Journal of Plant Protection and Pathology

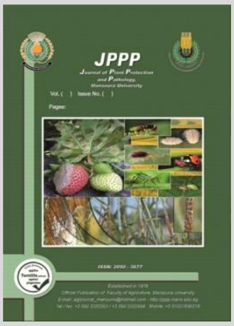
Journal homepage: www.jppp.mans.edu.eg
Available online at: www.jppp.journals.ekb.eg

Nematicidal Activity of Seed Powders of Some Ornamental Plants against Meloidogyne Incognita Infecting Pepper under Greenhouse Conditions

Shalaby, M. M.[1]; S. B. Gad[2]; A. E. Khalil[3] and A. G. El-Sherif[2]

[1] Agric. Zoology Dept., Fac. Agric., Damietta Univ., Egypt.
[2] Nematology Res. Unit, Agric. Zoology Dept., Fac. Agric., Mansoura Univ., Egypt.
[3] Nematology Division, Plant Pathology Inst. Res. A.R.C., Giza, Egypt.

Cross Mark



ABSTRACT

The present work was conducted to study the effectiveness of powdered seeds of six plant species namely: Brassica rapa, Eruca sativa, Juniperus communis, Lepidium sativum, Raphanus sativus, Sinapis alba on controlling Meloidogyne incognita infecting pepper plants cv. Top Star under greenhouse conditions. The application of S. alba seed powder overcome other treatments and accomplished the highest reduction percentages of nematode stages with the maximum values of 93.09, 93.94, and 95.75% for final nematode population, galls, and egg masses numbers, respectively at a rate of 6g/plant, while the least values were achieved by E. sativa seed powder with values of 67.88, 77.38 and 81.71 % for previous criteria, respectively at a rate of 2g/plant. There was a significant improvement in the plant characters (length, fresh weight & dry weight plant and leaf numbers). Among all treatments, the best plant growth character (plant length:143.1%, fresh weight:118.4%, dry weight plant:100.0%, and leaf numbers:99.5%) were observed with B. rapa grind seeds, followed by J. communis at a rate of 6g/plant. Increasing the used powdered seed rate from 4 to 6g/plant for S. alba and L. sativum cause a decrease in the plant growth parameters. Overall, all tested applications increased the percentages of chemical constituents i.e., nitrogen, phosphorus, and potassium concentrations, and phenol contents as well as decrease total chlorophyll percentages to a certain extent. The present study indicated the potential of screened plant seed powders to control M. incognita under greenhouse conditions and can be used as soil amendments after further investigations.

Keywords: *Capsicum annum*, bioagents, control, botanical pesticides

INTRODUCTION

Pepper (*Capsicum annum* L.) is one of the most important vegetable crops in many countries of the world. In Egypt, it supplies its importance as being a vegetable crop having marketing and exporting values, where the total area under production reaches 91840 feddans and annual production is estimated to be more than 676 thousand tones with a productivity of 7.37 tones/feddan in Egypt (Annual bulletin 2019). Pepper plants are recognized to be attacked by several soil-borne pathogenic fungi and nematodes which are responsible for serious diseases as root rot caused by *Fusarium solani*, *Rhizoctonia solani* and root-knot nematode caused by *M. incognita* Chitwood as well as complex diseases. In general, complex diseases are highly destructive and difficult to control (Kamali *et al.*, 2015).

Plant-parasitic nematodes caused damage in plants and produced secondary infection by facilitating other organisms such as viruses, bacteria, and fungi (Smant *et al.*, 2018). However, it is often not easy to distinguish damage caused by nematodes from other causes due to their microscopic size. They are usually live-in soil, roots, and leaves and pose a huge threat to agriculture, with annual losses amounting to about 157 billion US $ (Youssef *et al.*, 2013). Some nematodes are migratory in nature while others are sedentary (Palomares-Rius *et al.*, 2017 and Kihika *et al.*, 2017). The top three economically important plant-parasitic nematodes are root-knot nematodes, *Meloidogyne* spp., cyst nematodes, *Heterodera* and *Globodera* spp., and root-lesion nematodes, *Pratylenchus* spp. (Jones *et al.*, 2013).

