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Bioinsecticides Used Against Spodoptera Spp. In Watermelon (Citrullus Lanatus T.) In Los Ríos-Ecuador

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Abstract

The objective of this study was to analyze the use of organic insecticides from extracts of different plants to control the impact produced by the caterpillar pest Spodoptera spp. on the watermelon crop Citullus lanatus in the province of Los Ríos-Ecuador.

[Methodology] An experimental design of completely randomized blocks (DBCA) was used, consisting of five treatments with four replicates, which consisted of different extracts used as organic insecticides and an absolute control. Treatment T1 consisted of chili bell pepper extract plus soap, treatment T2 consisted of garlic extract with oil plus soap, treatment T3 consisted of nettle extract, treatment T4 consisted of rue extract and treatment T5 was defined as absolute control. The experimental units were established in randomly distributed plots with an area of 108 m^2, with a total of 20 plots. Differences between treatments were determined using Tukey's test. Statistically significant differences were considered when $p \leq 0.05$.

[**Results]** The treatments showed statistically significant differences, with the T3 treatment being the most important, reaching the lowest percentage of pest incidence with an average of 25%, and also presenting the lowest percentage of fruit damage with an average of 10%. This was followed by T1 and T2, which obtained good results. The absolute control T5 obtained the most unfavorable results, reaching 50% pest incidence with 37.50% fruit damage. Among the organic insecticide treatments, the most unfavorable results were observed in treatment T4.

[**Conclusions]** It is demonstrated that there are viable ecological alternatives for the control of caterpillars in the watermelon crop through the application of organic insecticides that fulfill the functions of synthetic insecticides used in traditional agriculture. Transferring the results of organic practices will encourage the development of new technologies that will boost large-scale organic horticultural production.

Keywords: organic agriculture; biopesticides; population dynamics; extracts; pest incidence.

Resumen

El presente trabajo tuvo como objetivo analizar el uso de insecticidas orgánicos procedentes de extractos de diferentes plantas, para controlar el impacto producido por la plaga de la oruga spodoptera spp. en el cultivo de sandía Citullus lanatus en la provincia de Los Ríos-Ecuador. **[Metodología]** Se utilizó un diseño experimental de bloques completamente al azar (DBCA) que comprendió de cinco tratamientos con cuatro repeticiones, que consistían en diferentes extractos usados como insecticidas orgánicos y un testigo absoluto. El tratamiento T1 consistió en un extracto de ají más jabón, el tratamiento T2 consistió de un extracto de ajo con aceite más jabón, el tratamiento T3

consistió en un extracto de ortiga, el tratamiento T4 consistió en un extracto de ruda y el tratamiento T5 fue definido como testigo absoluto. Las unidades experimentales se establecieron en parcelas distribuidas al azar con una superficie de 108 m^2, con un total de 20 parcelas. Las diferencias entre los tratamientos fueron realizadas mediante el test de Tukey. Se consideraron diferencias estadísticamente significativas cuando $p \leq 0.05$. **[Resultados]** Los tratamientos mostraron diferencias estadísticas significativas, siendo el tratamiento T3 el de mayor importancia alcanzando el menor porcentaje de incidencia de la plaga con una media del 25%, presentando de igual manera el menor porcentaje de daños en fruto con una media del 10%. Seguido del T1 y T2 que obtuvieron buenos resultados. El testigo absoluto T5 obtuvo los resultados más desfavorables alcanzando el 50% de incidencia de la plaga con un 37,50% de daño en frutos, entre los tratamientos de insecticidas orgánicos los resultados más desfavorables se observaron en el tratamiento T4. **[Conclusiones]** Se demuestra que existen alternativas ecológicas viables para el control de oruga en el cultivo sandía mediante la aplicación de insecticidas orgánicos que cumplen con las funciones de los insecticidas sintéticos que se utilizan en la agricultura tradicional. Transferir los resultados de prácticas ecológicas fomentara el desarrollo de nuevas tecnologías que impulsen la producción hortícola orgánica a gran escala

Palabras clave: Agricultura orgánica; bioplaguicidas; dinámica poblacional; extractos; incidencia de plagas.

