*Cultivos Tropicales, Vol. 46, No. 4, October-December 2025, e-ISSN: 1819-4087, p-ISSN: 0258-5936, https://ediciones.inca.edu.cu*

*Cu-ID: https://cu-id.com/2050/v46n4e09*

**Original article**

# Effect of extracts of *Solanum pimpinellifolium* and *Nicotiana tabacum* L. against the black weevil (*Cosmopolites sordidus*)

## Efecto de extractos de *Solanum pimpinellifolium* y *Nicotiana tabacum* L. frente al picudo negro (*Cosmopolites sordidus*)

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**ABSTRACT:** The objective of this research was to evaluate the bioinsecticidal effect of extracts of field tomato (*Solanum pimpinellifolium*) and tobacco (*Nicotiana tabacum* L.) against the black weevil (*Cosmopolites sordidus*). The extracts were obtained from dried leaves, ground, and bioactive compounds extracted with ethanol. Secondary metabolites (triterpenes, alkaloids, flavonoids, phenols, saponins, and reducing sugars) were identified. Insects were captured using *Musa paradisiaca* L. plantain pseudostem traps baited with cocoa placenta. Seven treatments with 10 replicates were established; each extract was exposed to a concentration of 20, 60, 100 %, and a control. Mortality was evaluated up to 12 days. The design was completely randomized; data were analyzed using ANOVA and Tukey's test ($p<0.05$). Morphological characterization of the weevil showed an elongated body measuring 10-14 mm, dark coloration, a prominent beak, bent antennae, and fused elytra with striations. Extracts from both plants induced mortality in *C. sordidus*, increasing with concentration and time; *N. tabacum* L. was significantly more effective than *S. pimpinellifolium*. In conclusion, phytochemical screening revealed the presence of bioactive compounds with similar insecticidal effects on tomato and tobacco. Morphological identification confirmed the species *C. sordidus*. The tobacco extract was more effective against the weevil, with mortality dependent on concentration and time, demonstrating a greater insecticidal effect than tomato.

**Key words:** Banana, biopesticide, insect, secondary metabolites, Musaceae, plantain.

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Received: 25/07/2025

Accepted: 03/09/2025

**Conflict of interests:** Authors declare they do not have conflict of interests.

**Contribución de los autores**: Mg. José Humberto Vera-Rodríguez: Ejecutó el plan experimental y escritura del documento, desarrollo de la investigación. MSc. José Omar Salavarría-Melo: diseñó el experimento y trabajó en la revisión del documento inicial. MSc. Henry Paúl Villón-Leoro: participó la supervisión de las evaluaciones realizadas. MSc. Daicy Veronica Rios-Catota participó en la conceptualización. MSc. Edison Macgyver Barragán-Taco: escritura del borrador inicial. MSc. Ingrid Lourdes Sandoval-Endara: Trabajó en la revisión del documento final y curación de datos. Ing. Angie Pamela Lopez-Orellana: Trabajó en la revisión del documento final.

**RESUMEN:** El objetivo de la investigación consistió en evaluar el efecto bioinsecticida de extractos de tomate de campo (*Solanum pimpinellifolium*) y tabaco (*Nicotiana tabacum* L.) contra el picudo negro (*Cosmopolites sordidus*). Los extractos se obtuvieron a partir de hojas secas, se molinaron y extrajeron compuestos bioactivos con etanol. Se identificaron metabolitos secundarios (triterpenos, alcaloides, flavonoides, fenoles, saponinas y azúcares reductores). Los insectos fueron capturados con trampas de pseudo tallo de plátano *Musa paradisiaca* L. cebadas con placenta de cacao. Se establecieron 7 tratamientos con 10 repeticiones, cada extracto se expuso a concentración de 20 , 60 , 100 % y un control. Se evaluó la mortalidad hasta los 12 días. El diseño establecido fue completamente aleatorizado, los datos se analizaron con ANOVA y Tukey ($p<0.05$). La caracterización morfológica del picudo negro mostró un cuerpo alargado de 10-14 mm, coloración oscura, pico prominente, antenas acodadas y élitros fusionados con estrías. Los extractos de ambas plantas indujeron mortalidad en *C. sordidus*, incrementándose con la concentración y el tiempo, *N. tabacum* L. resultó ser significativamente más efectivo que *S. pimpinellifolium*. En conclusión, el tamizaje fitoquímico reveló la presencia de compuestos bioactivos con efecto insecticida similares en tomate y tabaco. La identificación morfológica confirma la especie *C. sordidus*. El extracto de tabaco fue más efectivo para el picudo negro, con mortalidad dependiente de concentración y tiempo, demostrando mayor efecto insecticida que el tomate.

