Abanico Agroforestal. January-December 2020; 2:1-14. http://dx.doi.org/10.37114/abaagrof/2020.10
Original Article. Received: 17/03/2020. Accepted: 15/08/2020. Published: 10/09/2020. Code: e2020-8.

New strategies to control of Whitefly: a vector of viral diseases in serrano chilli pepper in central and northern Mexico

Nuevas estrategias de control de mosca blanca, vector de enfermedades virales en chile serrano en el centro y norte de México

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Abstract

The objective of this work is to identify new control strategies for whiteflies, vector of viral diseases in pepper. The cultivation was sprayed twice a week in September and October. The yield of serrano chilli in a first cut goes from highest to lowest in treatments with: a- Flupyradifurone 150 g of i.a/ha (0.75 L/ha) in September and October, b- Flupyradifurone 150 g of i.a/ha (0.75 L/ha) in September and Super Magro+Sulfocalcic Broth 10 L of each/ha in October. The treatment c was Super Magro+Sulfocalcic Broth 10 L of each/ha in September and October and treatment d- Imidacloprid 87.5 g of i.a/ha (0.25 L/ha) in September and October. Results shown that Flupyradifurone tratment is an effective option to achieve high yields and minimize whitefly related damage, and the life of this product can extend, avoiding insect resistance, if its use is alternated with organic products. The Flupyradifurone treatment followed by the use of Super magro + mineralized Sulfocalcic Broth mixture reduces insecticide applications by 50 % and reduces the presence of whitefly populations that are capable of severely infecting chilli plants. Despite having plants with whitefly damage, when organic products are applied, they are capable of achieving high yields per hectare. As a conclussion, Imidacloprid can be substituted by Flupyradifurone or by Super Magro + mineralized Sulfocalcic Broth mixture. The 15 applications carried out in the months of September (7applications) and October (8 aplications), with Imidacloprid, can be changed for 15 organic applications, which would allow detoxification of the productive environment on the producing regions of pepper.

Keywords: serrano pepper, effectiveness, chemical and organic products, whitefly, incidence of virosis, yield.

Resumen

El objetivo de este trabajo es identificar nuevas estrategias de control de mosca blanca, vector de enfermedades virales en chile. Con aspersiones dos veces por semana en septiembre y octubre, el rendimiento de chile serrano en un primer corte va de mayor a menor en los tratamientos con: a. Flupyradifurone 150 g de i.a. / ha (0.75 L/ha) septiembre y octubre, b. Flupyradifurone 150 g de i.a./ha (0.75 L / ha) septiembre / Súper Magro + Caldo Sulfocálcico 10 L de cada uno / ha octubre, c. Súper Magro + Caldo Sulfocálcico 10 L de cada uno / ha septiembre y octubre y d. Imidacloprid 87.5 g de i.a. / ha (0.25 L / ha) septiembre y octubre. El Flupyradifurone es una opción eficaz para lograr altos rendimientos y reducir al máximo los daños de mosca blanca y se puede prolongar la vida útil de este producto, evitando la

resistencia de los insectos si se alterna con los productos orgánicos. La secuencia Flupyradifurone / mezcla de Súper Magro + Caldo Sulfocálcico mineralizado permite reducir en un 50 % las aplicaciones de insecticida y reduce la presencia de poblaciones de mosca blanca que son capaces de infectar severamente las plantas de chile. A pesar de tener plantas con daño de mosca blanca, cuando se aplican los productos orgánicos, éstas son capaces de lograr altas producciones por hectárea. El Imidacloprid puede ser substituido por Flupyradifurone o bien por la mezcla de Súper Magro + Caldo Sulfocálcico mineralizado. Las 15 aplicaciones realizadas en los meses de septiembre (7) y octubre (8), con Imidacloprid, pueden cambiarse a 15 aplicaciones de orgánicos lo que permitiría una desintoxicación del ambiente productivo de las regiones productoras de chile.
Palabras clave: chile serrano, efectividad, productos químicos y orgánicos, mosca blanca, incidencia de virosis, rendimiento.

