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Research Article

Application of Kaolin as a Sustainable Strategy for Pest Control in Tomato Crop (Solanum lycopersicum L.)

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ARTICLE INFO	ABSTRACT
Received: 18 Dec 2024 Revised: 04 Feb 2025 Accepted: 20 Feb 2025	One of the main constraints in the production of tomato crops (Solanum lycopersicum L.) are pests. The main form of pest control is through the application of highly toxic pesticides. As an alternative strategy for pest control in tomato crops, different doses of kaolin were evaluated. Field experiments were carried out in the province of Los Ríos (Ecuador) during the dry season. Tomato plants were treated with kaolin in doses of 20 g, 40 g and 60 g kaolin/liter, its repellent effect under controlled conditions was also considered. During the research, five pest species were identified in tomato crops: Bemisia tabaci, Prodiplosis longifila, Euchistus sp. Myzus persicae, Manduca sexta. In all species identified in the field, after the application of kaolin, the

pest population is reduced or remains at low levels. The application of kaolin on tomato plants positively influences the characteristics of stem diameter, plant height and yields. Additionally, it was possible to verify that there is adult repellency of B. tabaci to plants exposed to kaolin during periods of 1 hour, 6 hours, 12 hours and 24 hours of exposure ($P<0.001$). Kaolin allows pest control, improves the agronomic and productive characteristics of tomato crops, therefore, its use could be considered in integrated pest management programs.

Keywords: Control, bioinsecticide, whitefly, repellency.

INTRODUCTION

The tomato (*Solanum lycopersicum*) is one of the most important vegetables in the world due to its nutritional and organoleptic quality. Ecuador has an area of 1,691 hectares, with a production of 55 thousand tons on a national scale (1). Tomato production occurs in both the coastal and highland regions of Ecuador and is a source of income for most farmers (2).

Among the limitations that affect the production of tomato crops we can mention pests. There are several diseases and insects that affect the crop and cause direct or indirect damage. Among the pests of importance in tomatoes in Ecuador are: whiteflies (*Bemisia tabaci*), mites (*Eutetranyichus* spp.), aphids (*Toxoptera aurantii* and *Aphis gossypii*) and snowflake (*Unaspis citri* and *Pinnaspis strachani*) (3).

Whitefly (*B. tabaci*) is considered the main pest in tomato cultivation. *Bemisia tabaci* has a sucking mouthpiece that sucks the sap and juices of the plant and at the same time transmits viruses and toxins (4). Although there are different methods available for pest control in tomato cultivation, the use of synthetic insecticides continues to be widely used, which puts the health of the producer and consumer of this vegetable at risk, as well as the environment (5).

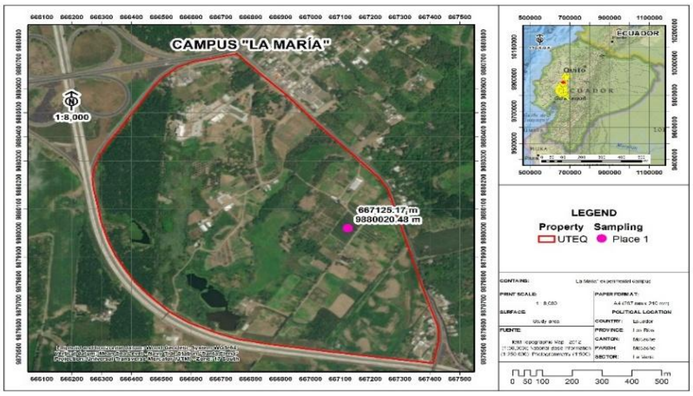
Kaolin is a natural mineral that has insecticidal properties; This product provides protection to leaves, fruits creating a uniform film acting as an insect repellent, prevents fungal diseases, bacteria and reduces stress. The application of this mineral acts as a physical barrier in the plant. Some records confirm the use of kaolin in the control of pests such as: Pear psylla, thrips, leafhoppers, curculionids and whiteflies (6).

Considering the above, the objective of this study was to evaluate the effect of kaolin as a strategy within integrated pest management programs for tomato (*S. lycopersicum*) cultivation.

MATERIALS AND METHODS

The research was carried out at the experimental campus "La María" belonging to the State Technical University of Quevedo (UTEQ), located in Mocache, kilometer 71/2 via Quevedo - El Empalme, entrance to Mocache, Province of Los Ríos (Ecuador), with the following projected coordinates (X/Y): 667125.17 and 9880020.48; and at 66 meters above sea level (Figure 1).

Figure 1. Experimental area



Type of Research: The research is experimental, trials were carried out in controlled conditions and field conditions to evaluate the effect of kaolin in different doses for the management of pest insects in tomato crops (*Solanum lycopersicum* L.). Tomato plants of the Miramar hybrid (Seminis) were planted to carry out the experiments. The Surround WP 95% (BASF) product was used as the kaolin source.

Experimental Design of the Research: In the study, two types of experimental designs were used. Under controlled conditions, the completely randomized design (DCA) was used with 5 replicates and four treatments (repellency experiment); while for the field trial, the completely randomized block design (DBCA) was used, with three blocks and five treatments.

