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Botanical Product Controlling Nematode on Tomato in Zalingei, Central Darfur, Sudan

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A B S T R A C T

Plant extracts are, nowadays extensively used as environmentally friendly ways for biological control of insect and plant diseases, instead of using chemical pesticides. Therefore, this study aimed to find out the effect of *Calotropis procera*, Poultry manure, Carbofuran, and *Beauveria bassiana* (Bals.) on root-knot nematode (M. incognita) in tomato crop. To study the efficacy of different botanical extracts for management of root-knot nematode, *M. incognita* in Zalingei, Central Darfur, Sudan, a pot experiments were conducted. Results showed that all biological extracts caused significant decreases in egg hatching and increasing nematode mortality and increasing growth and yield parameters of tomato crop. It found that these biological extracts are involved in plant defense and hence provide resistance against nematode attack that reveals with good response to the environment and saving human life.

Introduction

Tomato belongs to the Solanaceae family, and it is one of the most commonly cultivated vegetable crops worldwide. Solanum section Lycopersicon includes the cultivated tomato (*Solanum lycopersicum* L.) and 12 additional wild relatives, but *S. lycopersicum* is the only domesticated species. The tomato originated from South America, then spread globally through different levels of domestication, starting prior to the 15th century and continuing into Europe, arriving to its present status as one of the most highly consumed food crops of international acclaim (Sinno *et al.*, 2020).

Tomatoes are a rich source of micronutrients, such as minerals, vitamins, and antioxidants that are essential for the human diet. They also contain high levels of lycopene, an antioxidant that reduces the risks associated with many cancers and neurological diseases. Many pests and diseases affect both the quantity and quality of tomato production. Plant-parasitic nematodes are one of them (El-Sappah *et al.*, 2019).

Root-knot nematodes (Meloidogyne spp.) are economically important worldwide pathogens causing considerable damage to many crops, including cucumbers, tomatoes, rice, pepper, okra, watermelon, cantaloupe, onion, pumpkin, squash, sweet potato, sweet corn, carrot, eggplant, bean, pea and even cotton (He *et al.*, 2020).

Root-knot nematodes also feed and multiply on many garden weeds, although they may not injure these plants to any extent. Tomato (*Lycopersicon esculentum* L.) is one of the most popular and important commercial vegetable crops grown throughout the world. Tomato is a rich source of various micronutrients and antioxidants (Hassan, 2020).

Although chemical nematicides have been widely used in commercial agriculture to control nematodes, they are both highly toxic and very expensive. Nematicides are not suitable for home garden use. Control of root-knot nematodes in gardens involves a combination of growing resistant varieties where available, good cultural practices, and encouraging natural biological control. Scientists fined that the use of nematicides is an effective way of controlling plant-parasitic nematodes. However, the long-term use of traditional organophosphorus and carbamate chemical nematicides can lead to increased nematode resistance (Ji-xiang and Bao-an, 2021).

Alternative techniques based on agronomic practices are needed to solve the problem of nematode the most recent studies related to these techniques and their combinations and identify the most effective ones. Based on an agronomic point of view, the analysis focuses on a description of agricultural factors and practices, rather than on biological processes (Collange *et al.,* 2012). Bio fumigation is a technique that consists of the use of green manure material which is incorporated into the soil to reduce the population of a parasite and increase soil fertility (Sasanelli *et al.,* 2021). All the inoculum densities of M. incognita resulted in significant reductions in growth and yield variables of cucumber and increases in nematode infestations of both cultivars over their controls. The reductions in the resistant cultivar were significantly lower when compared to the highly susceptible one at all inoculum levels (Mukhtar, 2020). Root-knot nematode (Meloidogyne spp.) in tomatoes is reported to cause yield reduction in a considerable amount worldwide widely including symptoms ranging from stunted growth, galled roots, chlorosis, wilting, and eventually death of the host (Rawal, 2020).

Nematodes are non-segmented roundworms that are generally microscopic. They live in animal hosts, soil, plant roots, or water. Nematodes in agricultural systems usually live in soil and can be divided into three categories: (1) entomopathogenic nematodes that feed on insects; (2) free-living nematodes that feed on bacteria, fungi, or other nematodes and may be beneficial for crop production; and (3) plant-parasitic nematodes that feed only on plants and may drastically suppress yields on many crops, including peanut. This article is a guide to managing plant-parasitic nematodes in peanut production and is intended for use by agricultural professionals involved in the peanut industry through production, processing, advising research, or regulation (Grabau and Dickson, 2021).

Meloidogyne is a sedentary endoparasite that lives within the tissue, has a wide geographical distribution, and forms root knots. There are more than 90 species of Meloidogyne identified, however *M. arenaria, M. javanica, M. hapla,* and *M. incognita* are the most important because they cause major economic damage (Navarrete *et al.,* 2018).

