Control of Mites and Thrips and its Impact on the Yield of Avocado cv. "Hass" in Filo de Caballos, Guerrero, Mexico

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Abstract— *For social and economic reasons Avocado is an important crop; however, some arthropods, of which mites are especially important, can limit its production, as is the case in the state of Guerrero. In order to determine which treatment is the best for controlling these pests, an experiment was carried out in Filo de Caballos, Guerrero, where five treatments were applied, together with an absolute control. Sampling was continuous, and the mites found in each treatment were counted. The treatment was applied when the economic threshold of 10 mites/leaf/tree was reached. The best treatments for controlling mites were T1 (abamectin and azadirachtin), and T3 (abamectin and imidacloprid), with 8 and 10 applications each. The population of thrips never reached the economic threshold; their densities were low throughout the experiment. Treatments 4, 1, 3, 2, and 5 had higher weights and they were classified into the "Extra" caliber. The fruits with the greatest length were those from treatments 4, 1, 3, 2 and 5, ordered decreasingly according to their size. Regarding fruit quality, the differences were not well marked among the treatments. The choice of control to be used is left to the farmers; however, it is necessary to remember that there are alternatives to the control of mites and thrips that help to increase caliber, size, and fruit quality.*

Keywords— Avocado, Oligonychus punicae, Oligonychus perseae.

I. INTRODUCTION

The avocado (*Persea americana* Mill.) cv. "Hass" is the most widely grown cultivar in the world, and Mexico is its most important producer [1]. In Mexico, the state of Michoacán is the main producer, and the state of Guerrero is in sixth place according to its production. The total cultivated surface in 2012 in Mexico was 141,408 ha, of which 127,668 ha were harvested and had a production of 1,265,669 t, with a yield of 9.91 t•ha-1 [2].

The world production of avocado increased by 550,000 t in the last 15 years. It has a large market because it can be consumed fresh and in its processed forms, such as guacamole, frozen pulp, and paste [3].

Avocado production is an important source of jobs and me in the state, because its cultivated surface has increased in the last few years; however, its trade is affected by the attack of pests. The damages are manifested as yield losses and low fruit quality [4].

In 2009 CESAVEGRO identified two quarantine pests for avocadosin the state of Guerrero: the large avocado seed borer (*Heilipus lauri* Boheman), and the stem borer (*Copturus aguacatae* Kissinger); in the locality of Filo de Caballos; however, these pests have not been identified as a potential threat. The pests that are considered important due to the damage they cause are thrips, the spider mite (*Oligonychus punicae* Hirst), and the persea mite (*Oligonychus perseae* Tuttle, Baker and Abbatiello) [5].

High population densities of mites on avocado trees produce partial or total defoliation, which increases the risk of sunburn in young fruits, and also fruit abortion, which reduces yield [6], [7], [8]. Due to this situation, the objectives of this work were to evaluate several products to control thrips, spider mites and persea mites; and to increase yield and fruit quality.

II. MATERIAL AND METHOD

The research was carried out in Puerto General Nicolás Bravo (Filo de Caballos), in the municipality of Leonardo Bravo, state of Guerrero, in the orchard "Alarcón". The orchard is located at 17°38'56.52'' N and 99°50'21.54'' W, and at 2252 meters above sea level. The work started in October, 2011, and ended in September, 2012. The orchard is nine years old, the trees are on average 6 m high and the distance between trees and rows is 7 m, and the total population is 200 trees in 1.5 ha. The slope in the orchard is approximately 35%. The climate of the region is the most humid of the temperate sub-humid climates, with rains during the summer; rain precipitation ranges from 1100 to 1500 mm, and the average annual temperature varies from 17 to 21 °C [9].

2.1 Treatments

Acaricides and insecticides were used alternatingly; this strategy was used with the objective of delaying or diminishing the resistance that could arise from the use of these chemical molecules used in the control of these pests, and also to search for alternative products that are environmentally friendly [10].

Five treatments were designed, including the traditional control and an absolute control. The treatments were separated from each other by two trees to avoid contamination between or among treatments. The treatments and their corresponding doses of mL of pesticide/liter of water for mite control appear in Table 1.