The genus *Meloidogyne* is one of the most destructive pathogens (Xiang *et al.*, 2017). The root-knot nematodes are economically important parasites as well as one of the most destructive pests of vegetables and others crops (Anwar and McKenry, 2010; Castagnone-Sereno *et al.*, 2013). *Meloidogyne* has been controlled with synthetic chemicals but had been hazardous to the soil environment, expensive, and highly toxic. Some of synthetic chemicals are carcinogenic agents, which are caused by most nematicide chemicals that have been withdrawn from the market for example methyl bromide, ethylene dibromide, and di-bromochloropropane (Nicol *et al.*, 2011, and Onkendi *et al.*, 2014). Nowadays scientists are mainly focused on cultural practices, crop rotation, biocontrol, and plant resistance to overcome this problematic issue (Chitwood, 2002). Biocontrol agents are safe and environmentally friendly in application compared to chemicals because it has no residual effects on

* **Corresponding author.**
E-mail address:mahmoud_ms91@du.edu.eg
DOI: 10.21608/jppp.2021.198191

food (Cetintas *et al.*, 2018). The beneficial effects of certain types of plant-derived substances and soil microorganisms are attributed to reduce population density of plant-parasitic nematodes (Pinkerton *et al.*, 2000).

Botanical pesticides are preferred as alternatives to chemical pesticides in recent times. Several higher plants and their constituents have successfully combated plant disease control and proved to be harmless and non-phytotoxic to humans and soil (Cuadra *et al.*, 2008). The Brassicaceae is one of the world's most economically important plant families. Among the most important chemical compounds produced by Brassicaceae species are the Glucosinolates (GLS), which proved to have Glucosinolate compounds produced by the Brassicaceae plants when broken down to various allelochemicals and incorporated into soil control soil-borne pests, insects, and nematodes (McSorely *et al.*, 1997; Hafez and Sundararaj, 2001; Lazzeri *et al.*, 2004; Riga *et al.*, 2004).

It is believed that the fumigating effect of decomposing Brassicaceae plants results from chemical reactions that lead to the formation of biologically active products (Underhill, 1980). GSLs (Glucosinolates) are sulfur-containing phytochemicals present in Brassicaceae (Ahuja *et al.*, 2011). The most known GSLs in Brassicaceae vegetable are neoglucobrassicin, glucobrassicanapin, and glucobrassicin (Vallejo *et al.*, 2004). These bioactive compounds contain a cyano group and a sulphate group which confers them the protective role against plant pathogens and insects attack together with myrosinase (Wittstock *et al.*, 2016; Zrybko *et al.*, 1997). The management of plant-parasitic nematodes using such products and their derivatives is important considering increased environmental awareness and human health associated with chemicals for nematicides, biodegradability, and selective toxicity of targeted pests as well as the safety of non-targeted organisms. Therefore, the present study was conducted to study the nematicidal effect of six botanical seeds as dry powders on *M. incognita* infecting pepper plants under greenhouse conditions.

MATERIALS AND METHODS

Source of Nematodes

Coleus, *Coleus blumei* roots infected with single egg mass of *M. incognita* at the experimental greenhouse of the Faculty of Agriculture, Damietta University, Egypt, served as a pure culture of nematode. Pots (15 cm diameter) were filled with a sterilized mixture containing clay and sand in a ratio of 1:1 v/ v. Eggs of *M. incognita* were separated from the galled roots of Coleus (Hussey and Barker, 1973). Finally, the number of eggs per unit volume of water was determined, counted and then the plants were directly inoculated with eggs according to the design of each experiment.

Preparation of seed powder

Seeds of six plant species namely: *Brassica rapa* (Turnip), *Eruca sativa* (Watercress), *Juniperus communis* (Juniper), *Lepidium sativum* (Cress), *Raphanus sativus* (Radish), *Sinapis alba* (Mustard) were purchased from medicinal plant shop, Damietta City, Egypt (Table 1). One-kilogram seeds of each plant species were ground by the help of a grinder to obtain fine powder.