**Palabras clave:** Banano, bioplaguicida, insecto, metabolitos secundarios, musáceas, plátano.

# INTRODUCTION

The black weevil (*Cosmopolites sordidus*) is a species of curculionoid beetle belonging to the family Curculionidae. It is one of the main pests affecting banana and plantain crops, causing significant losses in agricultural production worldwide (1). Its adaptability and the resistance it has developed to chemical pesticides have prompted the search for alternative control methods that are more sustainable and less harmful to the environment (2). In this context, plant extracts such as those from wild tomato (*Solanum pimpinellifolium*), an herbaceous plant from the Solanaceae family, and tobacco (*Nicotiana tabacum* L.) have emerged as promising options for managing this pest.

Wild tomato, a native plant of the Americas, has traditionally been used for its edible fruits (3). Recently, its potential as a natural insecticide has been investigated due to the presence of bioactive compounds that can affect the physiology and behavior of various pest insects (4). Interest in its use as a bioinsecticide stems from the need to find viable alternatives that minimize environmental impact and protect human health (5).

On the other hand, Tobacco has long been recognized for its insecticidal properties. Nicotine and other alkaloids present in tobacco leaves are known for their effectiveness in controlling various pests (6). However, the use of tobacco in agriculture must be carefully managed due to its toxicity and the potential to affect non-target organisms (7). Research into its application as a bioinsecticide aims to maximize its benefits while minimizing associated risks.

The use of plant extracts for biological pest control aligns with current trends in sustainable agriculture. Wild tomato and tobacco extracts not only represent effective options, but can also be integrated into pest management strategies that promote biodiversity and soil health (8). Evaluating the bioinsecticidal effect of these extracts against the black weevil requires a detailed analysis of their efficacy and the conditions that may influence their performance (9). Factors such as extract concentration, application method, and environmental conditions are critical in determining their effectiveness. These studies are essential for establishing application protocols that ensure effective pest control without compromising the safety of surrounding ecosystems (10).

Traditional knowledge regarding the use of plants in agriculture can offer valuable insights and practices that complement scientific research (11). Collaboration among farmers, researchers, and communities can facilitate the implementation of locally sourced solutions and promote resilience in agricultural production (12). This interaction may lead to the development of innovative strategies that not only control the black weevil but also strengthen long-term agricultural sustainability.

Finally, the objective of this research is to evaluate the bioinsecticidal effect of wild tomato and tobacco extracts against the black weevil (*C. sordidus*). The results are expected to contribute to a better understanding of their potential as pest management tools and to the promotion of more sustainable and environmentally friendly agricultural practices.

# MATERIALS AND METHODS

## Study Site

The experimental work was conducted in the entomology laboratory of the Faculty of Agricultural Sciences at the Universidad Estatal Península de Santa Elena (UPSE), Ecuador. The collection of the black weevil (*Cosmopolites sordidus*) was carried out in a banana plantation located at Santa Trinidad farm in Juan Montalvo locality.

## Preparation of Plant Extracts

## Collection and drying of plant material

Leaves of wild tomato (*Solanum pimpinellifolium*) and tobacco (*Nicotiana tabacum* L.) were collected and washed with distilled water to remove surface residues. They were then dried at room temperature in darkness with adequate ventilation for 72 hours. Afterward, the samples were placed in a RONCO food dehydrator, Model FD-6000, at 45 °C for 24 hours to accelerate the drying process.

### Grinding of dried plant material

Once dried, the plant samples were ground using a FOSS laboratory mill, Model CT-293, until a fine powder was obtained.

### Extraction of bioactive compounds

Twenty grams of each powdered sample were weighed and placed in an Erlenmeyer flask with 80 % ethanol as the extraction solvent, using a solvent-to-plant ratio of 1:10 (w/v). This aimed to extract a broad range of polar and semi-polar compounds. The mixture was kept under constant agitation in a VWR orbital incubator shaker, Model 5000-I, for 48 hours at 25 °C to enhance extraction efficiency.

### Filtration of the extract

After extraction, the liquid extract was separated from the solid residue using Whatman No. 1 filter paper and a decanting funnel. The filtrate was stored in dark, airtight vials at 4-8 °C to prevent degradation of potential bioactive compounds.

### Determination of bioactive compounds

To identify triterpenes or sterols, the Liebermann-Burchard test was used. One drop of sulfuric acid was added to 1 mL of cold acetic anhydride, then mixed with 10 mg of dried plant extract dissolved in chloroform. The presence of these compounds was determined by observing color changes over 60 minutes.

To confirm the presence of alkaloids, the Mayer and Wagner tests were performed. Three drops of each reagent were added to 1 mL of extract. A white precipitate (Mayer) and a reddish-brown precipitate (Wagner) indicated the presence of alkaloids.

Flavonoids were identified using the Shinoda test. Magnesium shavings and three drops of concentrated hydrochloric acid were added to 1 mL of extract. A strong orange color with bubbling indicated a positive result.