Introduction

The watermelon crop whose origin is close to the African continent, where it currently continues to grow wild. It belongs to the family Curcubitaceae of the genus Citrillus whose species is C.lanatus (Thun) (Cantos & Giler, 2011). It is of great importance in Ecuadorian horticulture being one of the most important cucurbits in the country. Botanically, the watermelon is an herbaceous, annual, creeping or climbing plant if it is provided with a tutor. Petiolate and lobed leaves, male and female flowers (unisexual monoecious) of yellow color, solitary, peduncular and axillary, with characteristics of entomogamous flowers (Reche-Mármol, 2000)..

There are several cultivars of watermelon, including the Royal Charleston, which is a leading hybrid in the market for its excellent reception. It is productive within the quality standards required. It is oblong in shape with a light green skin and red flesh with a good brix content. It is an early variety that reaches physiological maturity at approximately 80 days, being a fairly tolerant variety to wilt caused by fusarium whose fruits can reach between 8 and 10 kg in weight. It is quite resistant so that its logistics and distribution is not a problem for growers (Orduz, León, Chacón, Linares, & Rey, 2000).

The edaphoclimatic requirements of the crop are based on soils with high concentrations of oxidizable organic matter (OM), with an effective depth of no less than 60 cm, well-drained soils with abundant porosity, since this crop does not tolerate waterlogging, given that the fruit is in contact with the soil. It is a crop moderately tolerant to salinity. The suitable climate for the optimal development of the crop is warm with temperatures ranging between 20 to 30°C, relative humidity should not exceed 80% (Panta, 2015; Peñarrieta, 2015).

As a food, watermelon is of great nutritional importance, providing important amounts of vitamins such as vitamin A, vitamin C, and a high-water content, since its seedless pulp contains 95.7% water (Orduz et al., 2000).

Cucurbit crops are attacked by various pests that considerably reduce their production, as is the case of the spodoptera spp. caterpillar, which wreaks havoc on the crop foliage, causing significant economic damage to producers. Therefore, the use of organic insecticides to develop an alternative for pest control becomes a sustainable practice, where the basis is the use of natural products that are biodegradable and do not pollute the environment where they are applied. The use of these ecological products

can reduce the impacts by increasing the mortality of larvae in the most juvenile stages (Cuevas, 2007).

The use of natural insecticides can have excellent results even when compared to an insecticide of synthetic or chemical origin as shown in the research conducted by Cabrera et al. (2016), where it is shown that the results obtained with chili bell pepper extracts presented similar results to those of the chemical control and even showed higher crop yields.

Pests, such as Spodoptera frugiperda, a polyphagous pest that affects a large number of crops, can reduce yields up to the totality of expected yields, for this reason, the use of significant doses of harmful chemicals are used in the management or control of this pest. As a clear alternative, natural insecticides are being developed to combat the budworm, reaching the possibility of implementing the use of bioinsecticides and biorationals for population control of the caterpillar, as in Mexico and other regions (Gonzalez, Gurrola, & Chairez, 2015).

It is possible to control up to 51.77% of the incidence of the budworm pest in corn with the use of chili bell pepper extracts according to research conducted by Velásquez (2016) who achieved these results, positively influencing the cost-benefit ratio in the implementation of bioinsecticides with reliable results.

The present research work seeks to determine if there is at least one treatment with the use of organic insecticides based on different botanical extracts that generates an efficient control in the population dynamics of Spodoptera spp. that affects the watermelon crop in the Ecuadorian coast.