Study Factor: The study factor was the different doses of kaolin as a measure of management of insect pests in tomato (*S. lycopersicum* L.) crops.

Treatments: Table 1 shows the treatments used for field experiments and under controlled conditions (the latter used in the experiment for whitefly (*B. tabaci*) repellency to kaolin.

Table 1. Treatments for field experiments and controlled conditions

Treatments	Field experiments	Controlled conditions
T1	Kaolin (20g/L)	Caolín (20g/L) vs Agua
S2	Caolín (40g/L)	Caolín (40g/L) vs Agua
S3	Caolín (60g/L)	Caolín (60g/L) vs Agua
S4	Water	Insecticide vs Water
S5	Insecticida (Thiamethoxam/Lambda cyalotrina	

The variables of insect quantity, stem diameter, plant height and crop yield were evaluated through analysis of variance. Tukey's test with a 95% probability was used to compare the means obtained in the data. For the repellency variable, the Chi 2 test was used. The assumptions of homoscedasticity and the normality of the data were verified using Bartlett's and Shapiro–Wilk's tests. The Infostat and R Studio programs were used for the analyses.

Experiment Management in Controlled Conditions

Breeding and multiplication of whiteflies (*Bemisia tabaci*):

- Specimens were collected from the "La María" campus.
- The flies were placed in 1 m² cages with 30 tomato plants.

Repellency test:

- Tomato plants treated with kaolin (different doses) or insecticide were compared with control plants (water only).

- Release of 10 individuals of *B. tabaci* into cages of 50 cm x 50 cm.
- Visual inspection and adult count after 1, 6, 12, 24 hours.

Kaolin preparation:

- Surround WP (95%) was mixed with soy lecithin (2 mL/L of water).
- Manual application (50 mL per plant) one day before the trial.

Experiment Management in Field Conditions

Preparation of the land and seedbed:

- Manual weed control, ploughing, grading.
- Seedbed: substrate (coconut fiber, biabor, soil 1:1:1).
- Transplant after 30 days in holes 30 cm deep.

Fertilization and Irrigation:

- Fertilization with 20 g/plant (3 applications: 8, 20 and 30 days).
- Manual irrigation as needed.

Pest and disease control:

- Application of kaolin (20, 40, 60 g/L) every 2 weeks.
- Fungicide (Fosetyl aluminium) (450 g/L) in the presence of fungi.

Harvest:

- Four harvests during the experiment at maturity grade 5 (60-90% red).
- Heavy fruits with electronic scales.

Variables Evaluated

In field conditions:

- Pest identification and population fluctuation: Manual collection, taxonomic identification, counting before and after applying kaolin.
- Tomato development: Stem diameter, plant height.
- Yield: Fruit weight and yield calculation (kg/ha).

For the calculation of tomato yield (kg/ha), the weight of the tomatoes (kg) for each block and treatment was considered, with the following equation:

$$\text{Rendimiento (kg/ha)} = \frac{\text{Rendimiento por parcela útil (kg)} * 10000\text{m}^2}{\text{Área de parcela útil (m}^2\text{)}}$$

Under controlled conditions:

- Repellency of *B. tabaci*: Comparison between treated plants and control by counting adults at time intervals.

RESULT AND DISCUSSION

Result:

Identification of the Main Pest Insects of the Tomato Crop (*S. lycopersicum* L.): Observing the morphological characteristics of the specimens collected, and with the taxonomic descriptions proposed by Choi et al. (7) and MacLEOD et al. (8), it was possible to identify five species considered pests in tomato crops. Monitoring was carried out for 9 weeks. Table 2 shows the most abundant species and the number of individuals monitored.

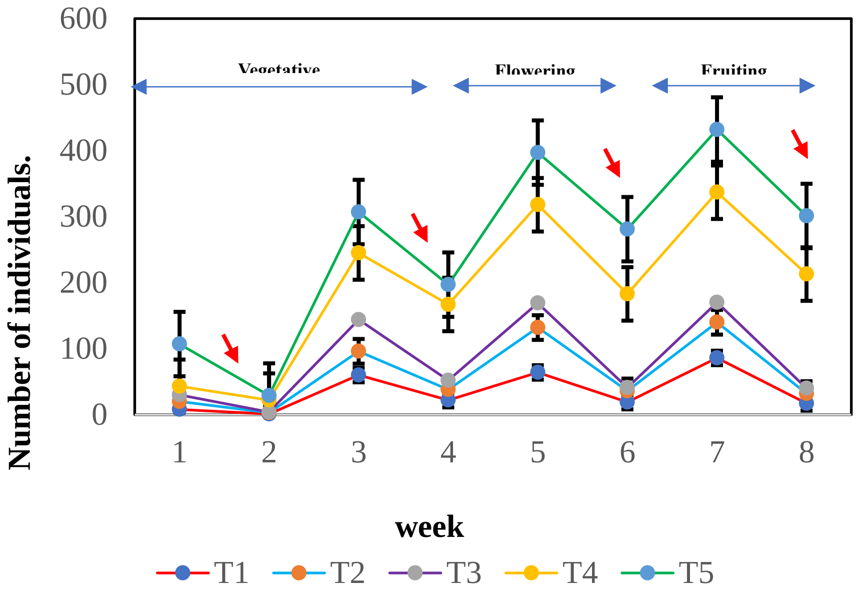
Table 2. Main pest species sampled in tomato cultivation