Meloidogyne incognita infection significantly reduced plant height, stem girth, fresh plant mass, fresh storage root number, and storage root weight. Percentage yield loss of between 41.8-88.4% was recorded in M. incognita-infected plants compared with non-infected controls (Akinsanya *et al.,* 2020).

Crude extract of *Calotropis procera* application in tomato nursery showed significant results in increased seedling growth and decreased nematode

population (Saravanapriya and Sivakumar, 2005). The results obtained from a study suggest that poultry manure possesses a great potential or effective control of root-knot nematodes. This is particularly so for the small-scale farmer, who may be limited by insufficient capital to acquire nematicides. The use of this and other organic amendments is fast gaining prominence in Nigeria, especially now that nematicides and fertilizers are becoming prohibitively expensive for small-scale farmers (Taylor *et al.,* 2008).

Significant control of *M. incognita* was obtained on tomato and eggplantby bare-root treatment in dimethoate, carbofuran, fenamiphos, ethoprophos, and phorate. In another experiment, the control of *M. incognita* and *R. reniformis* was observed by bare-root dip treatment in triazophos/hostathion, carbosulfan/posse, and rugby on tomato and eggplant(Siddiqui, 2007).

The plant extracts of Acacia modesta (roots), Segeratiathea (leaves), and Celtiscaucasic (aerial part) exhibited highly promising mortality decrease in egg hatching with an increase in extract concentration of Acacia modesta (roots), Segeratiathea (leaves), and Celtiscaucasic (aerial part) were found to be the most effective in reducing egg hatching. Larval mortality is strongly influenced by the concentration of extract, plant species, and duration of period(Incognita, 2020).

Both pre-planting and at-planting application of PL251 was found to reduce nematode populations and root galling in both tomato and cucumber (Kalele and Affokpon, 2010).

Application of compost and carbofuran to tomato seedlings in susceptible soil with RKN, showed a significant reduction of the population of RKN in soil and roots, and a significant increase in the growth and yield of tomatoes (Abolusoro *et al.,* 2020).

Application of phytochemicals caused a reduction in the number of galls, galling index, and egg masses on tomato plants and enhanced plant growth parameters under screen house conditions (Khan *et al.,* 2020).

The nematicidal activity of the aqueous extracts of garlic cloves and castor seeds was evaluated against the root knot nematode M. incognita, infecting tomato. The tested materials reduced the number of galls and egg masses on tomato roots, and root and soil J2 populations as compared to nematode-infected plants (El-nagdi *et al.,* 2013).

The study sites of Dire Dawa and HU indicated that soil application of BioNem proved significantly better over root dip treatment in reducing root-knot nematode and in increasing plant growth and yield of tomato over untreated control. Therefore, out of different dosages of BioNem evaluated the dosage of 200 kg/ha appeared to be the optimum dosage for nematode control and the crop yield (Terefe *et al.,* n.d.).

As with conventional plant disease control, much effort has been directed at the development of effective strategies and tactics for the biological control of plant pathogens. Although the goal has been to develop effective biocontrol based on ecological principles, many highly complex ecological interactions of soil-borne pathogens with resident fauna and microflora remain to be elucidated. Much progress has been made, nevertheless, in developing efficacious biocontrol of numerous plant pathogens. Currently, at least 37 biocontrol agents are available commercially.

Alcoholic or phenolic compounds are extensively present in plants and microorganisms and show a broad spectrum of biological activities. Some alkyl alcohols and enols have good nematicidal activity, with the strength of the nematicidal activity related to the chain length or position of the ethylenic bond (Ji-xiang and Bao-an, 2021).

Their use as a means for managing plant-parasitic nematodes can be synergistically improved by making a combination with other cultural and

biological nematode management strategies (Mokrini *et al.,* 2018).

Egg hatching inhibition and larval mortality decreased with a decrease in the concentration of the extracts. Juvenile mortality increased parallel to an increased time of exposure. The potential of using plant extracts in controlling plant-parasitic nematodes has been shown by several authors (Hayet *et al.,* 2021).

Synthetic or Chemical nematicides is one of the most fastest and effective nematode control methods, but they are hazard to humans, environment and are relatively unaffordable to the average small scale farmers (Reddy, n.d.). The nematicidal effect of the tested crude extracts of different plants may probably be because of the higher content of certain oxygenated compounds, which considered possessing lipophilic properties that allow them to dissolve the cytoplasmic membranes of nematode cells and their functional groups interfering with enzyme protein structure.