TABLE 1
DOSES OF PESTICIDES PER LITER OF WATER

Treatment	Dose
T1	Abamectin (1 mL), next, azadiractin (1.5 mL)
T2	Sulfur (1.6 mL), next, imidacloprid (1 mL)
T3	Abamectin (1 mL), next, imidacloprid (1 mL)
T4	Azadiractin (1.5 mL), next, imidacloprid (1 mL)
T5	Sulfur (1.6 mL) and malathion (1.5 mL) (traditional control)
T6	Absolute Control

The products were applied all over the tree, and in the upper side and under side of the leaves, due to the fact that *O. punicae* is found on the upper side of the leaves, and *O. perseae* on the underside [11].

2.2 Experimental design

The treatments were distributed in a two-factor completely randomized blocks design. Four blocks were considered according to the slope of the orchard, which varies from 35% to 40%. One of the factors of the study was the date of the measurement, which was carried out 26 times, from date 1 to date 26; the other factor was the pesticide with six levels, which are described in Table 1. Since there were four blocks and six levels in the factor pesticide where each tree was an experimental unit, the experiment was carried out on a total of 24 trees. Each level of the factor pesticide was separated by at least two trees to prevent contamination between and among treatments. To distinguish the treatments, the selected trees were marked with colored bands depending on the treatment assigned in the random distribution.

2.3 Data collection

Treatments were applied based on the economic thresholds of the evaluated arthropods, so general sampling was carried out every 15 days to evaluate treatment effectiveness. It is important to mention that at the beginning of the experiment all treatments were applied the same day and afterwards, samplings were carried out considering the economic thresholds, which according to Coria [12] are the following:

- For thrips, the economic threshold is 4 - 5 thrips/flower raceme or vegetative shoot
- For mites, the economic threshold is 10 mites/leaf

In the case of mites, sampling consisted in taking ten leaves: two from each cardinal point and two from the canopy of each tree. These leaves were placed in previously labeled paper bags and taken to the laboratory of physiology and nutrition of the Maestría Ciencias Agropecuarias y Gestión Local of UAGro, where the number of mites was examined; checking and counting was made on both sides of the leaves due to the location of each mite pest. Counting was carried out with the help of a microscope (stereoscopic of 10x) and a counter. To sample thrips the economic threshold is 4 – 5 thrips/vegetative shoot of flower raceme, so for each tree four equidistant points were selected around the equatorial band of the canopy, where a vegetative shoot and/or flower raceme was taken per point. The shoots were sprayed with a solution (9:1 v/v) of water-fabric softener, with a 1000mL sprayer. A plastic tray was placed under the vegetative shoots or flower shoots, where the solution with the soaked insects were collected, and the thrips were transferred to labeled jars with 70% alcohol with the aid of a camel hair brush (number 00). The jars were taken to the laboratory to quantify and observe the developmental stage of the thrips.

The analyzed variables were: number of living nymphs and adults for the collected and evaluated arthropods, for each treatment used. To evaluate harvest, the variables were caliber (in the sense of fruit weight) and fruit size. Federal order NMX-FF-008-1982 establishes the following commercialization calibers: “Súper extra”: above 266g, “Extra”; 211g-265g, “First”: 171g-210g, “Medium”: 136g-170g, “Commercial”: 85g-135g, and “Marble mites, hailstones and brushes. Damages known as smallpox, chicken pox or nail, burns caused by the sun or low temperatures. Free of mechanical damage and larvae.

- Quality I. Accepts 10% damaged fruits, with defects no bigger than 6cm^2. Slight defects caused by virus, mites, and thrips are accepted only if the pulp is not damaged. Free from mechanical damage and larvae.
- Quality II. Must be uniform in maturation stage, coloration and size. Up to 50% of the fruit with superficial defects is accepted. Sunburns not bigger than 30%.

To analyze the variable of harvest, 10 fruits per tree, per treatment, were randomly selecte

2.4 Statistical Analysis

Data were analyzed using analysis of variance and comparison of means, using the Tukey test with α=0.05, in a two-factor completely random blocks design, with the aid of the library Agricolae of the statistical software R version 2.15.

III. RESULTS AND DISCUSSION

According to the results from the statistical analysis, there was always an effect of the treatments (pesticide) (F=15.8645, p=1.937e-14), date (F=13.5092, p < 2.2e-16), and their interactions (F=5.0752, p < 2.2e-16) in the number of evaluated arthropods.