Order	Species	Number of specimens
Hemiptera	*Bemisia tabaci* (Gennadius, 1889)	808
Diptera	*Prodiplosis longifila* (Gagne, 1986)	219
Hemiptera	*Euschistus* sp. (Fabricius 1794)	134
Hemiptera	*Myzus persicae* (Sulzer, 1776)	112
Lepidoptera	*Manduca sexta* (Linnaeus, 1763)	24

Population Fluctuation of the main Pest Insects in the Tomato Crop (*Solanum lycopersicum*):

Population fluctuation of whitefly (*B. tabaci*) in tomato (*S. lycopersicum*) crop: Considering the descriptive analysis carried out, the population fluctuation of whiteflies is significantly reduced after the application of treatments in which kaolin was used (Figure 2). In addition, it was evidenced that there is a greater abundance of this species in the flowering and fruiting stages.

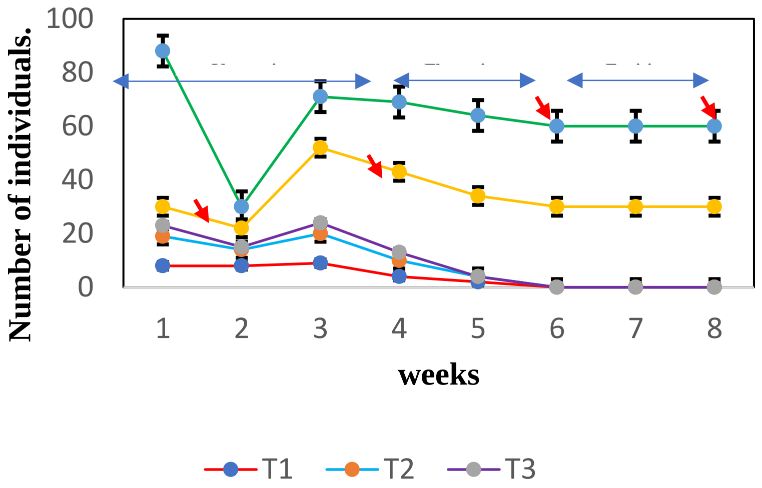
Figure 2. Population fluctuation of *Bemisia tabaci* in tomato cultivation



Treatments: T1 = 20 g Kaolin/L, T2 = 40 g Kaolin/L, T3 = 60 g Kaolin/L, T4 = water, T5 = insecticide. Arrows indicate monitoring performed after the application of each treatment.

Population fluctuation of the bold (*P. longifila*) in the tomato crop (*S. lycopersicum* L.): The population fluctuation of *P. longifila* varies during the evaluations carried out before and after the application of the treatments (Figure 3). During the first monitoring carried out after the application of each treatment, the reduction in the population of this insect was more evident. Only for treatments in which water and insecticide were used , *P. longifila* persisted until the fruiting stage (Figure 3).

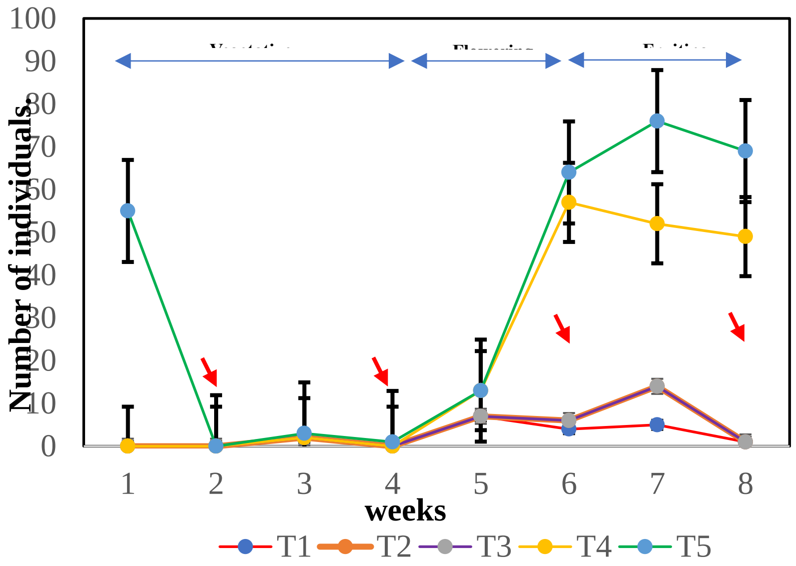
Figure 3. Population fluctuation of *Prodiplosis longifila* in tomato cultivation



Treatments: T1 = 20 g Kaolin/L, T2 = 40 g Kaolin/L, T3 = 60 g Kaolin/L, T4 = water, T5 = insecticide. Arrows indicate monitoring performed after the application of each treatment.