INTRODUCTION

In the Middle Potosina Zone, chilli pepper and tomato crops are the horticultural species of greatest economic and social importance (Garza and Rivas, 2003). The pests that cause the greatest damage are whitefly (*Bemisia tabaci*, Gennadius 1889) and (*B. argentifolii*, Bellows and Perring, 1994), jumping aphid, (*Bactericera cockerelli*, Sulc 1909), green aphid, (*Myzus persicae*, Sulzer, 1776), leaf miner, (*Liriomyza* spp., Mik, 1894), pepper weevil, (*Anthonomus eugenii*, Cano), red spider, (*Tetranychus urticae*, Koch). Also, fruit worm, (*Helicoverpa zea*, Boddie, 1850) and (*Heliothis virescens*, Fabricius, 1777), pinworm, (*Keiferia lycopersicella*, Walsingham, 1897), armyworm, (*Spodoptera exigua*, Hübner, 1808), hornworm, (*Manduca sexta*, Linnaeus, 1763), (*M. quinquemaculata*, Haworth, 1803) and cabagge looper (*Trichoplusia nii*, Hübner, 1800-1803) and (*Pseudoplusia includens*, Walker, 1858) (Garza, 2002; Garza and Rivas, 2003; Garza *et al* 2007). Together, these pests have caused capital losses to chilli and tomato producers (Barrón, 2019).

From 2002 to 2007, an IPM strategy was developed in chilli and tomato crops (Garza, 2002; Garza and Rivas, 2003; Garza *et al.,* 2007. In chilli, the whitefly is a transmitter of geminivirus (Pérez and Rico, 2004), these types of viruses cause atrophy in flowering and deformation of leaves and fruits (Rivas, 1994), as well as blisterings, dwarfism, mosaics, mottling, necrosis, chlorosis and shortening of the vegetative cycle (Murphy and Warren, 2003). For the management of whitefly and control of viruses, the solution was the application of Imidacloprid insecticide, already 20 years of use. In the particular case of the Middle Zone of San Luis Potosí, the problem is the re-emergence of viral diseases in the cultivation of chilli, due to the resistance developed by the whitefly to this insecticide, (Barrón and Garza 2019).

At present, there are new generation insecticide products, such as Flupyradifurone. It is of low toxicity for most beneficial insects, especially for pollinators, and for human health. It satisfies current requirements of modern insecticides needed for integrated pest management programs (Nauen *et al*., 2015); as well as organic products with the ability to control the populations of this vector insect, such as entompatogenic fungi (Abdel-Razek *et al*., 2017; Stansly and Natwick, 2009) and thus reduce the percentage of plants with viruses. The objective of this work is to identify new strategies to control the whitefly, a vector of viral diseases in chilli.

Whitefly (*Bemisia tabaci*) Biotype B (Hemiptera: Aleyrodidae)

Economic importance. The whitefly is a pest that in recent years has increased its incidence in chilli cultivation in Mexico. There are several causes, one of them is direct damage, since by sucking the sap from the plants it weakens them and can cause the death of it, especially in fields where they occur high populations of this insect. The greatest damage is related to the transmission of viral diseases (geminivirus), for which it is necessary to reduce the presence of high fly populations (Garzón *et al.,* 2002).

Morphological Description. Eggs**:** eggs are elliptical and elongated, with the upper pole more acute than the lower one, and they carry a short pedicel in this part. They are pale green in color when they have been laid and later acquire a dark brown color. Nymph**:** nymphs are oval in shape, pale yellow or greenish-yellow in color, go through four instars, the first has legs and is the only mobile, the others are oval and legless; In dorsal view the body is wider in the anterior part. After the nymph has begun feeding, it goes through two nymphal instars, which resemble "scales ". At the end of the third instar, it goes into a period of inactivity and latency called “pupa”, during which it does not feed until it reaches the adult stage. Adult: adult whiteflies are 1 to 2 mm long and have two pairs of white wings and a yellowish body. Its body is covered with a waxy powder produced by glands that are distributed throughout the body. Adults can be found in all parts of the plant and spend most of their time feeding, mating, and laying eggs on the underside of leaves. These insects are found on the underside of leaves and when disturbed they fly quickly (Garza and Rivas, 2003).