Nematicide

Krenkel 75% (Fosthiazate) EC, (RS)-S-sec-butyl-O-ethyl-2-oxo-1,3-thiazolidin-3-ylphosphono-thioate, Fosthiazate is a phosphonic ester, an organic phosphonate and an organothiophosphate insecticide. It has a role as an EC 3.1.1.7 (acetylcholinesterase) inhibitor, an agrochemical and a nematicide. It was used at the rate of 0.3 ml/plant.

Table 1. English, scientific, arabic, family and used part of botanical products as soil organic amendments

No.	Scientific name	Family	Part used	English name	Arabic name
1	*Brassica rapa*	Brassicaceae	Seeds	Turnip	لفت
2	*Eruca sativa*	Brassicaceae	Seeds	Watercress	جرجير
3	*Juniperus communis*	Cupressaceae	Seeds	Juniper	العرعر
4	*Lepidium sativum*	Brassicaceae	Seeds	Cress	حب الرشاد
5	*Raphanus sativus*	Brassicaceae	Seeds	Radish	الفجل
6	*Sinapis alba*	Brassicaceae	Seeds	Mustard	الخردل

Experimental design

The experiment was conducted under greenhouse conditions (29±3°C) using the randomized complete block design with four replications for 21 treatments including: *B. rapa* (Turnip), *E. Sativa* (Watercress), *J. Communis* (Juniper), *L. Sativum* (Cress), *R. Sativus* (Radish), *S. alba* (Mustard) at three rates (2, 4 and 6 g/ plant); nematode + krenkel nematicide (0.3ml/pot); nematode alone (nematode control); and plant free of any treatment and nematode (check). Pepper seedlings (*Capsicum annuum*) cv. Top Star (30 days old) were separately transplanted in Eighty-four plastic pots (15cm in diameter) each containing 1kg steam sterilized clay and sand (1:1; v/v). One week later, nematode inocula (1000 eggs of *M. incognita*) were added to eighty plastic pots (20 treatments). One week later, all treatments as well as krenkel nematicide were added according to experiment design and mixed with soil, whilst four plant pots inoculated by nematode only were served as nematode control.

Evaluation criteria for the effectiveness of treatments

Forty-five days from nematode inoculation, all plants related to each treatment were harvested and uprooted; both vegetative and root systems were used as fresh and dried tissues for evaluation analyses.

Plant growth parameters

Plant's parameters including length, fresh weight & dry shoot weight and number of leaves were measured and recorded. Increase percentage (Inc.%) was calculated by the formula:

$$\text{Inc.}\% = \frac{\text{Treatment} - \text{Nematode only}}{\text{Nematode only}} \times 100$$

Determination of nematode reproduction

Juveniles in soil were extracted using sieving and modified Baermann technique (Goodey 1957). The nematode suspensions were examined in a Hawksley counting slide with a dissecting microscope to quantify the numbers of juveniles. Roots were stained with acid fuchsin in lactic acid (Byrd *et al.*, 1983) and then examined for recording the number of developmental stages, females, egg masses, and galls per root system/replicate. The scale of 0-5 (Taylor and Sasser, 1978) for root gall index (RGI) or egg-masses index (EI) was used as follow; where 0 = No galls or egg masses on roots, 1 = 1-2 galls, or egg masses on roots, 2 = 3-10 galls or egg masses on roots, 3 = 11-30 galls or egg masses on roots, 4 = 31-100 galls or egg masses on roots, 5 = More than 100 galls or egg masses on roots. Final population (Pf.) was recorded as the sum of juvenile numbers in soil and developmental stages and females in roots. Reproduction factors (Rf) was calculated by the formula:

$$\textbf{Reproduction factor} = \frac{\textbf{final population (Pf)}}{\textbf{Initial population (Pi)}} = \textbf{RF}$$