Population fluctuation of the bed bug (*Euschistus* sp.) in tomato (*S. lycopersicum) crop*: The population of the bed bug *Euchistus decreases* every two days after the application of each treatment, however, in the first monitoring carried out after the application of each treatment, the reduction in the population was considerable, while in the water and insecticide treatments the population density was considerable. it increased in the flowering and fruiting stages (Figure 4).

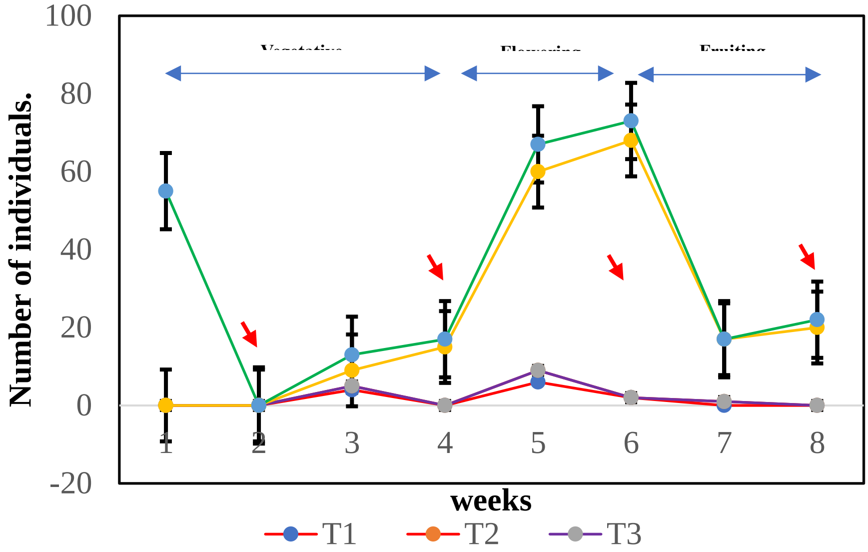
Figure 4. Population fluctuation of *Euchistus* spp. in tomato cultivation



Treatments: T1 = 20 g Kaolin/L, T2 = 40 g Kaolin/L, T3 = 60 g Kaolin/L, T4 = water, T5 = insecticide. Arrows indicate monitoring performed after the application of each treatment.

Population fluctuation of green aphid (*M. persicae*) in tomato (*Solanum lycopersicum* L.) crop: The population of *M. persicae* decreases after the application made for each treatment, however, treatments in which kaolin was used the population reduction was more evident compared to treatments in which water and insecticide were used (Figure 5).

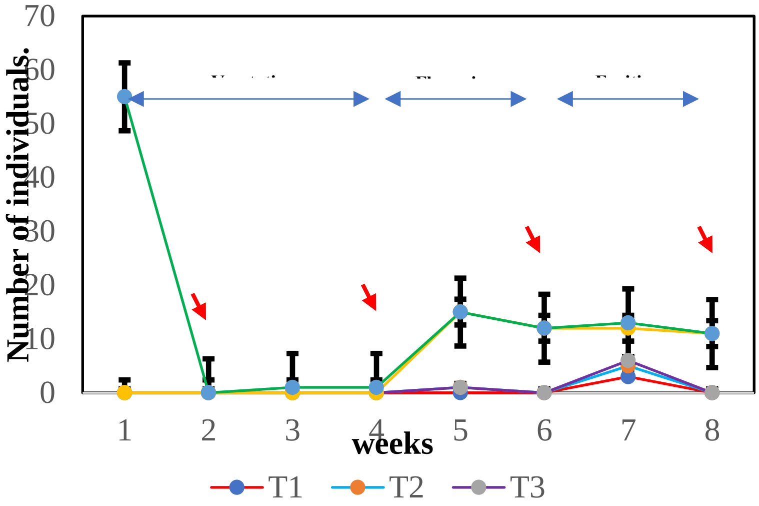
Figure 5. Population fluctuation of *Myzus persicae* in tomato cultivation



Treatments: T1 = 20 g Kaolin/L, T2 = 40 g Kaolin/L, T3 = 60 g Kaolin/L, T4 = water, T5 = insecticide. Arrows indicate monitoring performed after the application of each treatment.

Population fluctuation of larvae (*M. sexta*) in tomato (*S. lycopersicum) crops*: Considering the analysis carried out, the population fluctuation of *M. sexta* is significantly modified before and after the application of treatments (Figure 6). In the first monitoring carried out during the vegetative development of the tomato, its population behavior was similar between the treatments; however, from the fourth monitoring onwards, the reduction in the population was evident in the treatments in which kaolin was used compared to the treatments in which water and insecticide were applied.

Figure 6. Population fluctuation of *Manduca sexta* larvae in tomato cultivation



Treatments: T1 = 20 g Kaolin/L, T2 = 40 g Kaolin/L, T3 = 60 g Kaolin/L, T4 = water, T5 = insecticide. Arrows indicate monitoring performed after the application of each treatment.

Table 6 shows the results obtained from the analysis of variance and comparison of means of each of the insect-pest species identified in the tomato crop after the application of the treatments (Table 3).