Biology, Habits and Damages. The greatest damage from this pest is related to the transmission of viral diseases, which affect the yield and quality of crops, with damages that vary from 20 to 100%. Garzón *et al.,* 2002, determined the presence, distribution and alternate hosts of the Huasteco Virus of chilli (PHV) and the Texan Virus of chilli variant Tamaulipas (TPV-T) in Guanajuato, San Luis Potosí and Jalisco states. PHV was the geminivirus with the highest frequency in the samples analyzed with 70% positive reactions, 19% of TPV-T, and 11% of the mixture of both geminiviruses.

MATERIAL AND METHODS

The study was carried out in Rioverde, San Luis Potosí, in a plot of a producer, established on August 28, 2019 and cultivated with Serrano chilli variety Plata, in "second crops" (from August to November 2019), with plastic mulch and drip fertigation. The experiment consisted of seven treatments and four repetitions (Table 1).

Table 1. Chemical and organic products, applied in serrano chilli pepper twice a week to control whitefly, vector of viral diseases. Rioverde, San Luis Potosí, 2019.

Products
1. Imidacloprid 87.5 g of i.a./ha (0.25 L/ha)
2. Flupyradifurone 150 g of i.a./ha (0.75 L/ha)
3. Super Magro + Sulfocalcic Broth 5 L of each/ha
4. Super Magro + Sulfocalcic Broth 10 L of each/ha
5. Super Magro + Sulfocalcic Broth 15 L of each/ha
6. Super Magro + Sulfocalcic Broth 10 L of each/ha Flupyradifurone 150 g of i.a./ha (0.75 L/ha)
7. Flupyradifurone 150 g of i.a./ha (0.75 L/ha)/Super Magro + Sulfocalcic Broth 10 L of each/ha

Note: Treatments 1 - 5 the application was made from September to October.
Treatments 6 - 7, each product was applied one month (September - October).
i.a. = active ingredient

The Experimental Plot (EP) consisted of five beds of 1.4 m wide and 10 m in length, the useful plot (UP) consisted of three central beds of 8 m in length, and in them the plants with virosis and yield were counted. Fifteen applications were made, seven in September and eight in October.

Variables evaluated

1. **Whitefly population fluctuation.** At 23, 35, 44 and 51 days after transplantation (DAT), shortly before noon, samples were taken with a viewer to determine the population fluctuation. The number of whiteflies present in five plants per useful plot was counted, the viewer is a wooden cube without a base to introduce the plant, black inside with glass on the upper part to attract the whitefly adults to the light, (Ávila and Hinojosa, 2000).
2. **Number of plants with the presence of viruses.** At 44 and 57 DAT, plants with the presence of viruses were counted. Plants with viruses were taken into account as those that showed symptoms such as leaf deformation, blisterings, mottling, chlorosis and necrosis , (Barrón *et al.*, 2020).
3. **Number of plants with severe virus damage.** At 44 and 57 DAT, plants with severe virus damage were counted. It was taken into account that the plants showed symptoms such as dwarfism, atrophy in flowering and deformation of fruits, (Barrón *et al.*, 2020).

4. **Yield.** The production of serrano pepper obtained in a first cut of the three central beds of 1.4 meters wide by eight meters long, (Barrón *et al.*, 2020).

Experimental design and statistical analysis

The experimental design used was Random Blocks, with seven treatments and four repetitions, data were analyzed with the statistical package SAS version 9.3, with the data an analysis of variance was performed, when significant differences were found, the Tukey test was applied with a value of (P≤0.05) to differentiate treatments.

RESULTS

The experiment began with a deep intra-festival drought, with high temperatures and low rainfall (Table 2), later there was a reduction in temperature and an increase in rainfall. In the four sampling dates, the whitefly populations were always lower in the treatments 2) Flupyradifurone 150 g i.a/ha (0.75 L/ha) September and October and 7) Flupyradifurone 150 g of active ingredient / ha (0.75 L/ha) / Super Magro + Sulfocalcic Broth 10 L of each /ha (Table 3).

Table 2. Maximum, minimum and monthly average temperatures and precipitation in millimeters in the months of August, September and October 2019. Rioverde, San Luis Potosí, 2019.