Materials and Methods

A pot experiment was conducted at a Demonstrated farm near the Faculty of Agriculture, University of Zalingei. Pots of 15 cm diameter, disinfected with 4 % formaldehyde (Formalin 40 EC). After drying, pots were filled with nematode-infested soil (5 kg/pot).

Five treatments of botanicals and one control. Treatments were tried in a Completely Randomized Design with four replications. The pots were watered regularly for proper decomposition. Watering and plant protection measures were taken as per the requirement. The plants were removed carefully after 30 days of sowing and observations were recorded and analyzed.

Beauvaria spp

Beauvaria spp was brought from the University of Khartoum- Faculty of Agriculture.

Calotropis procera

The leaves of *Calotropis procera* were collected from Zalingei area. Five kilograms of Leaves were air-dried and ground to powder. It was soaked in water for twenty-four hours then soaked and sieved. The filtrate was taken as 100% concentration solution of leaf extract, and then diluted to, 50% and 25%.

Poultry litter preparation

Fresh poultry litter was collected from a chicken house in Zalingei, and then the manure was mixed to make uniform in composition, after that arranged in heap/pit will o.5 m × 0.5 m × 0.25 m (length × width × height or depth).

Data analysis

Data were subjected to statistical analysis of variance (ANOVA) using Statistix 8 1985-2003 software USA. Microsoft Excel 2016 software was used to insert data to Statistix software. Duncan's multiple range test was used to separate means at the 5% level of significance.

Results and Discussion

This study demonstrated the potential of biological nematicides to control *M. incognita* in tomato cultivars. Data present in table 1 shows the effect of different types of botanical materials on tomato plants to control nematode. *Meloidogyne incognita* infection significantly reduced tomato growth parameters (plant height, number of leaves, and root fresh weight) and yield parameters number of fruit, fruit weight, and total mass fresh weight these results are the same as the finding of (Akinsanya *et al.,* 2020). The result significantly shows that the cabofuran and *Calotropis procera* 50% recorded the highest yield of plant height the followed by *Beauveria bassiana* and the lowest yield was recorded in poultry manure and control. While after 60 days' data recoded showed no significant differences that might be to a reduction of natural

product materials on nematode. A significant increase in mortality rate as compared to control was observed.

Anwaar and Mckenry, (2012) reported that yield reduction of tomato ranging from 32-40% due to nematode infection. All the plants used as amendments caused significant reductions in *M. incognita* infections, resulting in increases of all growth parameters of tomato except root weight.

Natural products of different plants play a significant role in the management of nematodes according to their constituent in different ways. The results agree with those of Muller and Gooch (1982); Ali (1990) and Akhtar and Alam (1990).

The use of organic soil amendments is the cheapest and most effective way to control plant diseases caused by nematodes. Amendments not only change the physical and chemical properties of soil but also support a wide variety of antagonist microorganisms like fungi, bacteria, etc.

The decomposition products from soil amendments are direct might be toxic to plant nematodes, and manipulation of soil microbial populations by the addition of amendments initiates a cascade of events favoring the build-up of bacteria, microbivores, nematode-trapping fungi and other soil antagonists that destroy parasitic nematodes. The breakdown of organic matter releases compounds into soil that may be toxic to nematodes.

The botanical extract of (*C. procera*) probably released some alkaloids during decomposition which might be toxic to nematodes and at the same time enhanced the microbial population in the soil besides providing major elements required for plant growth were reported by (Saravanapriya and Sivakumar, 2005).

The soil amendments with organic additives such as leaves of different plants (*A. mexicana, C. procera, D. stramonium, E. crassipes,* and *E. citridora*), tea waste, kail sawdust, and neem sawdust significantly increase the plant growth and reduced the multiplication of root-knot nematode. This might have been partly due to the reduction in nematode population and partly to the fact that additives also served as manures. It has been suggested that the reduction in the nematode population might be due to the accumulated toxicity of the decomposing products (Ahmad and Khan, 2004).

Application of biocontrol such as that Neem and *Beauveria bassiana* were found effective treatments against *Meloidogyne graminicola* recorded with a maximum reduction of root galls population in rice seedlings (Niveditha *et al.,* 2019).

Effect of plant extracts on larval mortality of biological plant extracts presented in Figure 1. The rate of mortality was directly proportional to the exposure period and concentration of extracts. The result indicates that there is a significant effect on biological extract on mortality of nematode.