When considering the economic thresholds for the spraying of the treatments, these sprayings varied throughout the production cycle of the avocado, as indicated in Table 2. Mites reached the threshold more quickly and they were the indicators for spraying in all the treatments. Treatment T3 (abamectin/imidacloprid) had a statistically better efficiency to control the spider mite, but not the persea mite or thrips. However, treatments T1 (abamectin/azadirachtin) and T4 (azadirachtin/imidacloprid) had fewer sprayings, with 8 and 9 respectively (Table 2).

TABLE 2
SPRAYING OF PESTICIDES BASED ON THE ECONOMIC THRESHOLD FOR MITES IN AVOCADO CROPS, AND AVERAGE OF LIVING MITES AND THRIPS COUNTED PER LEAF OF AVOCADO “HASS” IN FILO DE CABALLOS, GRO. PRODUCTION CYCLE 2011-2012.

Treatments	Pesticides	Number of sprayings	Number of living *Oligonychuspunicae* nymphs and adults /leaf/tree	Number of living *O.perseae* nymphs and adults /leaf/tree	Number of living *Trips sp.* nymphs and adults /vegetative shoot or flower raceme/tree
T1	Abamectin/Azadiractin	8	7.49 bc	4.80 b	2.38bc
T2	Sulfur/Imidacloprid	16	10.21 bc	7.68 a	2.63b
T3	Abamectin/Imidacloprid	10	5.91 c	4.92 b	2.42bc
T4	Azadiractin/Imidacloprid	9	7.98 bc	5.37 b	2.23c
T5	Sulfur/Malathion	15	11.32 b	5.71 b	2.45bc
T6	Absolute control	0	19.40 a	9.47 a	4.04a

The mite that most quickly reached its threshold was the spider mite in most treatments (Figure 1 and 2).