2019											
MAXIMUM T °C			**MINIMUM T °C**			**MEAN T °C**			**PRECIPITATION mm**		
AGO	SEP	OCT	AGO	SEP	OCT	AGO	SEP	OCT	AGO	SEP	OCT
37	33	31	20	19	18	28.5	26.0	24.5	52.7	76.5	125.6

The statistical analysis of the number of whitefly adults in five serrano pepper plants, average of four sampling dates, showed statistical differences between the treatments (P=0.0087). The treatment with the smallest whitefly populations was Flupyradifurone 150 g of i.a/ha (0.75 L/ha) September and October (2.4 B) and Flupyradifurone 150 g of active ingredient/ha (0.75 L/ha)/Super Magro + Sulfocalcic Broth 10 L of each/ha (2.3 B). They are statistically similar to each other, but different from the rest of treatments (Table 3). Saint-Preux, 2015, working with *Myzus persicae* aphids in sweet pepper, reports Sulfoxaflor and Flupyradifurone as the products with the lowest survival of adults and nymphs after their application.

Table 3. Number of whitefly adults in chilli serrano, during four sampling dates and their average, in seven treatments with different chemical and organic products. Rioverde, San Luis Potosí, 2019.

Chemical and organic products and their dosage	Sampling dates and whiteflies in five chilli plants				Average of whiteflies
	20 sept.	02 oct.	11 oct.	18 oct.	
1. Imidacloprid 87.5 g of i.a/ha (0.25 L/ha)	3.3	7.8	3.8	3.3	**4.5 AB**
2. Flupyradifurone 150 g of i.a/ha (0.75 L/ha)	4.3	2.8	1.3	1.5	**2.4 B**
3. Super Magro + Sulfocalcic broth 5 L of each/ha	7.5	10.0	4.8	3.0	**6.3 A**
4. Super Magro + Sulfocalcic broth 10 L of each/ha	6.0	7.0	3.0	4.5	**5.1 AB**
5. Super Magro + Sulfocalcic broth 15 L of each/ha	5.5	6.0	4.5	4.0	**5.0 AB**
6. Super Magro + Sulfocalcic broth 10 L of each/ha/Flupyradifurone 150 g de i.a/ha (0.75 L/ha)	5.8	8.3	1.5	2.8	**4.6 AB**
7. Flupyradifurone 150 g de i.a/ha (0.75 L/ha)/Super Magro + Sulfocalcic broth 10 L of each/ha	2.0	2.3	1.8	3.0	**2.3 B**

Means with the same literal are not significantly different at 0.05% probability.
*(Average of 4 sampling dates: 23, 35, 44 and 51 DAT).
Note: Treatments 1 - 5 the application was made from September to October.
Treatments 6 - 7, each product was applied one month (September - October).
i.a. = active ingredient

Plants with virus symptoms

At 44 and 57 DAT the variable, % of chilli plants with virus symptoms reported statistical differences between the treatments (P <0.0001 and P = 0.0144, respectively; Table 4).

Forty-four DAT from the chilli crop, with 10 applications of the products evaluated the percentage of plants with symptoms of virus disease ranged from 3.7 to 23.4% (Table 4). The treatments least affected by viruses were Flupyradifurone 150 g of i.a/ha (0.75 L/ha) September and October (3.7% C), Flupyradifurone 150 g of active ingredient/ha (0.75 L/ha)/Super Magro + Sulfocalcic Broth 10 L of each/ha (4.0% C) and Super Magro + Sulfocalcic Broth 10 L of each/ha/Flupyradifurone 150 g of active ingredient/ha (0.75 L /ha) (6.8% C). Statistically is the same and different from the rest of the treatments (P ≤ 0.05).

57 days after the transplantation of the chilli crop, having elapsed 13 days after the first sampling, and having already completed 13 applications. The percentage of plants with virus symptoms increased and had a variation from 8.5 to 45.7% (Table 4), being less affected the treatment where Flupyradifurone 150 g ia/ha (0.75 L/ha) was applied.

September and October (8.5% B) and Flupyradifurone 150 g of active ingredient / ha (0.75 L / ha)/Super Magro + Sulfocalcic Broth 10 L of each/ha (15.9% C) were statistically the same and different from the rest of the treatments (P ≤ 0.05).