Table 3. Means of individuals collected after the application of each treatment

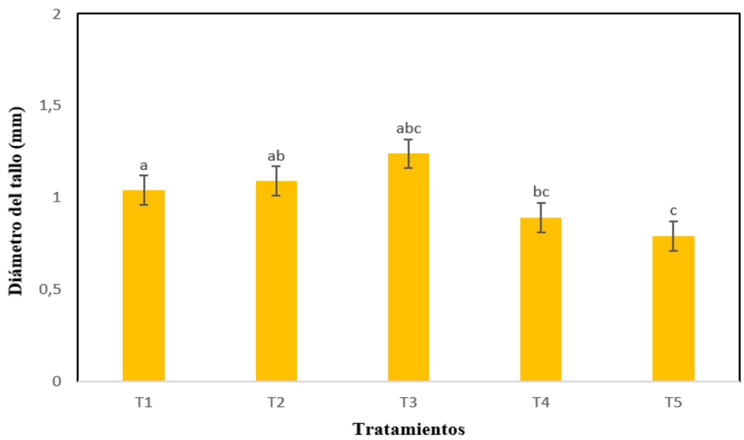
Species	*Bemisia* *I smoked*	*Prodiplosis longifila*	*Euschistus* sp.	*Myzus* *persicae*	*Manduca* *Friday*
T1 = Caolín (20 g/L)	19,67 c	4,00 b	1,67 c	0,47 b	0,00 b
T2 = Caolín (40 g/L)	16,67 c	4,00 b	0,67 c	0,00 b	0,00 b
T3 = Caolín (60 g/L)	9,33 c	1,33 b	0,00 c	0,00 b	0,00 b
T4 = Water	149,33 a	32,33 a	33,00 a	5,62 a	7,67 a
T5 = Insecticida	74,33 b	31,33 a	9,33 b	1,69 b	0,33 b
CV	12,36	16,50	19,50	61,28	21,35
P-value	<0,0001	<0,0001	<0,0001	<0,0011	<0,0001

*Different letters indicate significant differences between treatments (Tukey 95%)

Agronomic and Productive Characteristics of Tomato Cultivation (*Solanum lycopersicum*):

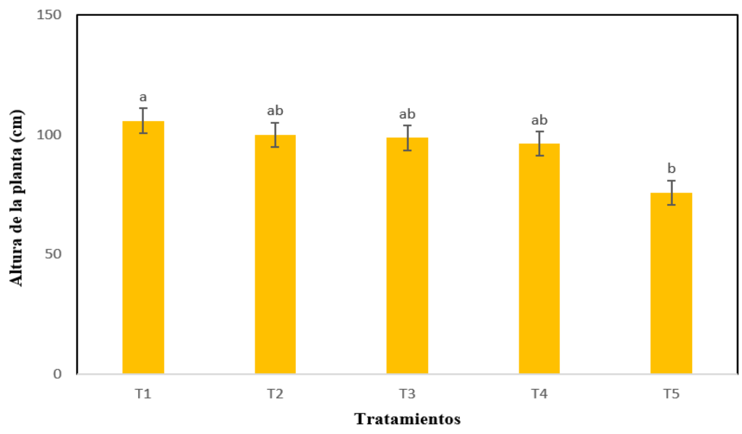
Stem diameter of tomato plants (*S. lycopersicum*): The analysis of variance performed for the tomato stem diameter variable during the fruiting stage indicated that the treatment with the dose of 60 g kaolin/L obtained the highest value with 1.24 mm diameter followed by the treatments with 40 g of kaolin/L and the treatment with 20 g of kaolin/L with 1.09 mm and 1.04 mm respectively. Water and insecticide treatment obtained the lowest diameter averages with 0.89 mm and 0.79 mm respectively (Figure 7).

Figure 7. Stem diameter of tomato plants exposed to different treatments. In original language Spanish



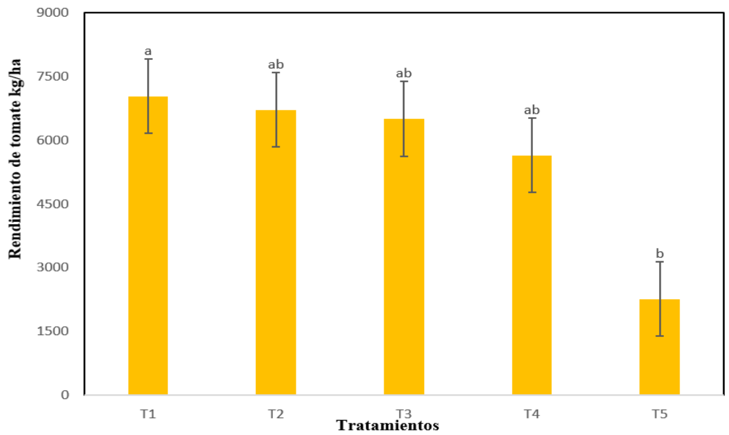
Height of tomato plants (*S. lycopersicum*): The analysis of variance performed for the height variable of the tomato plant during the fruiting stage indicated that in the treatment in which 40 g of kaolin/L was used, the highest average height was 105.73 cm, the treatments with kaolin doses of 20 g/L and 60 g/L obtained similar results. The treatment in which water was applied had an average height of 96.17 cm, while the insecticide treatment had the lowest average height in the plant with 75.73 cm (Figure 8).