Methodology

The present research is of an experimental nature, where a Randomized Complete Block Design (RCBD) was established, comprising five treatments with a total of four replications, in which organic insecticides based on Capsicum sativum (chili bell pepper), Allium sativum (garlic), Urtica dioica (nettle) and Ruta graveolens (rue) were used. The statistical analysis of the data was carried out with the Infostat software, 2020, where an analysis of variance (ANDEVA) was performed as described in Table 1. The coefficients of variation were determined, and as a comparative measure between treatments, a Tukey test was used with a significance level of 5%.

Table 1. ANDEVA schematic, 2021.

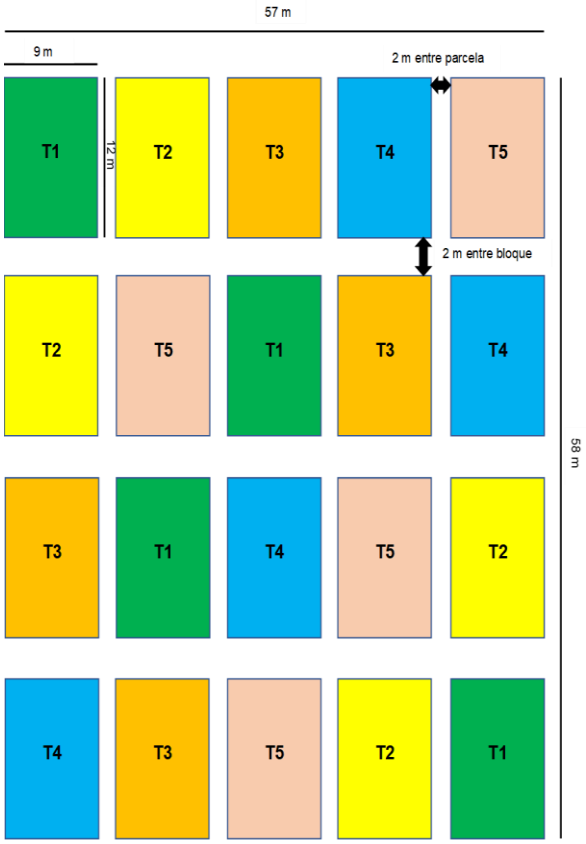
Source of Variation	Degrees of freedom
Treatments (t - 1) (5- 1)	4
Repetitions (r - 1) (4 - 1)	3
Error (t-1) x (r - 1) (4 x 3)	12
Total (t* r - 1) (4* 5- 1)	19

Note: Own research source.

The treatments proposed in this research consisted of the application of different extracts used in mixtures for the organic control of spodoptera spp. caterpillars. One of the treatments was determined as an absolute control (T5) established as shown in Table 2.

Table 2. Distribution of treatments. 2021.

Treatments	Product	Dosage/Ha	Dose/parcel	Frequency
T1	Chili extract + soap	1500cc	16cc	7 days
T2	Garlic extract + soap	1500cc	16cc	7 days
T3	Nettle extract	1500cc	16cc	7 days
T4	Russian extract	1500cc	16cc	7 days
T5	Absolute witness	-	-	-



The characteristics of the experimental plots were as follows: Distance between rows of 4 meters,

Figure 1. Characteristics of the experimental plots

Distance between plants of 0.90 meters, the total area of the plots was 108 mwith^2 a useful experimental area of 28 m^2, the population density of the project was 800 plants with 20 useful plants for each treatment. The plots were separated every 2m and the separation between blocks every 2m. The layout of the test units can be seen in Figure 1.

The preparation of the organic insecticides used in the project was carried out according to the guidelines proposed by Millán (2008) and by Luna et al. (2014) where extracts were obtained and used following the recommendations of the aforementioned authors.

Extract based on chili

This insecticide was obtained by collecting 1 kg of chili peppers, which were washed, macerated and diluted in one liter of water. It was left to stand for 2 days to favor the fermentation process, then it was filtered to separate seeds and residues of the chili, finally soap was added so that the solution is fixed to the plant tissue where it will be used. It should be stored in a cool, dry place, free from solar radiation and preferably refrigerated.

