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Nematode of the genus Steinernema sp. as a possible controller of *Frankliniella occidentalis* in the propagation of cuttings of four standard carnation cultivars in the savanna of Bogotá.

Nematodo del género Steinernema sp. como posible controlador de *Frankliniella occidentalis* en la propagación de esquejes de cuatro cultivares de clavel estándar en la sabana de Bogotá

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Abstract
Thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thrypidae), is a polyphagous quarantine pest that causes damage throughout the development cycle of plants; for carnation cuttings its damage is identified as leaf scrapings, tissue deformations and reduction of cuttings size, which affects their marketability. Entomopathogenic nematodes are efficient biological controllers, they associate symbiotically with gram-negative bacteria and kill the prey in a short time. The objective of this research was to determine the effect of the nematode genus *Steinernema*, evaluating the incidence of *F. occidentalis,* the efficacy of *Steinernema* sp. with respect to the production of cuttings and a cost-benefit relationship comparing biological and chemical control in a commercial carnation propagation crop in the Sabana of Bogota. The evaluation was performed on four standard carnation mother plant cultivars between weeks 44 and 52 of 2018, polyurethane foams containing 1 x ^{106} infective juveniles of Steinernema sp. applied using a flute irrigation system were used and compared with a control group (commercial chemical).
Key words: Biological control, cultivars, thrips, entomopathogenic nematodes, carnation.

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Received March 22, 2020
Approved: October 27, 2020

Resumen
Los trips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thrypidae), son una plaga cuarentenaria polífaga que ocasiona daños en todo el ciclo de desarrollo de las plantas; para los esquejes de clavel su daño se identifica como raspaduras en las hojas, deformaciones del tejido y reducción del tamaño del esqueje, lo que afecta su comercialización. Los nematodos entomopatógenos son controladores biológicos eficientes, se asocian simbióticamente con bacterias gram-negativas y matan a la presa en corto tiempo. La investigación tuvo como objetivo determinar el efecto del nematodo del género *Steinernema*, evaluando la incidencia del *F. occidentalis,* la eficacia de *Steinernema* sp. respecto a la producción de esquejes y una relación costo-beneficio comparando el control biológico y el control químico en un cultivo comercial de propagación de clavel en la Sabana de Bogotá. La evaluación se realizó en cuatro cultivares de plantas madre de clavel estándar entre las semanas 44 y 52 de 2018, se utilizaron espumas de poliuretano que contenían 1 x 10^6 de juveniles infectivos de Steinernema sp. aplicados mediante un sistema de riego por flauta y se compararon con un grupo control (producto químico comercial).
Palabras clave: Control biológico, cultivares, trips, nematodos entomopatógenos, clavel.

Introduction

In Colombia, flower production for export has been important for the country, ranking second only to the Netherlands. The main export destination for flowers is the United States, with roses, carnations, mini carnations, chrysanthemums, and foliage being the most in demand Quirós (2001). The flower industry in Colombia has become billions of dollars, with approximately 75% of exports to the United States, creating alliances and free trade benefits, to obtain success between the two countries and increase the employment rate (Salom & Sepúlveda, 2012). For 2018, Colombian flower exports reported US$75.5 million through April, with a volume of 14,415 t and for 2017 US$1,342 million. The area cultivated in flowers is equivalent to 8,000 ha planted and is concentrated in the Bogotá savanna with 66% (Lesmes-Fabian & Binder, 2013, p.23).)

Carnation is mainly propagated by cuttings while maintaining the mother plants in optimal conditions; however, productivity has decreased in recent years due to factors such as pathogens and pests Lopez et al.,(2010). One of the main pests affecting carnation is the thrips *Frankliniella occidentalis* (Thysanoptera: Thrypidae

Gillett-Kaufman et al., (2009); Picard et al., (2012) quarantine pest that causes damage from sowing to the end of the cycle, on leaves, buds, stems and flowers (Mouden et al., 2017, p. 34). In production cuttings, damage is identified as leaf scrapings, size reduction and deformations Rodríguez-Reina et al., (1992); (Arévalo et al., 2007).

The quality of cuttings is related to phytosanitary conditions; when symptoms of damage are present, they cause economic losses (Funderburk et al., 2000), in order to prevent them, control strategies such as ethological, cultural and chemical (Reitz et al., 2003) have been used in the management of thrips, whose inadequate management causes damage to soil, water and living beings. Agriculture in the new millennium must establish new control alternatives that produce less environmental impact and risk (Melo, Ortega, Gaigl, 2010, p. 19) that will reduce the use

of synthetic pesticides, which, due to their high cost, represent a limitation in their use. According to the World Health Organization (WHO), between 500,000 and one million people are poisoned annually by pesticides, and between 5,000 and 20,000 lose their lives, taking into account that 50% of those who die are agricultural workers and the other 50% from consuming contaminated products. It is important to take into account sustainable development, referring to the efficient use of natural resources, where it is possible to improve the welfare of the current community, without compromising the quality of life of future generations Guedez & Castillo (2016), therefore, alternatives such as biological control are important.