Figure 8. Height of tomato plants exposed to different treatments. In original language Spanish



Tomato crop yield (*S. lycopersicum*): The analysis of variance performed for the tomato crop yield variable indicated that there are significant differences between treatments (Figure 9). The treatment in which kaolin was applied in doses of 20 g/L obtained the highest yield, reaching the value of 8958.71 kg/ha. Surprisingly, the treatment in which insecticide was used obtained the lowest yield with 2260.48 kg/ha.

Figure 9. Tomato crop yield exposed to different treatments. In original language Spanish



Effects of Whitefly (*B. tabaci*) Repellency on Tomato (*S. lycopersicum*) Plants: According to the Chi^2 analysis used to verify the repellency of *Bemisia tabaci* to different treatments, it was possible to identify that in each evaluation period carried out there are significant differences between treatments: 1 hour (X^2 = 14.41; df = 3; P = 0.002), 6 hours (X^2 = 20.24; df = 3; P<0.001), 12 hours (X^2 = 15.67; df = 3; P = 0.001), 24 hours (X^2 = 22.47; df = 3; P<0.001). Considering the t-test, there are significant differences between treatments (P<0.005).

DISCUSSION:

The tomato is a crop of economic importance worldwide. In Ecuador, tomatoes are produced for national consumption, agribusiness, export and import of processed products, their production is considered as a form of strengthening peasant agriculture (9).

In the present study it was possible to identify five species that presented the highest abundance in tomato cultivation: whitefly (*Bemisia tabaci),* black fly (*Prodiplosis longifila*), bug (*Euschistus* sp.), aphid (*Myzus persicae*), larva (*Manduca sexta)*). These species of insects are quite common in tomato cultivation and coincide with what was mentioned by Álvarez et al. (10); Calderón et al. (11); Santos & Tavares (12); Borgues et al. (13); Garvey et al. (14), who indicate that these species used to be key pests of the crop and that they cause significant economic losses.

Kaolin is an inert powder that has important functions for the plant, one of them being its insecticidal action (15). The use of kaolin as an insecticidal product has been confirmed in several species of insects, its properties allow the reduction of the population of species such as: *Diaphoria citri*, psyllids (15); cabbage aphid (*Brevicoryne brassicae*) (16); mite (*Oligonychus yothersi*) (17); moths (*Phthorimaea operculella* and *Symmetrischema tangolias*) (18); corn weevil (*Sitophilus zeamais*)) (19); olive fly (*Bactrocera oleae*), almond tiger (*Monosteira unicostata*), big-headed worm (*Capnodis tenebrionis*) (20), fruit fly (*Ceratitis capitata*) (21).

In the present research, the use of 95% kaolin allowed the reduction of the populations of whitefly (*B. tabaci*), black (*e*), bug (*esp.), aphid (M. persicae*), larva (*M. sexta*). At least for the species *B. tabaci*, the results coincide with those proposed by Johnston et al., (8) who confirm that the use of kaolin and limonene reduces the population of *B. tabaci* in pepper cultivation. Kaolin reduces whitefly oviposition rates and the number of adults that settle when sprayed on vegetable leaves (22).

According to Moarefi, (23), 5% kaolin was effective in controlling the bug (*Euschistus* sp.) in peach cultivation by creating a physical barrier on the plant, creating an unfamiliar environment for the pest avoiding knowing its host. In another study, Galdino et al. (24) demonstrated larval mortality (Lepidoptera: Noctuidae) using the entomopathogenic fungus *Beauveria bassiana* and kaolin. A study by Barker, (25), showed that kaolin provides a physical barrier against pests showing a potential to control *M. persicae* by avoiding the kaolin-sprayed host plant.

In cabbage leaves, Surround (kaolin) 60 g/L was applied, producing the mortality of *Trichoplusia* larvae, nor did this occur because kaolin particles affect the mobility of the insect causing dehydration, in addition to modifying the taste stimulus (26); we consider that in the present research kaolin in the different doses used probably had the same mode of action as what happened with Liang & Liu, (22).

Kaolin, in addition to causing the mortality of several species of insects, has repellent properties. Kaolin's repellency to insects is given by the visual cues they have to recognize their host (27).

In the study carried out it was evident that the 95% kaolin product caused repellency in all doses used. Whitefly (*B. tabaci*) is a species that is visually attracted to the wavelengths of yellow and green light reflected by certain plant host plants (28); (29); (8), spraying the leaves with kaolin covers the plant with a white film and this may have the potential to disrupt the regular visual cues that *B. tabaci exhibits* (8).

Research carried out by Pedreira, (15) mentions that when applying 3% kaolin in oranges, the ability of *Diaphoria citri* to locate hosts in citrus fruits was altered, causing psyllids to avoid kaolin-treated trees, probably due to changes in the visual characteristics of the plant. Kaolin changes the light that is reflected on the plant and the film formed by this product changes the texture of the leaf and fruit acting as an insect repellent (27).