Table 4. Percentage of chilli plants with virus symptoms 44 and 57 days post-transplant, in treatments with different chemical and organic products. Rioverde, San Luis Potosí, 2019.

Chemical and organic products and their dosage	% of chilli plants with virus symptoms	
	(44 DAT)	**(57 DAT)**
1. Imidacloprid 87.5 g of i.a/ha (0.25 L/ha)	12.8 BC	28.6 AB
2. Flupyradifurone 150 g of i.a/ha (0.75 L/ha)	3.7 C	8.5 B
3. Super Magro + Sulfocalcic Broth 5 L of each/ha	11.3 BC	29.1 AB
4. Super Magro + Sulfocalcic Broth 10 L of each/ha	23.4 A	45.7 A
5. Super Magro + Sulfocalcic Broth 15 L of each/ha	21.0 AB	33.9 AB
6. Super Magro + Sulfocalcic Broth 10 L of each/ha/ Flupyradifurone 150 g of i.a/ha (0.75 L/ha)	6.8 C	25.8 AB
7. Flupyradifurone 150 g of i.a/ha (0.75 L/ha)/Super Magro + Sulfocalcic Broth 10 L of each/ha	4.0 C	15.9 B

Means with the same literal are not significantly different at 0.05% probability.
Note: Treatments 1 - 5 the application was made from September to October.
Treatments 6 - 7, each product was applied one month (September - October).
i.a. = active ingredient

Plants with severe virus damage

At 44 and 57 DAT, the variable, % of chilli plants with severe virus damage, reported statistical differences between the treatments (P = 0.0070 and P = 0.0167, respectively; Table 5).

At 44 DAT of the chilli crop and 10 applications of the evaluated products, the percentage of plants with severe virus damage changed from 0.2 to 2.9% (Table 5). The least affected treatments were where Flupyradifurone 150 g i.a/ha (0.75 L/ha) September and October (0.2% B) and Flupyradifurone 150 g of active ingredient/ha (0.75 L/ha)/Super Magro+ Sulfocalcic Broth 10 L of each/ha (0.2% B), statistically the same and different from the rest of the treatments (p ≤ 0.05).

At 57 DAT of the chilli crop, having elapsed 13 days after the first sampling and completing 13 applications, the percentage of plants with severe virus damage varied from 0.7 to 9.6% (Table 5), the treatment with Flupyradifurone being less affected 150 g ai/ha (0.75 L/ha) September and October (0.7% B) and Flupyradifurone 150 g of active ingredient/ha (0.75 L/ ha) / Super Magro + Sulfocalcic Broth 10 L of each / ha (1.0% B), statistically the same and different from the rest of the treatments (P ≤ 0.05).

Table 5. Percentage of chilli plants with severe virus damage 44 and 57 days post-transplant, in treatments with different chemical and organic products. Rioverde, San Luis Potosí, 2019.

	Chemical and organic products and their dosage	% of chilli plants with severe virus damage	
		(44 DAT)	**(57 DAT)**
1.	Imidacloprid 87.5 g of i.a/ha (0.25 L/ha)	2.9 A	5.7 AB
2.	Flupyradifurone 150 g of i.a/ha (0.75 L/ha)	0.2 B	0.7 B
3.	Super Magro + Sulfocalcic Broth 5 L of each/ha	2.8 A	4.2 AB
4.	Súper Magro + Sulfocalcic Broth 5 L of each/ha	1.8 AB	6.0 AB
5.	Súper Magro + Sulfocalcic Broth 5 L of each/ha	1.8 AB	9.6 A
6.	Súper Magro + Sulfocalcic Broth 5 L of each/ha/ Flupyradifurone 150 g of i.a/ha (0.75 L/ha)	1.0 AB	3.1 AB
7.	Flupyradifurone 150 g of i.a/ha (0.75 L/ha) / Super Magro + Sulfocalcic Broth 5 L of each/ha	0.2 B	1.0 B

Means with the same literal are not significantly different at 0.05% probability.
Note: Treatments 1 - 5 the application was made from September to October.
Treatments 6 - 7, each product was applied one month (September - October).
i.a. = active ingredient