Phenols were confirmed by adding two drops of ferric chloride to the extract. A dark green color indicated their presence.

Saponins were detected by shaking the extract vigorously for 30 seconds. The formation of stable foam lasting three minutes confirmed their presence.

Reducing sugars were identified by heating 0.5 mL of extract with 1 mL of Fehling's solution A and 1 mL of solution B in a water bath. A dark red precipitate indicated a positive result.

### Collection of Black Weevil

Traps were made using pseudostems cut in a "V" shape and placed on the ground. To enhance effectiveness, cacao placenta (CCN-51) was added to the center as an attractant, creating a space for insect entry. Collected black weevil specimens were transported to the laboratory for taxonomic identification and life stage classification using a Better Scientific Q170-T trinocular stereomicroscope.

### Experimental Design

Experimental units were distributed in individual plastic containers (500 mL volume), each ventilated with ten 2-mm diameter perforations to ensure proper air exchange. Each container served as one experimental unit, randomly assigned with three adult *C. sordidus* individuals. As a food source and substrate for treatment application, fragments of *Musa paradisiaca* L. stem (5 cm², ≈10 g fresh weight) were introduced and assigned as follows:

T1: *S. pimpinellifolium* extract 20 %
T2: *S. pimpinellifolium* extract 60 %
T3: *S. pimpinellifolium* extract 100 %
T4: *N. tabacum* L. extract 20 %
T5: *N. tabacum* L. extract 60 %
T6: *N. tabacum* L. extract 100 %
T7: Control

Insect mortality percentage was evaluated at 4, 8, and 12 days. The study assessed three extract concentrations (20, 60, and 100 %) over a 12-day period, with mortality recorded at each interval.

The experiment followed a completely randomized design (CRD), with seven treatments and ten replicates. Data were analyzed using one-way analysis of variance (ANOVA), and when significant differences were found, mean comparisons were performed using Tukey's test (HSD) at $p < 0.05$, with InfoStat software version 2020.

## RESULTS

Phytochemical screening. Table 1 presents the results of the phytochemical screening of *Solanum pimpinellifolium* (wild tomato) and *Nicotiana tabacum* L. (tobacco). This analysis is qualitative in nature and indicates the presence (+) of chemical compounds (triterpenes, alkaloids, flavonoids, phenols, reducing sugars, and tannins) in the plant extracts.

### Taxonomic Characterization of the Captured Black Weevil Species

Figure 1 shows the banana black weevil (*Cosmopolites sordidus*) observed under a stereomicroscope. The characterization reveals adult-stage insects with moderate body sizes ranging from 10 to 14 mm in length, featuring an elongated and cylindrical shape. Their coloration typically varies from black to dark brown, with a hard and shiny exoskeleton surface. A distinctive feature of this insect, as a member of the Curculionidae family, is the presence of a prominent and elongated snout projecting from the head. The antennae are inserted laterally on the rostrum and exhibit an elbowed structure with a club-shaped tip. The compound eyes are small and located on the sides of the head. At the tip of the rostrum, strong and sclerotized mandibles are visible, adapted for chewing and piercing plant tissue.

**Table 1.** Results of the phytochemical screening of wild tomato and tobacco plants

| Compound | Reference Method | Tomato | Tobacco |
|---|---|---|---|
| Triterpenes | Lieberrmann-Burchard | + | + |
| Alkaloids | Mayer Reactive | + | + |
| | Wagner Reactive | + | + |
| Flavonoids | Shinoda | + | + |
| Phenols | Ferric chloride | + | + |
| Reducing sugars | Fehling | + | + |
| Tannins | Foam | + | + |
| Saponins | Foam | + | + |

(+) Positive

**Figure 1.** *C. sordidus* viewed under the Better Scientific Q170-T stereomicroscope (Germany)

The thorax is divided into segments, with the prothorax bearing the first pair of legs. The elytra, which are modified and hardened forewings, cover the abdomen and the second pair of membranous wings used for flight. In *C. sordidus*, the elytra are fused and display well-defined longitudinal striae (grooves) or parallel lines along their surface. The number and characteristics of these striae, as well as the absence of hairs on them, are useful for identification. The insect has six legs, each segmented into coxa, trochanter, femur, tibia, and tarsus. The tarsus, the distal segment of the leg, ends in several tarsal claws, whose morphology may hold taxonomic value. The abdomen, in dorsal view, remains hidden beneath the protective elytra, while the ventral plates are observable from below.

Mortality rate of *C sordidus* under the effect of *Solanum pimpinellifolium* and *Nicotiana tabacum* L. extracts

Table 2 presents the results of the effect of plant extracts from two species, Solanum pimpinellifolium and *Nicotiana tabacum* L., on the mortality of the black weevil Cosmopolites sordidus.