The height, diameter and yield of the tomato crop presented the highest values when kaolin was used; These results are probably due to the fact that this inert powder acts as a protector against heat stress and reduces water stress in tomato production (30); (37). Kaolin allows high moisture absorption and has adherent properties, these characteristics prevent the decrease in plant growth or reduction of photosynthetic activity (31); (32), their mode of action may be directly related to the performance values obtained in this study.

Research confirms that among the various benefits of the use of kaolin it allows the increase of yields, for example, in the crops of potato (Solanum tuberosum L.), corn (*Zea mays*), beans (*Phaseolus vulgaris*), olive fruit (*Olea eropaea*), melon (*Cucumis melo* L.) (33); (34); (53); (35); (36).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

- Five species of insect pests were identified in tomato cultivation, with Bemisia tabaci being the most abundant (No. 808 specimens), followed by the following species: *Prodiplosis longifila* (No. 219), *Euschistus* sp. (No. 134), *Myzus persicae* (No. 112), *Manduca Sixth* (No. 24).

- The use of kaolin (Surround WP, kaolin 95%) at doses 20, 40, and 60 g/L, significantly reduces the population of *Bemisia published*, *Prodiplosis longifila*, *Euschistus* sp. *Manduca Sixth* and *Myzus persicae*, by creating a physical barrier between the insect and the host.
- Kaolin in different doses and insecticide repels whiteflies (*Bemisia published*) during the first 24 hours of product application. This is because a white film is formed that generates repellency in the insect.
- The highest values of stem diameter, plant height and yield were obtained in the treatments in which kaolin was used (T3 = 1.24 mm; T2 = 105.73 cm and T1 = 8958.71 kg/ha respectively). These results were probably presented because kaolin avoids plant stress and works as a photosynthetic activator.

Recommendations:

- Apply kaolin in doses of 20 g/L four times during the vegetative cycle of the tomato crop.
- Evaluate the repellency of kaolin and insecticide for periods greater than 24 hours under controlled conditions.
- Perform physiological tests to verify the beneficial effects of kaolin on tomato crop yields.
- Identify natural adjuvants in order to reduce the production costs of tomato cultivation.

BIBLIOGRAPHIC REFERENCES

[1] SIPA. Situational bulletin on kidney tomato cultivation. [Online].; 2022. Available in: http://sipa.agricultura.gob.ec/index.php/situacionales-agricolas/situacional-tomaterinon.
[2] Cacoango PM. Study of the adaptation and yield of 10 varieties of kidney tomato (Solanum lycopersicum L) under greenhouse, Riobamba canton, Chimborazo province Riobamba: Chimborazo Polytechnic High School; 2018.
[3] Zamora R, Villafuerte A. Diagnosis of pesticide use and impacts on tomato (Solanum lycopersicum) cultivation in the Río Chico parish, Portoviejo Canton, Manabí Province, Ecuador.
[4] Porcuna JL. White Flies Bemisia tabaci. Plant Health Service. 2010.
[5] Rodríguez S, Ortíz O, Castillo J. Evaluation of the environmental impact of pesticides for pestcontrol in the main horticultural crops of the Chancay-Huaralvalley, Lima. Peruvian Journal of Agronomy. 2023.
[6] Valverde A. Bacillus sp and Kaolin in the Control of Oligonychus sp in the Cultivation of Avocado Peru: Universidad Nacional Hermilio Valdizán; 2021.
[7] Choi H, Kim H, Lee W, Shin S, Lee S. Taxonomic Review of Genus Myzus (Hemiptera: Aphididae) in The Korean Peninsula with Descriptions of Three New Species. Journal of Asia-Pacific Entomology. 2019; 22(3).
[8] MacLEOD N, Canty R, Polaszek A. Morphology-Based Identification of Bemisia tabaci Cryptic Species Puparia via Embedded Group-Contrast Convolution Neural Network Analysis. En Biologists SoS, editor; 2021. p. 1-15.
[9] Johnston N, Paris T, Paret M, Freeman J, Martini X. Repelling whitefly (Bemisia tabaci) using limonene-scented kaolin: A novel pest management strategy. Protección de Cultivos. 2022.
[10] InfoStat. InfoStat version 2018. Universidad Nacional de Córdoba ed. Argentina: Grupo Infostat; 2018.
[11] RStudio T. RStudio: Integrated Development Environment for R. [Online]; 2015. Disponible en: http://www.rstudio.com/.
[12] Excel M. [Online]; 2016.
[13] Álvarez T, Bravo E, Armendaris E. Food sovereignty and access to horticultural seeds in Ecuador. La Granja: Revista de Ciencias de la Vida. 2014; 20(2): p. 45-57.
[14] Álvarez J, Cortez H, García I, Ceja L, Pérez J. Incidence of pests in tomato grafts (Solanum lycopersicum) on wild relatives. Colombian Journal of Entomology. 2009; 35(2): p. 150-155.

[15] Calderón O, Bolaños A, Muriel M. Evaluation of damage caused by Prodiplosis longifila Gagné (Diptera: cecidomyiidae) in the culture of Solanum lycopersicum L. in Gigante, Huila. Agricolae & Habitat. 2018; 1(1).