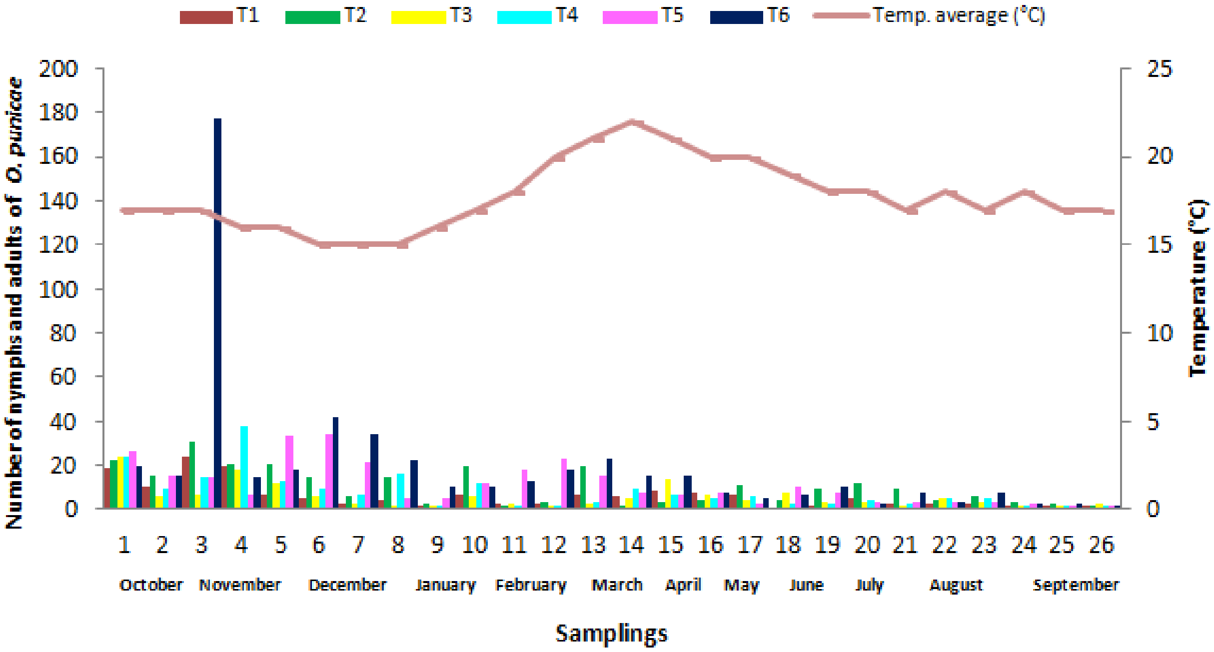

FIGURE 1.AVERAGE OF NYMPHS AND ADULTS OF THE SPIDER MITE (*OLIGONYCHUS PUNICAE* HIRST) COUNTED PER AVOCADO LEAF CV. "HASS" IN FILO DE CABALLOS, GRO. PRODUCTION CYCLE 2011-2012.

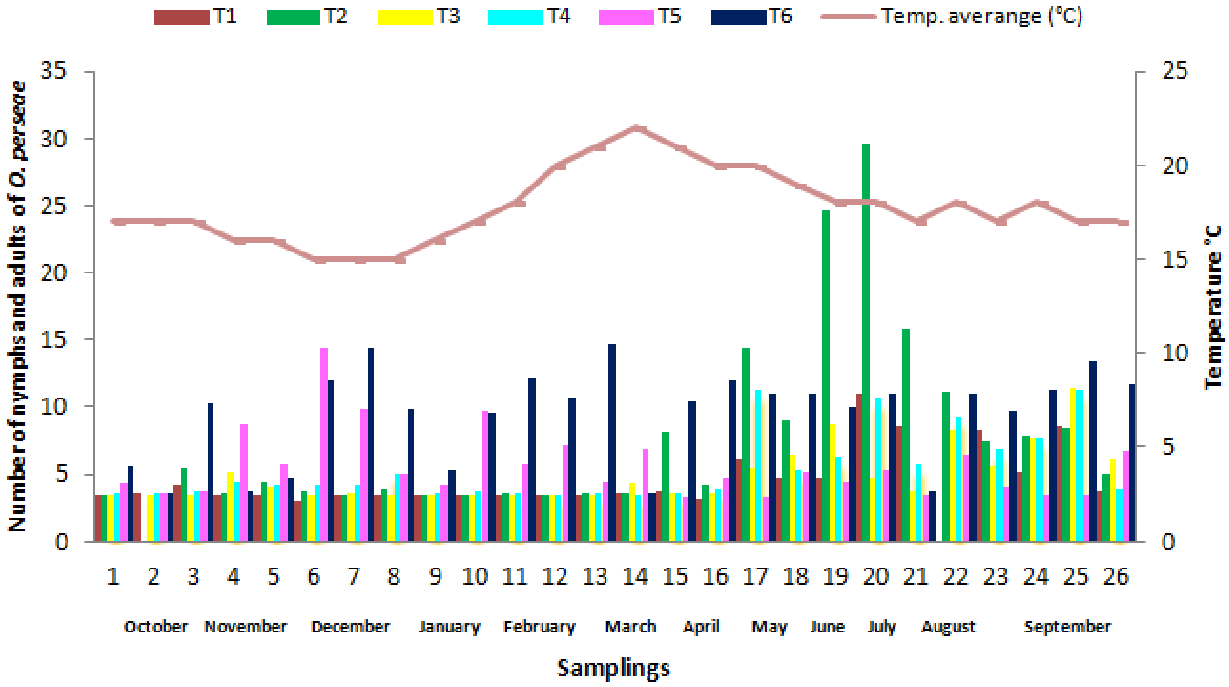

FIGURE 2.AVERAGE OF NYMPHS AND ADULTS OF THE PERSEA MITES (*OLIGONYCHUS PERSEAE* TUTTLE, BAKER AND ABBATIELLO) COUNTED PER AVOCADO LEAF CV. "HASS" IN FILO DE CABALLOS, GRO. PRODUCTION CYCLE 2011-2012.

With respect to the good control that represents treatment T3, Hernández *et al.* [13] mention that a single spraying of abamenctin would be enough to effect an important reduction of *Oligonychus* sp. However, in the case of sulfur, which was also effective in controling*O. perseae*, they carried out a bioassay of different active substances among which sulfur was included, and it showed the highest efficacy, with an 83% mortality.