One of the biological control methods used for thrips management, which have been little studied in conditions of the Bogotá savanna Jiménez et al, (2012) are nematodes, individuals recognized for their efficiency in predation since they can take less than 48 h to kill their prey and are associated with gram-negative bacteria of the genera *Xenorhabdus* and *Photorhabdus*, produce proteases that digest insect tissues and antibiotics capable of inhibiting the growth of secondary colonizers Melo et al. (2009)The life cycle of the *Steinernema* nematode begins when it enters the insect through natural openings such as spiracles, mouthparts and anus, the juvenile infective travels through the hemolymph and regurgitates the bacteria of the genus *Photorhabdus*, from inside its intestine, the bacteria proliferate and produce toxins that kill the insect, antibiotics, enzymes that degrade tissues and essential nutrients for the growth of *Steinernema*, which, after three generations, remains in the soil until it finds the next host.

To date, there are no reports in Colombia on the effects of entomopathogenic nematodes in carnation propagation agricultural production systems. Therefore, research was carried out to determine the effect of the use of the nematode *Steinernema* sp. on the population fluctuation of thrips *Frankliniella occidentalis* (Thysanoptera: Thrypidae) and the productivity of cuttings of four standard carnation cultivars in a commercial crop in the Bogotá savanna.

Materials and methods

The trial was carried out at FLORVAL Sede QFC, located in Gachancipá, Cundinamarca (5°00'34.5 "N, 73°51'13.7 "W, 2,664 masl). In this area the average temperature is 14°C, the average relative humidity is 81% and the monthly sunshine is 126.4 hours. There was a wooden greenhouse in the carnation mother plant propagation area, which consists of 17 bays each with an area of 435.5 ^{m2}, each bay has eight benches 31 m long and 1 m wide, where the standard carnation mother plants are located, where 1400 plants/bench of different cultivars are planted in a substrate based on mineral coal slag; For the study, the greenhouse was divided into two parts (A and B), A (test) where the product was applied and B (control) where the product was not applied.

Based on the commercial importance and damage caused by *Frankliniella occidentalis* thrips, four standard carnation cultivars were chosen: Rafflesia, Aragon, Moon Light and Selene.

The product applied was based on entomopathogenic nematodes of the genus *Steinernema*, in inert polyurethane sponges of 15 x 18 cm without dispersants; each sponge contained 10 million infective juveniles, being a safe product for human and environmental use. The nematodes were kept at a temperature between 8 and 12 °C; direct light and freezing of the product should be avoided; they should remain in their original packaging until use and in a horizontal position to avoid precipitation of the material.

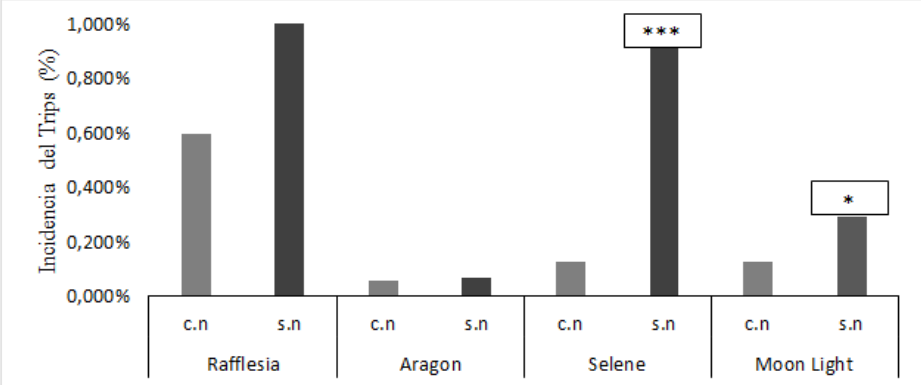
The product mixture was prepared in a container with a capacity of 60 L, taking into account that 2 L of water would be applied to the container for each application bank for a total of 16 L per vessel, and then a foam was introduced with the juvenile infectives of *Steinernema.* To remove the foam, three rinses were performed and 2 cm3 of a coadjuvant was added to the mixture for each application bank, which acts as an adherent and penetrant. For the application, the mixture was connected to a venturi tube and the banks were irrigated by means of a flute irrigation system for 1 min per bank.

The number of cuttings harvested per cultivar and the number of cuttings removed per cultivar were taken into account for the collection of trial data. Data were recorded daily for nine weeks. For count analysis the data were fitted to a generalized linear model of a logistic regression with proportions and a Poisson regression, using the R statistical package.

