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Effect of biological and chemical application for the control of the red spot vector in banana (*Musa paradisiaca* L.) crops

Efecto de aplicación biológica y química para el control del vector de la mancha roja en el cultivo de banano (*Musa paradisiaca* L.)

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Abstract

The aim of the research was to evaluate the effect of biological and chemical application for the control of the red spot vector in banana (*Musa paradisiaca* L.). The experimental design was randomized complete blocks (RCB), composed of three treatments, each with 20 experimental units or banana plants. The study was based on two types of red spot control, being chemical control and biologicalcontrol, as well as a referential control. Bowties impregnated with the insecticides were used on the banana bunches. The use of chlorpyrifos was used as chemical control, while for biologicalcontrol a commercial product based on *Metarhizium anisopliae* 1x10^9 strains was applied. The study variables were: number of hands, length of fingers, incidence of red spot, percentage of damage, bunch weight, crop yield and cost benefit analysis. The data were statistically evaluated using the analysis of variance and the comparison of measures was carried out using the Tukey test at 5% probability. The results show that there are no significant differences between the treatments that control the red spot of the

banana fruit, obtaining 796 boxes of bananas from the chemical control and 787 boxes of bananas from the biologicalcontrol, in the same way the profitability was higher $ 2.24 and $ 2,19 respectively.

Palabras claves: Banana, bowties, chlorpyrifos, red spot, *Metarhizium anisopliae*.

Resumen

Se evaluó el efecto de aplicación biológica y química para el control del vector de la mancha roja en el cultivo de banano (*Musa paradisiaca*). El diseño experimental fue BCA, compuesto por tres tratamientos y valorados sobre 20 plantas. El ensayo experimental se conformó por 60 unidades experimentales o plantas de banano. El estudio se basó en dos tipos de control de la mancha roja, siendo control químico y control biológico, además un testigo referencial. Se utilizó corbatines impregnados de los insecticidas sobre los racimos de banano. Como control químico se empleó el uso de clorpirifos, mientras para el control biológico se aplicó un producto comercial a base de cepas *Metarhizium anisopliae* 1x109. Las variables de estudio son: número de manos, longitud de dedos, incidencia de la mancha roja, porcentaje de daños, peso del racimo, rendimiento del cultivo y análisis beneficio costo. Los datos se evaluaron estadísticamente mediante el análisis de varianza y la comparación de medidas se realizó mediante el Test de Tukey al 5% de probabilidad. Este análisis se realizó en el software Infostat. Los resultados muestran que no existe diferencias significativas entre los tratamientos que controlan la mancha roja del fruto de banano, obteniendo 796 cajas de banano el control químico y 787 cajas de banano el control biológico, de igual manera la rentabilidad fue superior $2,24 y $2,19 respectivamente.

Keywords: Banano, corbatines, clorpirifos, mancha roja, *Metarhizium anisopliae*.

1. INTRODUCTION

Banana cultivation in Ecuador is one of the non-oil sectors with the greatest impact on the economy (Reyes y Vargas, 2019)

In Ecuador at the end of 2019, the banana export record was 357.4 million boxes, which exceeds 1.93% of 2018 destined for the European Union, Russia, the United States, the Middle East, East Asia, among others (El Productor, 2020).

The highest percentage of bananas is found on the coast due to the climate in the region. Among the main provinces is Oro with 41%, Guayas with 34% and Los Ríos with 16%. Furthermore, in the Sierra there are places where production adapts to the climate (Medranda, 2019).

The provinces of El Oro and Guayas are the main banana producers as mentioned above, which allocate their production to the United States and the European Union. Furthermore, bananas that do not meet the characteristics to be exported are those that are marketed nationally (Merchán, 2016).

Insect pests and diseases of economic importance, which cause damage to the plant organs such as the root, stem, fruit, affecting the absorption of nutrients, photosynthetic activity and reducing yields and quality of the bunch banana (Rojas, 2013), affect the banana crop.

One of the limiting factors for banana production is the presence of insects such as Thrips, which cause the red spot on the fruit. Among the species that affect the crop are

Chaetanaphothrips signipennis, *C. orchidii* and *C. leeuwenii*, studied in entomological laboratories, taken from field samples in the Province of Guayas (Vera, 2013).

