, which causes his death (Mc Murtry *et al*., 1970; Singh *et al*., 2004, Gibbs, 2009).

Phytophagous species and their parasitoids do not have the same sensitivity to pyrethroids. The delay of onset parasitoids in treated plots can be explained by three types of possible insecticide action of the product on the host, and action of the product on the parasitoids. The Group of parasites showed a high sensitivity to the lambda-cyhalothrin, and spinosad in approuved dose and half dose. Lambda cyhalothrin treatments cause a delay of the parasitoids action, for at least a week, compared with the untreated plot. This period corresponds to the time required for the manifestation of parasitism in the mummies form. Concerning the product effect related to the host deltamethrin and lambda cyhalothrin decreased the attack of the aphids of cereals and their parasitoids Hymenoptera infestation. Adults are exposed on the one hand, to the spray residue on the foliage or in contaminated food (nectar, pollen, leaf exudates or honeydew excreted by Homoptera). The immature stages are protected during the Mummy stage but their hosts may be killed on the other hand. Neurotoxic insecticides such as lambdacyhalothrin can result in changes of olfactory responses in insects parasitoids. The $DL_{0,1}$ of lambda cyhalothrin modifies the behavior of olfactory orientation of *Aphidius ervi* in olfactometer, while the DL0,1 and DL20 of chlorpyrifos ethyl disrupt pheromonal communication in the Trichogramma wasps.

Conclusion:

Lambda-cyhalothrin in approved dose has a high efficiency for 16 days in the regularization of the aphid population in the environmental conditions of the orange studied orchard. The tested half dose has a regulatory effect on the aphid population, but the dose is more effective. Spinosad has shown a neutral effect on this population. The sensitivity of the population goes with a full dose of Lambdacyhalothrin, the dose of spinosad, the half dose of Lambdacyhalothrin, and finally the half dose of spinosad-treated populations. We noticed that the pest populations increase after the two weeks that followed the treatment. This increase is related to a phenomenon of resistance towards the tested treatments. The parasites group showed a high sensitivity to the lambda-cyhalothrin, and spinosad in dose and half dose. The predators group showed a high sensitivity to the lambda-cyhalothrin compared to spinosad.

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