Rate of population increase (RPI) was calculated by the formula:

$$\textbf{RPI} = \frac{\textbf{Pf} - \textbf{Pi}}{\textbf{Pi}}$$

Reduction percentages was calculated by the formula:

$$\textbf{Reduction \%} = \frac{\textbf{N alone} - \textbf{Treatment}}{\textbf{N alone}} \times \textbf{100}$$

Biochemical analyses

Leaves of fresh pepper of each replicate/treatment were taken for the assessment of the amount of chlorophyll according to Goodwine methodology (Goodwine 1965). The dried leaves of pepper plants were ground and wet digested for determination of nitrogen, potassium and phosphorus contents (Jones *et al.,* 1991, Peters *et al*., 2003). The total phenol contents were extracted and calculated at 520 nm via spectrophotometer by chatichole as standard (Slinkard and Singleton, 1977).

Statistical analysis

Statistical analysis of the data was performed using version 6.303 of a computer program Costat (2005). Statistically significant differences between means were compared using analysis of variance (ANOVA) with the least significant difference (LSD) and standard error at a probability of 0.05.

RESULTS AND DISCUSSION

The obtained results in Tables 2, 3 and 4 revealed that the application of grinded seed powder for six plant species as a soil amendment, had a significant effect ($P < 0.05$) on nematode development and plant growing parameters). The results in Table (2) confirm that all tested components exhibited a protective performance within pepper plants against *M. incognita* (RKN) infection in terms of reducing the final nematode populations in such host plant i.e., juveniles in soil, developmental stages, females, galls, and egg masses numbers were significantly ($P \leq 0.05$) affected by all tested treatments. It is evident that the increase in seed powder rates resulted in a pronounced reduction in the final number of nematode populations.

Among the six plants species, *S. alba* seeds powder at the highest rate (6g/plant), overwhelmed other treatments and accomplished the highest reduction percentage of nematode parameters with the values of 93.09, 93.94, and 95.75 % for the final nematode population, galls, and egg masses numbers, respectively. *L. sativum* application ranked the second with values of 92.45, 90.74 and 95.07 %, respectively, then *J. communis* with values of 90.96, 90.58, and 94.73 % respectively, for the same parameters. The least reduction nematode values of the same nematode criteria were achieved by *E. sativa* with values of 86.53, 86.54 and 91.78 % for final nematode population, galls, and egg masses numbers, respectively at a rate of 6g/plant.

Table 20Influence of seed powder for six plants as a soil amendment on population and reproduction of *Meloidogyne incognita* infecting pepper under greenhouse conditions (29±3ºC).