Among the alternatives used in the control of insects and diseases in banana, field work, chemical and biologicalcontrol are mentioned, however, many species show resistance to certain inputs, so the use of different methodologies is considerable (Espinosa, 2015).

"Industries have used chlorpyrifo in the manufacture of polyethylene films for plastic covers and scarves impregnated with insecticide for agricultural use; Studies about these compounds refer to the use of fumigation in banana plantations" (Rendon, 2016, p. 1)

Furthermore, entomopathogenic fungi act as controlling agents of great potential, with a countless number of species. They are used for the total or partial destruction of pest insects or pathogenic fungi, using natural enemies (Motta and Murcia, 2011).

2. MATERIALS AND METHODS

2.1. Location

The present experimental trial was carried out in the Pancho Negro Parish, La Troncal Canton, Cañar Province, Ecuador.

2.2. Materials

For this investigative work, information was extracted from: Books, Theses, Brochures, Magazines, Newspapers, Websites. Among the materials used: Ties, Chlorpyrifos, *Metarhizium anisopliae* $1x10^9$, machetes, stakes, signs with names of treatments and repetition, irrigation pump, fumigate pump, fertilizers, banana covers, measuring equipment, scale, boxes, knife, magnifying glass, computer, notebook, pen, camera.

2.3. Treatments

The study was based on two types of red spot control, chemical control and biologicalcontrol, as well as a reference control. Bowties impregnated with insecticides were used on banana bunches. The use of chlorpyrifos was used as a chemical control, while for biologicalcontrol a commercial product based on *Metarhizium anisopliae* $1x10^9$ strains was applied. The treatments and application days are detailed in Table 1.

Table 1. *Treatments under study*

N	Treatment	Description	Applications (Days)
1	Chemical Control	Bowtie wth clorpirifos	On day 1 of sheathing and day 3 of unsheathing
2	Biological Control	*Metarhizium anisopliae* $1x10^9$	On day 1 of sheathing and day 3 of unsheathing
3	Witness	With out application	With out application

2.4. Experimental design

The experimental design was randomized complete blocks (RCB), composed of the three treatments mentioned in Table 1 and evaluated on 20 plants each one. The comparison of means was performed with the Tukey test at 5% probability.

2.5. Methods and techniques

2.5.1. Plant marking

Twenty banana plants were taken for each treatment, which were considered as experimental units and a sign was placed specifying the name of the treatment and repetition.

2.5.2. Red Spot Control

This work was carried out with the help of the treatments mentioned in Table 1. Through two controls: chemical and biologicalal, as well as a reference control.

2.5.3. Harvest

At the end of the trial, the bunches were harvested and weighed to average. In the banana plantation, the work corresponding to the dismantling was carried out, and they were put in boxes for marketing.

2.5.4. Statistical analysis

The data were statistically evaluated by analysis of variance and the comparison of measurements was carried out using the Tukey Test at 5% probability (Table 2). This analysis was performed in Infostat software version xxx.

Table 2. *Variance analysis scheme*

Sources of variation	Degrees of freedom
Treatments	2
Repetitions	19
Experimental error	38
Total	59

2.6. Variables to evaluate

2.6.1. Number of hands

The number of hands in the bunches after harvest was counted. Data were averaged by treatment.

2.6.2. Finger length

The length of the central fingers of the last hand was measured, from the base of the peduncle to the flower of the finger with the help of a tape measure. At the end the data were averaged by treatments.

2.6.3. Incidence of red spot

The incidence was taken using the arbitrary scale 1 = diseased bunches and 0 = healthy bunches, the data were transformed and averaged by treatments.

2.6.4. Damage percentage

Cluster damage caused by Red Spot Thrips was evaluated using the following scale 1 = 0%, 2 = 1% to 25%, 3 = 26% to 50%, 4 = 51% to 75% and 5 = 76 % to 100%, which was used in each treatment.

2.6.5. Bunch weight

When the bunches were harvested, the weight was obtained with the help of a scale in kg and averaged.