Result

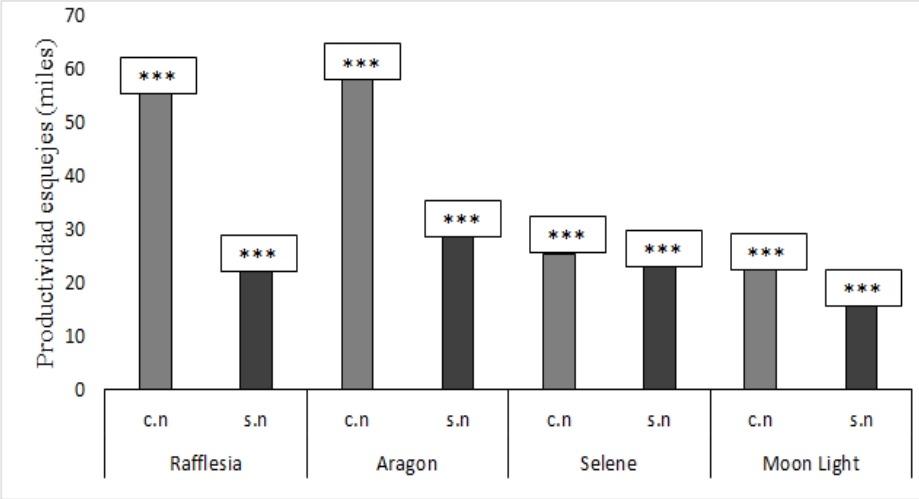
The data were fitted to a generalized linear model with a logistic regression with proportions to measure thrips incidence in Rafflesia, Selene, Aragon and Moon light cultivars, the regression model presents a significant difference between treatments and cultivars. Thrips incidence was significant for Selene cultivars with (P<*.001) and* Moon light with (P<*.05) (*Figure 1).

Figure 1. Incidence of *Frankliniella occidentalis* thrips on standard carnation propagation cultivars (Rafflesia, Aragon, Selene, Moon Light). c.n: with nematodes, s.n: without nematodes.



The data were fitted to a generalized linear model with a Poisson regression to measure the efficacy of *Steinernema* nematode on the productivity of good cuttings of Rafflesia, Selene, Aragon and Moon light cultivars of the treatments with nematodes and without nematodes, the Poisson regression model presents a significant difference between treatments and cultivars. The efficacy of nematodes was significant for all cultivars with (*P<.001) (*Figure 2).

Figure 2. Productivity of cuttings of the four cultivars (Rafflesia, Aragon, Selene, Moon Light) to measure the efficacy of the nematode genus *Steinernema*. c.n: with nematodes, s.n: without nematodes.



When measuring the incidence of thrips, the variables of the number of total cuttings with respect to the number of cuttings affected by the pest were taken into account, by means of a logistic regression with proportions the incidence was measured in the four carnation propagation cultivars resulting in a higher incidence in two of the cultivars Selene and Moon light, being the white carnation cuttings with a higher incidence compared to the red ones, since thrips has a visual stimulus capacity of attraction to white color (Castresana et al., 2009, p. 98). In a study they measured the incidence of thrips populations on three species of solanaceae in different cropping systems by a method of beating leaves on white cardboard, the incidence of thrips were susceptible in some varieties of solanaceae species by the influence of genotype (Gonzalez & Suris, 2011, p.10).)

The effectiveness of the nematode was evident, since it fulfilled the proposed objective of lowering the incidence of thrips, by means of a Poisson regression model and taking into account the productivity of the cuttings with respect to the two treatments, it was significantly evident that where the application was made there was greater productivity of the propagation cuttings, being highly significant for all cultivars. In a study, the effectiveness of the nematode *Heterorhabditis bacteriophora* (Nematoda: Heterorhabditidae) for the control of larvae of *Phyllophaga spp*. (Coleoptera: Scarabaeidae), they measured the efficiency of the nematode

by applying a different amount of nematodes in a lettuce crop through a drip irrigation system. It is important that in carnation propagation another trial be conducted later to measure the efficiency of the Steinernema nematode at different application rates and to make a comparison between cultivars.

Conclusions

The incidence of *Frankliniella occidentalis* thrips was more significant in white cultivars (Selene and Moon ligth) than in red cultivars (Raflessia and Aragon). However, other tests such as color traps are required to measure the incidence according to the visual stimuli developed by the thrips. The efficacy of the nematode was highly significant; it fulfilled the objective of reducing thrips damage because a higher productivity of cuttings was obtained in the nematode treatment. It is required to test the efficiency of entomopathogenic nematodes at different doses.

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