Garlic extract

About 1 kg of garlic seeds were used, which were crushed and vegetable oil was added and left to stand for 24 hours, then a liter of water was added and finally filtered and soap was added to act as a fixative. It was placed in a glass container and should be stored in a cool, dry place to maintain its characteristics.

Nettle extract

1 kg of nettle plant foliage was used, which was chopped for subsequent maceration. Once the paste is obtained, a liter of water is added and it was left to stand for 24 hours. Once the time has elapsed, it should be filtered and stored in a cool, dry place. The extract should be used as soon as possible so as not to affect its effectiveness.

Extract based on rue

1 kg of rue plant foliage was used, it should be chopped to start the maceration process, and once this process is finished, a liter of water is added, leaving it to stand for 24 hours. The best use of the active principle of rue is obtained after filtering and stabilizing the extract solution, using it as soon as possible.

To calculate the percentage of caterpillar incidence (PI), quantifications must be made every 24 hours after the application of insecticides (DDA) in each of the treatments with their respective replicates, applying the following formula.

$$\%\text{deincidencia} = \frac{\text{Númerodeplantasafectadas}}{\text{Númerodeplantasevaluadas}} \text{x}100$$

The determination of the population dynamics of spodoptera spp. caterpillars was carried out by quantifying the number of live caterpillars before and after the application of organic insecticides. The following formula was used.

$$\text{D}(\%) = [1 - \left(\frac{\text{Od}}{\text{Oa}}\right) \text{x}100$$

Where:

D= Decrease in percentage.

Oa= Number of live caterpillars before application.

Od= Number of live caterpillars after application.

Field practices were standardized among the experimental units, where the soil was prepared by mechanical disk plowing and harrowing, sowing was done with seeds in germination trays, which were then transplanted to their definitive site as defined in the experimental units described above. Irrigation was carried out by means of a drip system, with the soil remaining at field capacity to meet the water demand of this cucurbitaceae.

Fertilization was carried out organically using worm humus at a dose of 140 gr/plant with a frequency of 15 days, and biol was also used at a dose of 100cc per 20L applied by foliar application. Then, weed control was carried out manually.

In the present study, it was hypothesized that at least one of the treatments using organic insecticides has a significant effect on the control of the caterpillar spodoptera spp. in the watermelon crop Citrullus lanatus.

Analysis and results

Based on the results obtained in the percentage of incidence of the pest, it can be observed according to Figure 2, that the highest percentages of incidence were obtained in the control treatment (T5) with an average of 50%, followed by the rue extract (T4) which reached an average of 45%. The lowest incidence was obtained in the treatment (T3) corresponding to nettle extract, which reached 25% of the incidence of the pest with a coefficient of variation between treatments of 24.83%.

The results obtained were statistically significant, being T5 different from T3, for the comparative means between T4, T2 and T1 there was no statistically significant difference.

The results obtained in the percentage of fruit damage as shown in Figure 3, it is evident that the caterpillar generated greater damage in the T5 treatment corresponding to the control, where it reached an average of 37.50%, followed by T4 corresponding to the rue extract with 25% damage.

Figure 3. Percentage of fruit damage, 2021.