2.6.6. Yield kg/ha

The data obtained were transformed into kg/ha to determine production.

2.6.7. Cost benefit analysis

It was based on the B/C ratio of each of the treatments, according to the production costs and benefits on the evaluated variables.

3. RESULTS AND DISCUSSION

3.1. Effect of Evaluating Metarhizium anisopliae 1x109 and the bowtie with chlorpyrifos on red spot in banana crops

3.1.1. Number of hands

According to the analysis carried out on the variable number of hands, differences between the treatments studied are concluded. The chemical control obtained 8 average coats, while the treatments based on the biologicalcontrol and control presented 7 average coats. It concludes that the control methods did not influence the increase in the number of hands of the banana bunch. The C.V. was 10% (Table 3).

3.1.2. Finger length (cm)

Through the analysis carried out on the finger length variable, it appears that there are no statistical differences between the red spot control treatments. The chemical and biologicalcontrol presented an average of 23 cm in finger length. Concluding that the control methods do not influence the development of the fruit, in addition, the control obtained 21 cm in length. The CV obtained was 4.65% (Table 3).

3.1.3. Percentage of damage (%)

The analysis carried out on the cluster damage variable shows that the control has the highest percentage of damage to the fruit with 85%. While the biologicalmethod controlled the disease, obtaining 13% damage. In addition, the chemical method significantly reduced red spot damage to 2%. The coefficient of variation obtained was 21.86% (Table 3).

3.1.4. Bunch weight (kg)

The analysis of variance shows a difference between the control methods and the evaluated control. The chemical control obtained an average of 26.95 kg of bunch weight, while the biologicalcontrol obtained an average of 26.65 kg. The witness presented a lower value of 20.40 kg. It is concluded that control methods influence improving fruit weight and quality. The coefficient of variation obtained was 8.01% (Table 3).

Table 3. *Average number of hands, finger length, percentage of damage, bunch weight and crop yield*

Treatments	Number of hands	Finger length (cm)	Percentage of damage (%)	Bunch weight (kg)	Crop yield (kg/ha)
T1: Chemical control	8a[1]	23 a	2 c	26.95 a	17 518 a
T2: Biological control	7b	23 a	13 b	26.65 a	17 323 a
T3: Witness	7b	21 b	85 a	20.40 b	13 260 b
CV %	10	4.65	21.86	8.01	8.01

1/ Average (n=19)

3.1.5. Crop yield (kg/ha)

The analysis of variance carried out on the performance variable shows a statistical difference between the control methods (chemical - biologicalal) and the evaluated control. The chemical control obtained 17 518 kg/ha average production, while the biologicalcontrol obtained 17 323 kg/ha average production. The control presented a lower value of 13 260 kg/ha. Transforming the data into boxes/ha of 22 kg, T1: 796 boxes of bananas, T2: 787 boxes of bananas and T3: 603 boxes were obtained. It is concluded that control methods reduce the risk of production and economic losses of bananas. The coefficient of variation obtained was 8.01% (Table 3).

3.2. Incidence of red spot

The control has a higher incidence of red spot on the banana bunch, obtaining mostly diseased plants. While biologicalcontrol presents the lowest average incidence, showing mostly healthy plants, and biologicalcontrol shows a greater number of healthy plants. It concludes that control methods, whether chemical or biologicalal, influences reducing the incidence of red spot on the fruit (Figure 1).

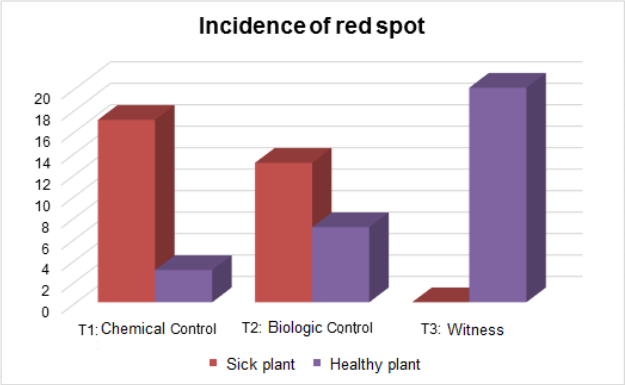

Figure 1. Incidence of red spot.