Treatments	Rate	Nematode parameters												
		Nematode population in			Pf.	RF	RPI	Red. %	No. of galls	RGI	Red. %	No. of egg masses	EI	Red. %
		Soil	Root											
		J_2/pot	D.V. stages	Females										
Brassica rapa	2g	470.0^{c}	68.0^{c}	50.7^{b}	588.7^{cd}	0.59	-0.41	72.2	50.0^{b}	4	73.1	22.0^{bc}	3	84.9
	4g	221.7^{g}	46.5^{de}	35.0^{cde}	303.2^{h}	0.30	-0.70	85.7	34.5^{cd}	4	81.4	14.7^{def}	3	89.9
	6g	167.0^{gh}	30.7^{fgh}	11.7^{h}	209.5^{i}	0.21	-0.79	90.1	11.7^{g}	3	93.7	8.7^{ghi}	2	94.0
Eruca sativa	2g	556.7^{b}	78.5^{b}	45.5^{bc}	680.7^{b}	0.68	-0.32	67.9	42.0^{bc}	4	77.4	26.7^{b}	3	81.7
	4g	465.2^{c}	45.5^{de}	27.7^{defg}	538.5^{de}	0.54	-0.46	74.6	27.7^{def}	3	85.1	20.0^{cd}	3	86.3
	6g	229.5^{g}	31.0^{fgh}	25.0^{efg}	285.5^{h}	0.29	-0.71	86.5	25.0^{def}	3	86.5	12.0^{e-i}	3	91.8
Juniperus communis	2g	383.7^{de}	50.2^{d}	44.75^{bc}	478.7^{ef}	0.48	-0.52	77.4	44.7^{b}	4	75.9	19.5^{cd}	3	86.6
	4g	155.5^{h}	29.5^{fgh}	28.2^{defg}	213.2^{i}	0.21	-0.79	89.9	27.2^{def}	3	85.4	13.0^{e-h}	3	91.1
	6g	150.5^{h}	23.5^{ghi}	17.7^{gh}	191.7^{i}	0.19	-0.81	91.0	17.5^{fg}	3	90.58	7.7^{hi}	2	94.7
Lepidium sativum	2g	424.2^{cd}	70.5^{bc}	44.5^{bc}	539.2^{de}	0.54	-0.46	74.6	40.5^{bc}	4	78.2	22.5^{bc}	3	84.6
	4g	290.5^{f}	50.0^{d}	30.25^{def}	370.7^{g}	0.37	-0.63	82.516	29.7^{de}	3	84.0	14.5^{d-g}	3	90.1
	6g	105.7^{h}	36.0^{ef}	18.25^{gh}	160.0^{i}	0.16	-0.84	92.5	17.2^{fg}	3	90.7	7.2^{hi}	2	95.1
Raphanus sativus	2g	544.2^{b}	44.75^{de}	34.5^{cde}	623.5^{c}	0.62	-0.38	70.6	33.5^{cd}	4	82.	26.5^{b}	3	81.9
	4g	373.2^{de}	36.5^{ef}	26.5^{defg}	436.2^{f}	0.44	-0.56	79.4	25.7^{def}	3	86.2	15.7^{de}	3	89.3
	6g	141.0^{h}	34.2^{efg}	21.7^{fgh}	197.0^{i}	0.20	-0.80	90.7	21.2^{efg}	3	88.6	14.2^{d-g}	3	90.3
Sinapis alba	2g	351.2^{e}	46.5^{de}	37.2^{cd}	435.0^{f}	0.44	-0.75	79.5	34.25^{cd}	4	81.6	19.5^{cd}	3	86.6
	4g	174.0^{gh}	21.5^{hi}	17.7^{gh}	213.2^{i}	0.21	-0.79	89.9	17.5^{fg}	3	90.6	9.5^{f-i}	2	93.5
	6g	117.7^{h}	16.5^{i}	12.25^{h}	146.5^{i}	0.15	-0.85	94.	11.25^{g}	3	93.9	6.2^{i}	2	95.8
Krenkel	0.3ml	117.0^{h}	15.7^{i}	16.7^{gh}	149.5^{i}	0.15	-0.85	93.	16.7^{fg}	3	91.0	7.2^{hi}	2	95.1
Only Nematode		1736.0^{a}	194.2^{a}	189.2^{a}	2119.5^{a}	2.12	1.12	----	185.7^{a}	5	----	146.0^{a}	5	----
$LSD_{P=5\%}$		49.01	8.05	7.68	50.49	----	----	----	7.23	----	----	3.91	---	----

Means in each column followed by the same letter(s) did not differ at p<0.05 according to Duncan's multiple-range test., Each treatment is an average of four replicates, $\textbf{eproduction factor (RF)} = \frac{\textbf{final population}}{\textbf{Initial population}}$**,** $\textbf{Reduction \%} = \frac{\textbf{N alone} - \textbf{Treatment}}{\textbf{N alone}} \times \textbf{100}$**,** $\textbf{RPI} = \frac{\textbf{Pf} - \textbf{Pi}}{\textbf{Pi}}$ **, Root gall index (RGI), egg-masses index (EI).**

In the meantime, at a rate of 4g/plant, *S. alba*, and *J. communis* seed powders ranked first with values of 89.94% for suppressing final nematode population the same parameters. While the least values were achieved by *E. sativa* with values of 74.59, 85.08, and 86.30 % for final nematode population, galls, and egg masses numbers, respectively.