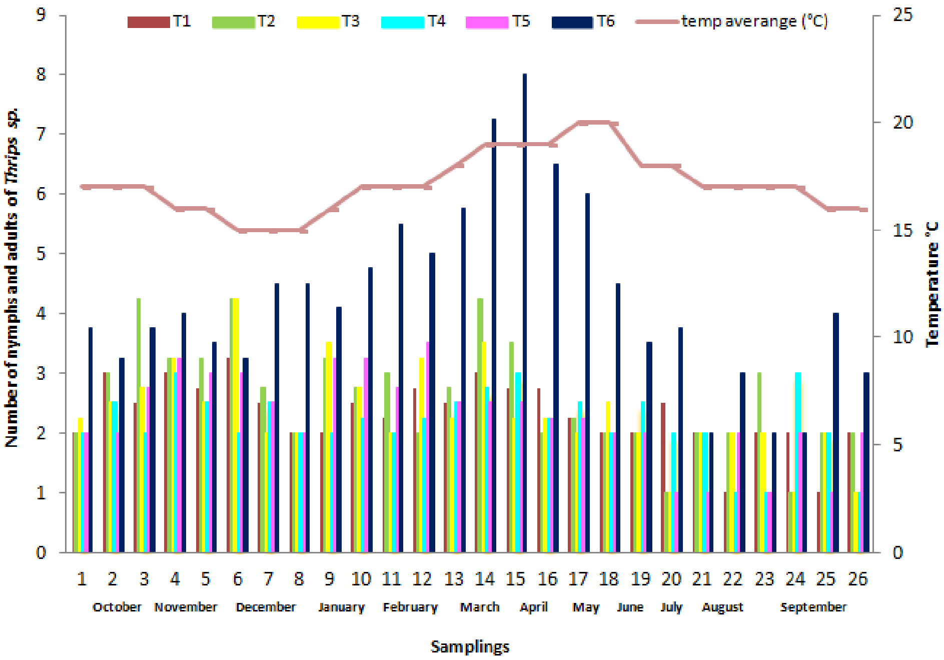

FIGURE 3. AVERAGE OF NYMPHS AND ADULTS OF *THRIPS* SP COUNTED PER AVOCADO LEAF CV. "HASS" IN FILO DE CABALLOS, GRO. PRODUCTION CYCLE 2011-2012.

Regarding thrips control, the population remained within the limits of the economic threshold (4 - 5), with an average of three thrips (Table 2 and Figure 3), and thus there were no statistical differences among the evaluated treatments. However, we can observe that in the control, the highest population occurred in the months from February to May, when the temperature increased. This coincides with Bentanzos *et al*. [14], after concluding his study about the population fluctuation of thrips in avocado Hass, they conclude that seasons with higher temperatures and drought favor the abundance of thrips, which coincides with fruit set. On the other hand, Larral and Ripa[15], after carrying out a study about chemical control of thrips in avocadotrees, found that abamectin and imidacloprid were efficient in controlling the pest, which reached levels of no detection at the end of the evaluation period. Tapia, *et al*. [16], in their work where they evaluated the effect of mineral oil and endosulfan 50, the best results of control were in the treatment where endosulfan 50 was applied.

3.1 Comparison of effect on avocado caliber

According to the caliber classification, treatments T1 (abamectin-azadirachtin), T2 (sulfur-imidacloprid), T3 (abamectin-imidacloprid), and T4 (azadirachtin-imidacloprid) had fruits with weights that belonged to the caliber "Extra" (211g-265g). In decreasing order, the treatments with higher weights were T4, T1, T3, and T2, and there were no statistical differences between them. On the other hand, treatment 6 (absolute control) belonged to the caliber "Primera" (171g-210g) and had the lowest weight, followed by T5; both treatments are statistically different from the rest of the treatments (Figure 4).