Among plant extracts, maximum mortality was recorded with Carbofuran followed by *Calotropis procra* and Beauvaria spp and Poultry manure respectively. In a study conducted by (Hussaini *et al.,* 1996) it has been reported that leaf extracts of 11 plant species inhibited egg hatching and caused 90% larval mortality in *M. incognita, M. javanica*, and *M. arenaria*. Our results are in a parallel line with the results of (Hussaini *et al.*, 1996)

In addition, the results of the current study are in agreement with the results of (Nandal and Bhatti, 1983) who have reported that some of the plant extracts showed significant nematicidal properties. According to (Khan, 1990) many wild and cultivated medicinal plants shown to possess nematicidal properties against several plant-parasitic nematodes.

Data present in Figure 2 show the effect of biological plant extracts on the hatching of nematode larvae. All plant extracts showed an inhibitory effect on the hatching of *nematode larvae* juveniles.

Table.1 The Effect of Biocontrol of Nematode on Tomato Growth and Yield Parameters

Treatments	Plant Height	Leave number	No of Fruits	Fruit weight	Total F. weight	Root F. weight	Root D. weight
Poultry manure	70.450ab	17.250 a	5.2500 b	99.500 b	222.94 c	11.357 c	1.3250 a
Calotropis procera 50%	71.000ab	16.000 a	6.0000 b	106.50 a	259.91 a	16.832 a	1.2375 a
Calotropis procera 25%	71.010ab	16.000 a	6.2500 b	102.25 b	244.69 b	16.703 a	1.4025 a
Beauverabassiana	70.483ab	14.000 b	5.7500 b	100.00 b	224.47 c	14.415 a	1.6350 a
Carbofuran	72.127 a	17.000 a	8.2500 a	109.50 a	262.91 a	17.463 a	1.9325 a
Control	69.850 b	9.7500 c	3.5000 c	93.750 c	217.31 c	18.473 a	1.6775 a
LSD	0.93	0.77	0.81	1.88	4.63	1.04	0.35

Fig.1 The Effect of Biocontrol on Nematode Mortality.

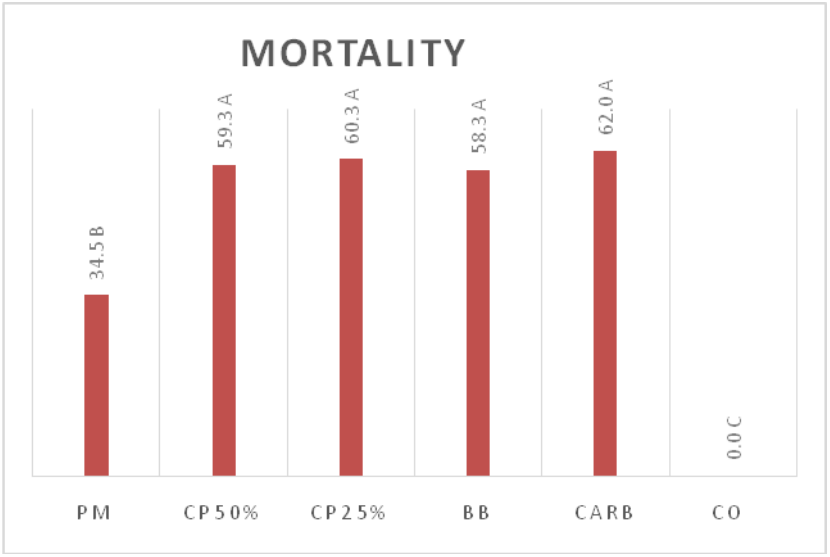

Fig.2 The Effect of Biocontrol on Nematode Egg Hatching.

The rate of hatching was directly proportionate to it is exposure, plant constituent, and to some extent to the concentration of extracts as it has decreased with an increase in concentration. There were no significant differences due to the use of the biological plant, while there is a significant difference between plant extract and control.

PM significantly reduced both root galling and nematode population with 4t/ha significantly increasing yield characters of carrot. Since PM significantly reduced ($p < 0.05$) nematode infestation and promoted growth and yield of carrots, farmers are encouraged to use it preferably at 4 t/ha (Kankam *et al.*, 2015). The suppression of galling in treated plants could be due to the production of substances such as propionic, butyric, and acetic acids from PM, which have nematicidal properties (Sikora and Fernandez, 2005). *B. bassiana* has a repressive action on nematodes of the genus. *Meloidogyne* spp (Bradley *et al.*, 1992; Bekanayake and Jayasundar 1994; Liu *et al.*, 2008). Although some of the traditional practices of plant nematode control are still used around the world biotechnological approach plays a great role in recent days. It can be concluded that tomato plants infected with root-knot nematodes (*M. incognita*) showed significant physiological responses and promoted plant growth and health by decreasing shoot and root systems while treated with Biological extract showed the significant result in increasing growth and production of tomatoes. Also, it can have induced the excitation of the immune responses of plants against infection with the nematode. The use of biological extract is cheap and very good to have a clean environment.

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