[16] Santos S, Tavares M. Monitoring of insects in tomato plantation with silicate fertilization. Tevista Biodiversidad. 2017; 16(3): p. 60-67.

[17] Borgues M, Zhang A, Camp M, Aldrich J. Adult Diapause Morph of the Brown Stink Bug, Euschistus servus (Say) (Heteroptera: Pentatomidae). Neotropical Entomology. 2001; 30(1).

[18] Garvey M, Creighton C, Kaplan I. Tritrophic interactions reinforce a negative preference–performance relationship in the tobacco hornworm (Manduca sexta). Ecological Entomology. 2020; 45(4): p. 783-794.

[19] Pedreira M, Tomaseto AF, Zanuzo O, Linhares HX. HLB: influence of kaolin on the ability of Diaphoria citri to locate host plants under field conditions. PHYTOMA. 2017.

[20] Valverde A, Valverde N, Solano R. Efficacy of neem oil, eucalyptus oil and kaolin in the biological control of Brevicoryne brassicae. Agroindustrial Science. 2021; 11(2): p. 185-192.

[21] Gonzales F, Jacobo S, Valverde R. Effectiveness of Bacillus sp and kaolin in the control of Oligonychus yothersi (McGregor) in avocado cultivation. Mangrove. 2020; 17(3): p. 233-238.

[22] Mamani D, Sporleder M, Kroschel J. Effect of inert materials from bioinsecticidal formulas on the protection of stored tubers against potato moths. Peruvian Journal of Entomology. 2011; 46(2): p. 43-49.

[23] Aguayo G, González P, Hepp R, Casals P. Control of sitophilus zeamais motschulsky with inert powders. Agrociecia. 2004; 38(5): p. 529-536.

[24] González M, Sánchez I, Cobos G, Marcotegui A, Cobo A, Pascual S. Evaluation of kaolin as a pest control tool in organic Mediterranean crops. Sustainable agriculture. 2011; 7: p. 12-23.

[25] Mazor M, Erez A. Processed kaolin protects fruits from Mediterranean fruit fly infestations. Crop Protection. 2004; 23(1): p. 47-51.

[26] Liang G, Liu T. Repellency of a Kaolin Particle Film, Surround, and a Mineral Oil, Sunspray Oil, to Silverleaf Whitefly (Homoptera: Aleyrodidae) on Melon in the Laboratory. Horticulture Entomology. 2002; 95(2): p. 317-324.

[27] Moarefi M, Seddigh S, Hamrahi, Ali. Effects of processed kaolin on Aphis fabae and Hippodamia variegata on broad bean: A lab and field case study. Crop Protection. 2022; 11(2): p. 211-227.

[28] Galdino, S, Silva C, Zanuncio J, Castellani M. Susceptibility of Alabama argillacea and Chrysodeixis includens (Lepidoptera: Noctuidae) larvae to Beauveria bassiana associated with kaolin. Brazilian Journal of Biology. 2021.

[29] Barker J, Holaschke M, Fulton A. Effects of kaolin particle film on Myzus persicae (Hemiptera: Aphididae) behaviour and performance. Bulletin of Entomological Research. 2007; 97(5).

[30] Díaz B, Garzo E, Duque M. Kaolin particles: effect on the mortality and development of Trichoplusia ni Hubner. Centre for Environmental Sciences, CSIC. 2002.

[31] Glenn M. The Mechanisms of Plant Stress Mitigation by Kaolin-based Particle Films and Applications in Horticultural and Agricultural Crops. HortScience. 2012; 47: p. 710-711.

[32] Hasanuzzaman A, Islam M, Zhang Y, Zhang C, Liu T. Leaf morphological characters can be a factor for intra-varietal preference of whitefly Bemisia tabaci (Hemiptera: Aleyrodidae) among eggplant varieties. PLoS ONE. 2016; 11(4).

[33] Johnston N, Martini X. The Influence of Visual and Olfactory Cues in Host Selection for Bemisia tabaci Biotype B in the Presence or Absence of Tomato Yellow Leaf Curl Virus. Insects. 2020; 11(2): p. 115.

[34] Catore V, Pace B, Albrizio R. Kaolin-based particle film technology affects tomato physiology, yield and quality. Environmental and Experimental Botany. 2009; 66: p. 279-288.

[35] Sétamou M, Sanchez A, Patt J, Nelson S, Jifon J. Diurnal patterns of flight activity and effects of light on host finding behavior of the Asian citrus psyllid. Journal of Insect Behavior. 2012; 25: p. 264-276.

[36] Muñoz C, Brainard A. Use of kaolin and fulvic acid biostimulants in the production and postharvest quality of tutored watermelon (Citrullus lanatus). In. Honduras: Zamorano; 2022.

[37] Río M, Quiroz J, Atuna O, Espinoza A. Agronomic response of four maize hybrids using kaolinite to reduce the effect of high temperature stress in Torreón, Coahuila. CEA Technology Magazine. 2021; (15): p. 90-94.