Overall results show a trend of increasing mortality over time for most treatments, suggesting a cumulative effect of the extracts. Additionally, within each type of extract, a dose-response relationship was observed, where higher concentrations generally resulted in higher mortality percentages at each evaluated time point.

A significant difference in effectiveness was noted between the two plant extracts, with *N. tabacum L.* consistently demonstrating greater efficacy in inducing mortality in *C. sordidus* compared to *S. pimpinellifolium* at equivalent concentrations and time intervals. The control group, which showed no mortality, confirms that the observed insect deaths in treated groups were directly attributable to the action of the plant extracts.

Statistical analysis indicates that the *Nicotiana tabacum* L. extract is the most effective, based on the observed relationship between higher concentrations and increased mortality, as well as longer exposure times and higher mortality rates. These factors had a significant effect on the mortality of *C. sordidus.*

## DISCUSSION

Alkaloids, most notably nicotine in tobacco are well known for their insecticidal activity (13). They primarily act as neurotoxins in insects (14). The presence of other alkaloids in wild tomato, although in lower concentrations, may also contribute to its defense mechanisms against pest insects (15). Certain alkaloids found in solanaceous plants have demonstrated insecticidal activity against various species (16). Similarly, some triterpenes have shown insecticidal, antifeedant, and growth-disrupting effects in insects (17). Their presence in both extracts suggests a potential role in protecting against phytophagous insects.

Polyphenolic compounds may act as feeding deterrents, toxins, or growth regulators in insects (18). Some flavonoids can inhibit digestive enzymes in insects, while phenols may function as antioxidants in plants, indirectly contributing to defense by enhancing resistance to insect-induced stress (19). Tannins, due to their ability to bind to proteins, can reduce leaf digestibility for herbivorous insects, acting as antifeedants (20). Their presence in tomato and tobacco may contribute to induced resistance in these plants against certain insect pests.

**Table 2.** Effect of Solanum pimpinellifolium and *Nicotiana tabacum* L. extracts on *C. sordidus*

| Mortality rate (%) | *S. pimpinellifolium* | | | *N. tabacum* L. | | | Control | S.E. |
|---|---|---|---|---|---|---|---|---|
| | 20 % | 60 % | 100 % | 20 % | 60 % | 100 % | | |
| Days | T1 | T2 | T3 | T4 | T5 | T6 | T7 | |
| 4 | $0^{e}$ | $0^{e}$ | $10^{d}$ | $22^{c}$ | $54^{b}$ | $68^{a}$ | $0^{e}$ | 3.67 |
| 8 | $14^{f}$ | $24^{e}$ | $35^{d}$ | $46^{c}$ | $85^{b}$ | $100^{a}$ | $0^{g}$ | 1.93 |
| 12 | $29^{e}$ | $42^{d}$ | $60^{c}$ | $78^{b}$ | $100^{a}$ | $100^{a}$ | $0^{f}$ | 2.03 |

S.E.: Standard error. Identical letters within the same row indicate no statistically significant differences

Some saponins have demonstrated insecticidal and antifeedant activity by interfering with insect cell membrane permeability or disrupting the digestive system (21). The presence of saponins in both extracts may be a natural factor in their interaction with insects. The presence of these secondary metabolites with known bioinsecticidal activity in *S. pimpinellifolium* and *N. tabacum* suggests that extracts or isolated compounds from these plants may have potential for the development of botanical insecticides. Plant-derived bioinsecticides offer a more sustainable and environmentally friendly alternative to traditional synthetic insecticides (22).

The banana black weevil (*C. sordidus*) is taxonomically distinguished by its prominent snout, striated elytra, and dark coloration features easily observable under a stereomicroscope (23). These morphological traits are crucial for its identification and differentiation from other pest weevils. Accurate identification of weevil species is essential for implementing effective management strategies. External morphology, though basic, provides the first clues for recognizing *C. sordidus* in both field and laboratory settings.

## CONCLUSIONS

Phytochemical screening results indicate that both tomato (*Solanum pimpinellifolium*) and tobacco (*Nicotiana tabacum* L.) contain a similar array of secondary metabolites, including triterpenes, alkaloids, flavonoids, phenols, reducing sugars, tannins, and saponins. These findings suggest the need for further studies focused on quantifying the concentrations of these compounds.

Stereoscopic observation reveals that *C. sordidus* exhibits distinctive morphological features such as an elongated rostrum, striated elytra, and dark coloration that allow for preliminary identification.

The extract of *N. tabacum* L. proved significantly more effective than that of *S. pimpinellifolium* in causing mortality in *C. sordidus*. As extract concentration and exposure time increased, *N. tabacum* L. consistently demonstrated greater insecticidal potential, even at lower concentrations.

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