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# EFFECT OF SULFOXAFLOR AND SPIROTETRAMAT APPLICATION TIMING ON THE CONTROL OF SAN JOSE SCALE (*Diaspidiotus perniciosus* Comstock) IN APPLES

# EFECTO DE LA ÉPOCA DE APLICACIÓN DE SULFOXAFLOR Y SPIROTETRAMATO EN EL CONTROL DE ESCAMA DE SAN JOSÉ (*Diaspidiotus perniciosus* Comstock) EN MANZANAS

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## ABSTRACT

***Diaspidiotus perniciosus*** **is a pest that requires chemical control in an annual basis, whose presence in orchards has increased in the last few seasons. Sulfoxaflor (7.2 g of ai $hL^{-1}$) and spirotetramat (10 g of ai $hL^{-1}$) (ai: active ingredient) were applied against first generation nymphs of *D. perniciosus* (Comstock) at 75, 150 and 228 day degrees (DD), and Chlorpyrifos (60 g of ai $hL^{-1}$) at 228 DD starting at the biofix (first male capture), in severely infested apple trees located in central Chile, during the 2012-2013 season. The untreated control trees were sprayed with water. Application was performed using handgun with a sprayer equipped with membrane pump delivering 40 L per minute at 250 psi and a water volume of 3500 L per hectare. Evaluation was performed in laboratory on December 20 of 2012, at the end of first *D. perniciosus* generation nymphs movement, counting the number of nymphs fixed by lineal meter of new twigs collected from infested areas in the tree. Results were subjected to ANOVA and Duncan multiple range test. It was concluded that under the high *D. perniciosus* pressure present in the trial, all treatments significantly reduced ($P \leq 0.05$) the number of nymphs fixed in twigs compared to the untreated trees. However, treatment with spirotetramat applied at 228 DD provided only a partial control of *D. perniciosus*, being statistically different from all other treatments.**

**Key words:** day degrees, insecticides, effectiveness, fixing, scales

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## INTRODUCTION

Chile is an important country in apple production. Within the southern hemisphere, it occupied the first position in production and exportation, and the third place in planted area, with a total of 35,075 ha of red and green apples in the 2007-2008 season (González et al., 2012). In 2013, total apple production was close to 833,110 tons (ODEPA, 2014).

Some of the main limitations for pome fruit exports are pesticide residues in fruit, especially for German and English supermarkets, and the detection of live insects in the phytosanitary inspections for Latin-American markets (Galdames, 2009). In the 2009-2010 season about 2.5 million boxes were rejected prior to exportation to all external markets (Baeza and Espíndola, 2009). San Jose scale, *D. perniciosus* (Comstock) (Hemiptera-Homoptera: Diaspididae), was the key rejection cause for the Latin American market, with about 925,725 boxes (Galdames, 2009).

*D. perniciosus* is a pest that requires chemical control in an annual basis, whose presence has increased in the orchards in recent seasons due to poor coverage of wood. This occurs mainly because of low volume applications, and the difficulty of using pesticides in critical periods, like 2nd *D. perniciosus* nymph movement due to harvest nearness (Sazo and Campos, 1986). Rice and Jones (1997) demonstrated that San Jose scale populations collected in 1994 from the commercial orchards of the Reedley-Parlier area, California, USA, presented high resistance levels to organophosphate insecticides such as chlorpyrifos or diazinon. Similar results were obtained by Cañas (2010), who determined high resistance levels to chlorpyrifos in San Jose scale populations collected in central Chile from commercial apple and plum orchards.

Resistance of different pests to insecticides and or miticides has become a global issue lately due to the continuous use of active ingredients with a similar mode of action; therefore, one of the ways to manage resistance is through the rotation of pesticides with different modes of action (Whalon et al., 2008). Additionally, regulatory restrictions towards commercially important and effective insecticides have increased. Recently, new insecticides with different modes of action have been developed (Elbert et al., 2007), such as spirotetramat (Bruck et al., 2009) and sulfoxaflor (Babcock et al., 2011). Both insecticides are used to control sucking pests. Spirotetramat is effective against a broad spectrum of Homoptera insects, like aphids, scales and white flies (Bell et al., 2008; Cantoni et al., 2008; Kühnhold et al., 2008; Brück et al., 2009), while sulfoxaflor has demonstrated cross spectrum activity on sucking insects of different families, such as Aleyrodidae, Aphididae, Delphacidae, Margarodidae and Miridae (Babcock et al., 2011).