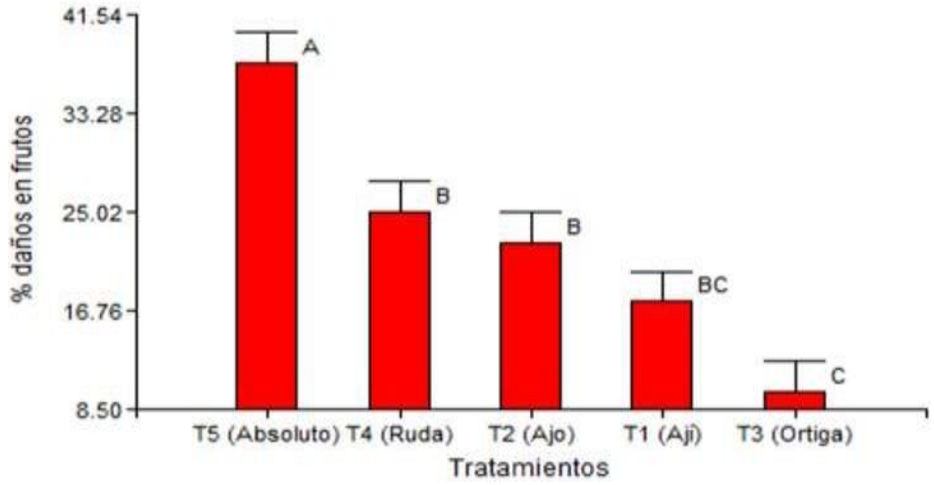
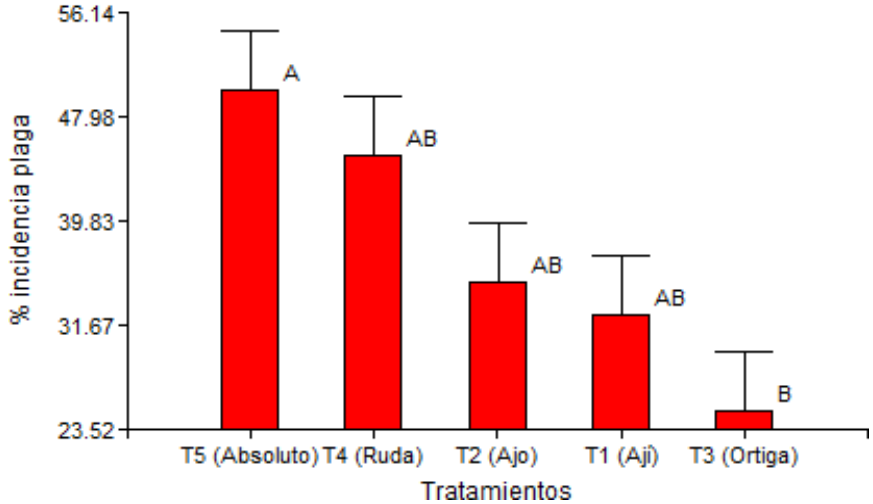


Figure 2. Percentage of pest incidence, 2021

Statistical differences were found among treatments with a coefficient of variation of 22.59%. Treatments T4 and T2 showed no significant differences, while T3 showed the greatest difference compared to T5.

The best results were again presented in T3 corresponding to nettle extract, which reached an average of 10% of fruit damage.

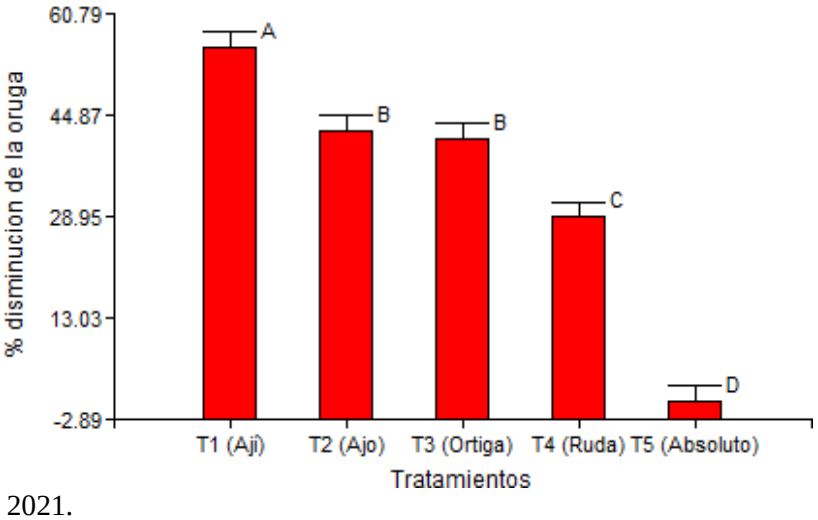
The results corresponding to the percentage of reduction of the caterpillar can be seen in Figure 4. Where the mean that represented the greatest reduction of the pest was T1 corresponding to the extract of chili bell pepper and soap, reaching 55.57% control, followed by T2 corresponding to



The extract of garlic and soap, which reached 42.42%. The lowest results were obtained for treatments T5 and T4 respectively, with the lowest obtained by the control treatment.