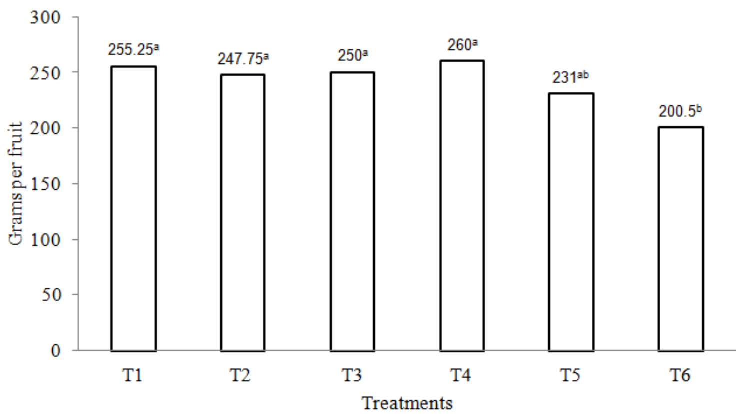

FIGURE 4. CALIBERS OF "HASS" AVOCADO IN FILO DE CABALLOS, GRO. PRODUCTION CYCLE 2011-2012. SAME LETTERS ARE STATISTICALLY IDENTICAL.

3.2 Comparison of means for avocado size

According to the length of the fruits, treatments T2 (sulfur-imidacloprid), T1 (abamectin-azadirachtin), T3 (abamectin-imidacloprid), and T4 (azadirachtin-imidacloprid) were better than the rest of the treatments and they are statistically identical. The treatment with the smallest fruit size was T6 (absolute control), followed by T5 (sulfur) (Figure 5).

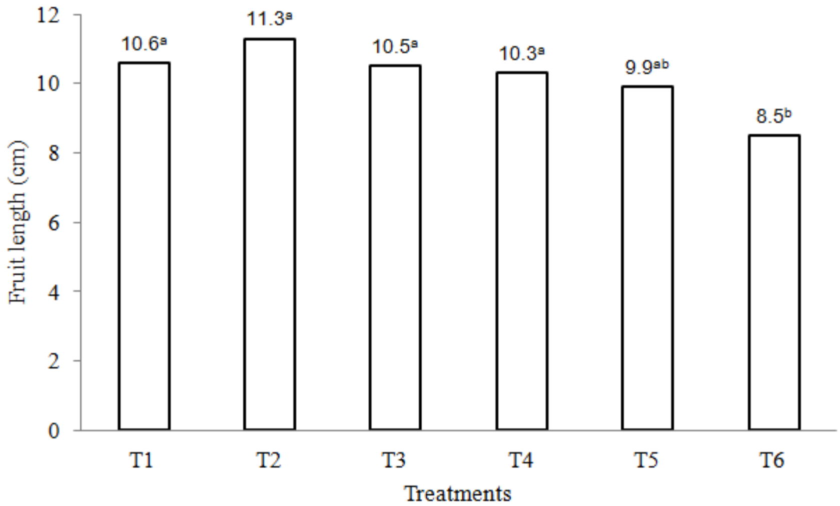

FIGURE 5. SIZE OF AVOCADO "HASS" IN FILO DE CABALLOS, GRO. PRODUCTION CYCLE 2011-2012. SAME LETTERS ARE STATISTICALLY IDENTICAL.

IV. CONCLUSION

Treatment T1 (abamectin-azadirachtin) had a higher reduction of the spider mite and the persea mite with eight sprayings. In this case and under these conditions, it is the best alternative, since besides diminishing mite incidence; it also reduces the labor cost related to spraying.

With respect to thrips, they did not surpass three thrips/tree on average; that was due to the fact that in the product to control mites, there was an insecticide or insecticide/acaricide, and thus the population of thrips was always under control.

Avocados from treatments T4 (azadirachtin-imidacloprid), T1 (abamectin-azadirachtin), T3 (abamectin-imidacloprid), T2 (sulfur-imidacloprid), and T5 (sulfur) were grouped within the caliber "Extra"; this means that the weight can be considered for commercialization. With respect to fruit size in treatment T2 (sulfur-imidacloprid), the biggest fruits measured 11.3 cm, and in treatment 6 (absolute control), the smallest fruits were found (8.5 cm). In the case of both caliber and fruit size, there is a noticeable difference between traditional control (T5) and absolute control (T6) with respect to the rest of the treatments (T1, T2, T3 y T4), since the latter were statistically better in caliber and size.

It is important to mention that the orchard was under the same management conditions during the whole evaluation cycle.

Therefore, there are alternatives for controlling mites and thrips, and they help to increase caliber and fruit size.

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