Sulfoxaflor is a new active ingredient belonging to the sulfoximine insecticide class, which has a unique interaction with nicotinic receptors (Watson et al., 2011). Sulfoxaflor has broad spectrum activity against sucking pests, including insects of the following families: Aleyrodidae, Aphididae, Delphacidae, Margarodidae, y Miridae (Babcock et al., 2011; Zhu et al., 2011).

Spirotetramat is a new two-way systemic (ambimobile) insecticide against sucking pest species. It is a lipid biosynthesis inhibitor, similar to tetronic acid derivatives (spirodiclofen and spiromesifen) (Wachendorff et al., 2000; Nauen et al., 2005). It moves upwards and downwards through its translocation in the xylem and phloem, respectively (Nauen et al., 2008). It controls the pest by inhibiting lipid biosynthesis, resulting in a delayed mortality of insects in immature stages and a marked reduction in both fecundity and fertility of adult species (Neuen et al., 2008).

The objective of this study was to evaluate the insecticidal effect of spirotetramat and sulfoxaflor agains *D. perniciosus* in apples located in the central region of Chile, when applied in springtime.

## MATERIALS AND METHODS

The study was performed in a 10-year-old commercial Granny Smith apple orchard located in 'El Olivar' (34°13′31.5′′ S; 70°48′58.4′′ W), VI Region, Chile. The orchard presented a high *D. perniciosus* infestation with *D. perniciosus* and it had not been treated with specific insecticides in the past two seasons. Experimental units were marked first and then grouped in blocks according to their infestation level.

Three insecticides were studied: sulfoxaflor (Closer® 240 SC), spirotetramat (Movento® 100 SC), Chlorpyrifos (Lorsban® 75 WG). A control treatment only with water was also included. The concentrations tested and the results obtained are shown in Table 1.

After selecting the experimental units, these were grouped into blocks according to the level of infestation, taking into consideration a visual scale of 4 categories: severe (central and lateral branches infested mother axes), regulating 3 or more branches of the structure, mild (1-2 sprigs and/or twigs) and emerging (isolated detection only). A sprayer equipped with a membrane pump (Levera, Arrastre, Santiago, Chile, of 220 L) was used, providing 40 L $min^{-1}$ at 250 psi. Hand guns were used, resulting in a water volume of

3500 L ha$^{-1}$.

Application timing was determined according to accumulated day degree (DD) above 10°C (Rice et al., 1982), starting with the first captured male (biofix) in a Pherocon®, *D. perniciosus* pheromone trap (September 14, 2012). Treatments were evaluated after the birth of nymphs of the first generation had concluded (December 20). Ten twigs of the new growth season were collected from infested tree areas and taken to the laboratory, where all live nymphs fixed in the first basal 10 cm (1 lineal meter per experimental unit) were counted under stereoscope lens. San Jose scale nymphs of bright yellow lemon color and turgid aspect were considered as live.

A completely randomized block design was used, with 8 treatments and four replications. Each experimental unit consisted of three trees.

Results regarding the number of fixed nymphs per lineal meter season twig were transformed by natural log (X+1). ANOVA test and Duncan (1955) multiple range tests were previously performed to separate means.

## RESULTS AND Y DISCUSSION

The levels of individuals in the control correspond to a place with high infestation, insofar a low infestation, affecting only a few dozen (40-60), is recorded. On the other hand, severe infestations affect several hundreds. The results are shown in Table 1.