Rodríguez and Terán (2017), based on studies of the agrochemical effectiveness in sorghum, recommend the use of the insecticide Flupyradifurone to combat sucking insects such as the yellow sorghum aphid (*Melanaphis saccharih*) in agricultural areas where Imidacloprid has been used massively, thus increasing the options for chemical control. It reduces the risk of pest developing resistance when using products from different chemical groups. Rodríguez *et al*. (2012), in laboratory tests with whiteflies collected in the field, found high resistance to Methamidophos and some cases of intermediate resistance to Cypermethrin, Imidacloprid and Thioxyclam hydrogen oxalate in whitefly adults; likewise in localities with exaggerated use of insecticides; found levels of intermediate resistance to Imidacloprid, Buprofezin and Diafentiuron.

Table 6 shows that at 87 days after transplantation and after 15 applications, statistical differences were observed between the treatments (P = 0.0172). The treatment where Flupyradifurone 150 g i.a/ha (0.75 L/ha) September and October had a production of 18.4 tons of serrano chilli pepper per hectare (A) statistically different from the rest of the treatments. In the rest (1, 3, 4, 6 and 7) there were no differences statistically significant among them (P≥ 0.05), the treatment with the application of Super Magro + 15 L Sulfocalcic Broth of each/ha September and October 5) was also different, but with the lowest chilli production per hectare (10.9 B).

Table 6. Tons of chilli pepper per hectare in the first cut 87 days after transplantation, in treatments with different chemical and organic products. Rioverde, San Luis Potosí, 2019.

Chemical and organic products and their dosage, sprinkled twice a week on serrano chilli plants established on August 28, 2019	Tons of chilli per hectare in a single cut
1. Imidacloprid 87.5 g of i.a/ha (0.25 L/ha)	14.3 AB
2. Flupyradifurone 150 g of i.a/ha (0.75 L/ha)	18.4 A
3. Super Magro + Sulfocalcic Broth 5 L of each/ha	14.3 AB
4. Super Magro + Sulfocalcic Broth 10 L of each/ha	14.5 AB
5. Super Magro + Sulfocalcic Broth 15 L of each/ha	10.9 B
6. Super Magro + Sulfocalcic Broth 10 L of each/ha/Flupyradifurone 150 g of i.a /ha (0.75 L/ha)	16.1 AB
7. Flupyradifurone 150 g of i.a. /ha (0.75 L/ha) / Super Magro + Sulfocalcic Broth 10 L of each/ha	15.2 AB

Means with the same literal are not significantly different at 0.05% probability.
Note: Treatments 1 - 5 the application was made from September to October.
Treatments 6 - 7, each product was applied one month (September - October).
i.a. = active ingredient

DISCUSSION

The treatment of Flupyradifurone 150 g i.a/ha (0.75 L/ha) September and October is effective to reduce the presence of virosis in chilli plants, as well as whitefly populations. The technical data sheet for this product indicates that its action is translaminar and systemic via xylem (Nauen *et al*., 2015). The active ingredient is deposited on the leaves and stems with spray application. After absorption in the plant, it passes acropetically (upward) into the xylem, following the flow of transpiration, and is translaminarly distributed to the adjacent cells of the plant (Nauen *et al*., 2015). Due to this translaminar movement, it is successful against insects that feed on the underside of the leaf, even when applied only to the upper part of the leaf. The long-lasting effect of the product results in a disorder of the insect's nervous system, by affecting the nicotinic receptors of acetylcholine (Nauen *et al*., 2015), causing its collapse. Flupyradifurone is an effective option to achieve high yields and minimize damage from sucking insects, Rodríguez and Terán (2017) and the useful life of this product can be prolonged, avoiding insect resistance if it is alternated with organic products.