3.3. Benefit/ Cost analysis

The benefit-cost analysis was based on crop production in kg/ha and transformed into boxes/ha, box cost, production costs, income and benefit obtained from each treatment. According to the data obtained, chemical and biological control show benefits on the productivity and profitability of bananas. Treatment 1 (Chemical Control) obtained 796 boxes/ha, the B/N was $3 524.15 and its B/C $2.24, that is, the farmer receives $1.24 for every dollar he invests, justifying the investment of this method. Consequently, the biological control obtained 787 boxes/ha, B/W $3 461.42 and B/C $2.19, obtaining the farmer $1.19 (Table 4).

Table 4. *Benefit/ Cost analysis of banana cultivation*

Components	T1: Chemical Control	T2: Biological Control	T3: Witness
Yield (kg/ha)	17 518	17 323	13 260
Box performance (22 kg)	796	787	603
Price per box ($)	6.40	6.40	6.40
Fixed cost ($)	1 500	1,500	1 500
Variable cost ($)	72	78	0
Total costo ($)	1 572	1 578	1 500
Gross income ($)	5 096.15	5 039.42	3 857.45
Net Profit ($)	3 524.15	3 461.42	2 357.45
Benefit/Cost Ratio	2.24	2.19	1.57

The fruit variables number of hands and length of fingers did not present differences in averages regarding the treatments, that is, the different control methods did not influence their development. Regarding the control of red spot caused by Thrips, its presence was reduced in response to chemical and biological methods. The use of bowties impregnated with chlorpyrifos significantly reduced the damage to 2%, while the use of the fungus Metarhizium anisopliae obtained a similar result by reducing the damage caused to 13%. (Morocho, 2013), agrees that the use of bowties with chlorpyrifos reduces and partially controls pests. Furthermore, (Ayllón, 2015) maintains that the use of fungi such as Metarhizium anisopliae is 89.8% effective in controlling red spot thrips.

In the evaluations carried out, the control methods influence banana production, the chemical treatment mostly reduced the damage; The crop yield was 17 518 kg/ha, which when transformed into boxes obtained an average of 796 boxes/ha. While the treatment based on the fungus presented 17 323 kg /ha, which shows 787 boxes /ha, similar to its averages, it concludes that, the control of red spot reduces damage to the fruit, improving its quality and production. (Guerrero, 2017), maintains that the use of entomopathogenic fungi reduces the damage of red spot thrips and therefore production is not affected. However (Vargas & Rivas, 2011), they determined that the use of lamellae does not influence the expression of fruit scar rejection, that is, it did not improve the box-per-cluster ratio.

The economic analysis carried out justifies the farmer's investment in control methods. With the use of bowties impregnated with chlorpyrifos belonging to the chemical control, he obtained B/N $3 524.15 and his B/C $2.24, that is, the farmer receives $1.24 for every dollar he invests, therefore, the application Metarhizium anisopliae corresponding to biological control obtained B/N $3 461.42 and B/C $2.19, obtaining the farmer $1.19. (Montilla, 2013), the use of chemicals is a response to reduce crop damage and reduce economic losses; however, it can cause a negative effect on the environment in very high doses. Therefore, (Villalva, 2017), considers that chemical-free treatments generate better results both economically and environmentally, promoting effective control of insects and diseases, without causing damage to the environment and the health of producers.

4. CONCLUSIONS

Based on the results obtained, the following is concluded:

The control methods did not influence the variables number of hands and finger length, obtaining similar averages in the studied treatments.

The use of bowties with chemical and biological insecticide reduced the presence of red spot on banana fruit, obtaining mostly healthy plants and the % damage was 2% and 13% respectively, considered low compared to the control.

The chemical treatment based on bow ties with chlorpyrifos reduced the incidence of the disease and was reflected in the production of 796 boxes of bananas, while the use of Metarhizium anisopliae reached an average of 787 boxes of bananas.

The profitability was acceptable for both control methods, with the chemical treatment showing $2.24 B/C and the biological treatment $2.19

B/C, values that justify the producer's investment.

Declaration of interests

Ninguna.

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