The high number of *D. perniciosus* nymphs fixed by lineal meter in the untreated treatment corroborates that the orchard presented a high infestation, confirming the lack of effective treatments against this pest in past seasons. All sulfoxaflor treatments (7,2 g of ai hL$^{-1}$) and spirotetramat (10 g of ai hL$^{-1}$) statistically outperformed the untreated. All sulfoxaflor treatments were statistically similar between them, similar to spirotetramat when applied at 75 and 150 DD and to chlorpyrifos (60 g of ai hL$^{-1}$), considered as a standard treatment against *D. perniciosus* nymphs in springtime. All treatments statistically outperformed spirotetramat when applied at 228 DD after the biofix. These results confirm that spirotetramat, applied at 75 and 150 days degree, controls fertilized females (present during the application state) more effectively. These results are consistent with those reported by Nauen et al. (2008) who found that spirotetramat reduced fecundity and female fertility, and consequently resulted in reduced insect populations.

After finding a definitive feeding site, *D. perniciosus* nymphs insert their mouthparts in the vegetable tissue and start to secrete a white waxy material, similar to cotton, that is seen as a "white cap" (Marín, 1987; Sazo y Charlín, 1988). According to this, sulfoxaflor action would be triggered once the insect starts feeding from the sap containing this systemic insecticide (Babcock et al., 2010).

The three sulfoxaflor treatments were equal probably due to the large residual effect that authors, like Lysandrou et al. (2010), have reported plus a speed of action similar to the neonicotinoid insecticides (Santhram et al., 2004; Razaq et al., 2005).

The greater number of nymphs fixed in the 228 DD spirotetramat treatment can be explained by the product's mode of action. Due to its systemic nature, it must be absorbed and translocated by the plant to affect the insect when it feeds. According to Nauen et al. (2008), spirotetramat activity would be slower that imidacloprid against *Myzus persicae*, reaching a similar control level only five days after application. This enables

**Table 1. Treatment dosages, day degree, date of application and average of *D. perniciosus* nymphs fixed by lineal meter of new growth twigs.**

| Treatments | mL o g ai hL$^{-1}$ | DD | Date of application | Nymphs per lineal m |
|---|---|---|---|---|
| Control | 0 | - | | 140.5 a |
| Sulfoxaflor | 7.2 | 75 | 17 October | 15.0 b |
| Sulfoxaflor | 7.2 | 150 | 31 October | 14.5 b |
| Sulfoxaflor | 7.2 | 228 | 14 November | 19.8 b |
| Spirotetramat | 10 | 75 | 17 October | 13.8 b |
| Spirotetramat | 10 | 150 | 31 October | 15.5 b |
| Spirotetramat | 10 | 228 | 14 November | 35.8 c |
| Chlorpyrifos | 60 | 228 | 14 November | 17.3 b |

Means in a column followed by same letters do not differ significantly according to Duncan (1955) tests ($p \leq 0.05$).
DD: Day degree.

to infer that for *D. perniciosus* something similar should happen because spirotetramat treatments applied before nymph birth in the present study significantly outperformed the latest application timing.

Spirotetramat produces inhibition of lipogenesis in treated insects, resulting in decreased lipid contents, growth inhibition of younger insects, and reduced ability of adults insects to reproduce (Nauen et al., 2006). Therefore, applications at 228° after the first male on fertilized females have less effect on the offspring due to a lower action of spirotetramat in lipogenesis embryo, compared to that observed at 75° and 150° in this this study.

## CONCLUSIONS

Sulfoxaflor (7,2 g of ai $hL^{-1}$) applied in apples at 75, 150 and 228 DD starting at biofix of first male in springtime, significantly reduces *D. perniciosus* nymphs fixation in seasonal growth twigs. Similar results were also observed with spirotetramat (10 g of ai $hL^{-1}$) applied at 75 and 150 DD and with chlorpyrifos (60 g of ai $hL^{-1}$) applied at 228 DD. Spirotetramat treatment (10 g of ai $hL^{-1}$), when applied at 228 DD of biofix, only partially reduced San Jose scale nymph fixation in twigs. In addition, the effect of spirotetramat on female San Jose scale decreases as the process of embryogenesis of the offspring progresses.

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