Under the proposal of resorting to strategies that minimize the adverse impact of spraying on agricultural ecosystems, the Flupyradifurone 150 g i.a/ha (0.75 L/ha) September/Super Magro + Mineralized Sulfocalcic Broth 10 L of each/ha October treatment emerged as a control alternative for whiteflies. These intercropped products maintain a smaller population of whitefly adults and a low percentage of virus-bearing plants. The Flupyradifurone sequence/ Super Macro + Mineralized Sulfocalcic Broth mixture reduces insecticide applications by 50% and reduces the presence of whitefly populations that are capable of severely infecting chilli plants. It is another management option that it allows reducing the amount of insecticide applied, as reported for the management of *B. tabaci* in cotton by combining the insecticides profenophos, imidacloprid or cyhalothrin with acetyl salicylic acid (El *et al*., 2019). With the Super Magro treatment + Mineralized Sulfocalcic Broth 10 L of each/ha in September and October, an acceptable chilli production per hectare is achieved.

The Super Magro + Mineralized Sulfocalcic Broth mixture is synergistic for cultivation for the following reasons: Super Magro is an organic fertilizer (fermented anaerobically), with a lot of balanced energy and mineral harmony. It nourishes, recovers and reactivates the soil life, increases plant nutrition and stimulates crop protection against pest attack, activates plant defenses through organic acids, growth hormones, antibiotics, vitamins, minerals, enzymes, coenzymes, carbohydrates, amino acids and sugars. The mineralized Sulfocalcic Broth is prepared based on sulfur + lime, enriched with minerals. When sulfur and lime are boiled, it reacts to form calcium polysulfide, which enriches and increases the solubility of elements retained in the soil and as an insecticide. It controls the whitefly, killing it by asphyxia and by its abrasive action. It is also mentioned that it has a welding effect on the chain of free amino acids and sugars (Restrepo, 1996). The mixture of the two previous products is aimed at altering one or more of the primary participants in the virus transmission process by whitefly (the vector insect, the host plant that is the source of the virus and/or the culture) (Horowitz *et al*., 2011).

Plant defense activation against the attack of pests, using the Super Magro and mineralized Sulfocalcic Broth, in the crop, despite having damage by whitefly. The plants are capable of achieving high productions per hectare, a situation that coincides with that documented by Jarquín *et al.* (2013), in addition to being one of the current challenges in whitefly management: maintaining crop productivity and minimizing the impact on the environment and biodiversity (Stansly and Natwick, 2009). According to Restrepo, (2007), plants with insect damage, when organic products are applied, are capable of achieving high productions per hectare.

It should be noted that, in this work, the regional insecticide Imidacloprid always presented a high percentage of plants with viruses despite the high number of applications.
The applications to be carried out in the months of September and October with Imidacloprid can be changed for applications of organic products, which will allow a detoxification of the productive environment of the producing regions of chilli.

This strategy can be applicable in all chilli regions that have whitefly problems. It is necessary to attend to the recommendations that its label recommends for each insecticide. It is very common to make two or three applications during the control period;

more applications can cause resistance problems, however, this can be variable for each region according to the history of use of the same insecticide.

CONCLUSIONS

- With sprinkling twice a week in September and October, the yield of serrano chilli pepper in a first cut goes from highest to lowest in treatments with:
    a. Flupyradifurone 150 g of i.a/ha (0.75 L/ha) September and October
    b. Flupyradifurone 150 g of i.a/ha (0.75 L/ha) September/ Super Magro+ Sulfocalcic Broth 10 L of each/ha October
    c. Super Magro + Sulfocalcic Broth 10 L each/h in September and October
    d. Imidacloprid 87.5 g of i.a/ha (0.25 L/ha) September and October
- Flupyradifurone is an effective option to achieve high yields and minimize whitefly damage and the useful life of this product can be prolonged, avoiding resistance from insects if it is alternated with organic products.
- The Flupyradifurone sequence / mixture of Super Magro + Mineralized Sulfocalcic Broth reduces insecticide applications by 50 % and reduces the presence of whitefly populations that are capable of severely infecting chilli plants.
- Despite having plants with whitefly damage, when organic products are applied, they are capable of achieving high productions per hectare.
- Imidacloprid can be substituted by Flupyradifurone or by the mixture of Super Magro + mineralized Sulfocalcic Broth.
- The 15 applications made in the months of September (7) and October (8), with Imidacloprid, can be changed to 15 organic applications, which would allow a detoxification of the productive environment of the producing regions of chilli pepper.

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