According to the comparative tests, the results were statistically different among treatments, all treatments presented significant results, highlighting the comparison between T1 and the control treatment T5.

Figure 4. Number of caterpillars controlled, 2021.



The results obtained in the percentage of caterpillar reduction can be seen in Figure 5. The treatment with the highest percentage of reduction was T1 corresponding to the extract of chili bell pepper and soap, followed by the treatments corresponding to the extracts of garlic and nettle T2 and T3 respectively, with the lowest result corresponding to the control. A significant statistical difference was found with a coefficient of variation of 13.84%.

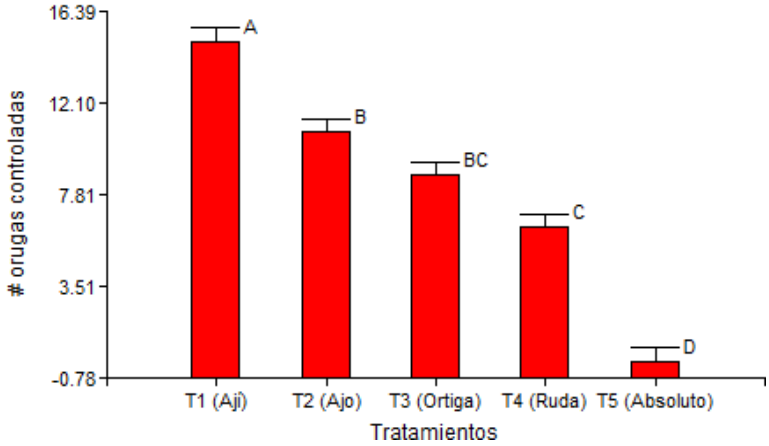


Figure 4. Number of grains per plant, 2021.
Source: Own research source.

The results obtained in the population dynamics in the control treatment T5 show a high number of specimens in the last weeks, as shown in Figure 2. Since it was a treatment

without the application of any product, the increase in damage and consequences was notably higher than in the other treatments tested.

The effect of nettle extract application affects the agronomic behavior of watermelon with a greater number of guides, length of guides, tonality and vitality in plants, yield per experimental plots. This is in agreement with what Chauca mentions (2012) the different types of biostimulants, including nettle, had a significant influence on the agronomic performance of fodder beet and its yield.

Conclusions

Based on the evaluation of the application of insecticides on the agronomic behavior of watermelon, it was determined through the application of insecticides that T1 (chili bell pepper extract + soap) causes small burns on the watermelon foliage, although it effectively controls caterpillars. As for T3, a greater length and number of guides per plant, a significant number of flower buds and greater productivity at harvest time were observed.

T1, based on chili bell pepper extract + soap, was the treatment that presented the highest percentage of reduction of caterpillar specimens with 55.57%. Therefore, it is concluded that the chili bell pepper extract, used as an organic insecticide, reduces the attack and the caterpillar population in the watermelon crop.

It is possible to implement ecological integrated pest management systems that contribute to organic agriculture, obtaining positive results in the agronomic variables of importance, which generate profitability for small and large farmers who opt for the use of these alternatives in their direct contribution to key elements of sustainable development in horticultural crops.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Statement of authors' contribution

All authors acknowledge that the final version of this article has been read and approved. The total percentage of contribution for the conceptualization, preparation and correction of this article was as follows: I.V. 25%, P. J. 25%, B.A.F 25% and P.S.C. 25%.

Declaration of data availability

Data supporting the results of this study will be made available by the corresponding author [**I.V.**] upon reasonable request.

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