Pepper plants amended *S. alba* or *J. communis* (2g/plant) seed powders showed intermediate reduction values which were amounted to 79.48 and 77.41% for the final nematode population, respectively. However, the least values of the same nematode criteria were achieved by *E. sativa* treatment with values of 67.88, 77.38, and 81.71 % for final nematode population, galls, and egg masses numbers, respectively, at a rate of 2g/plant. It is valuable to remind that Krenkel nematicide recorded the reduction percentages of the final nematode population (92.95%), galls (91.01%), and egg masses (95.07%).

The egg masses indices for the tested treatments ranged from (2.0) to (3.0) compared to inoculated untreated plants (5.0). Nematode reproduction (RF) and rate of population increase (RPI) were negatively affected as *S. alba* in par with krenkel had the lowest reproduction rate (0.15) and population rate (-0.85) at the same time *E. sativa* showed the highest RF (0.68) and RPI (-0.32) (Table 2).

Data in Table (3) confirm that all tested components were a significant improvement in the plant growing characters (length, fresh weight & dry shoot weight and leaf numbers) of the pepper plants cv. Top Star as compared with control. Among all the treatments, the best plant growth (plant length (143.1 %), fresh weight (118.4 %), dry weight plant (100.0 %) and leaf numbers (99.5 %) were stated when pepper pots were treated with *B. rapa* seed powder at the rate of 6g/plant. The application of *J. communis* seed powder recorded the second rank for the same parameters (plant length :143.1 %, fresh weight: 116.6 %, dry weight plant: 88.2 % and No. of leaves: 98.4 %) then *R. sativus* seed powder (plant length :132.3 %, fresh weight :101.2 %, dry weight plant: 85.3 % and No. of leaves: 97.9 %) at the rate of 6g/plant.

Raising seed powder rates from 4g/plant to 6g/plant in both *S. alba* and *L. sativum* recorded a decrease in the pepper plant parameters as (plant length, fresh weight, dry weight plant and leaf numbers). Moreover, the nematicide krenkel (0.3ml/plant) pointed out a considerable enhancement (plant length: 75.0 %, fresh weight: 43.6 %, dry weight plant: 32.4 % and leaf numbers: 24.6 %). Meanwhile, plant free of any tested materials and nematode (check) showed reasonable percentage increase values (plant length: 91.4%, fresh weight: 64.4%, dry weight plant: 52.9 % and leaf numbers: 28.3 %), comparing to nematode alone (Table 3).

Table 3. Impact of seed powder of six plants species as soil amendment on growth parameters of pepper plants infected with *Meloidogyne incognita* under greenhouse conditions

Treatments	Rate	Plant growth response											
		Plant Length (cm)				Plant Fresh weight (g)				Shoot dried W. (g)		No. of	Inc.
		Shoot	Root	Total	Inc. %	Shoot	Root	Total	Inc. %	wg	Inc. %	leaves	%
Brassica rapa	2 g	27.0^{ef}	14.0^{g}	41.0^{g}	76.7	16.0^{ef}	10.2^{d}	26.2^{ef}	60.7	4.4^{ef}	29.4	34.3^{a}	83.4
	4 g	29.1^{d}	16.4^{e}	45.5^{e}	96.1	18.3^{cd}	11.3^{c}	29.7^{cd}	82.2	5.1^{d}	50.0	35.6^{a}	90.4
	6 g	34.0^{ab}	22.4^{a}	56.4^{a}	143.1	22.5^{a}	13.1^{a}	35.6^{a}	118.4	6.8^{a}	100.0	37.3^{a}	99.5
Eruca sativa	2 g	22.5^{hi}	11.5^{i}	34.0^{i}	46.6	13.3^{h}	8.3^{f}	21.6^{h}	32.5	4.2^{f}	23.5	24.3^{b}	29.9
	4 g	24.5^{g}	12.9^{gh}	37.3^{h}	60.8	15.0^{fg}	8.4^{f}	23.4^{g}	43.6	4.3^{ef}	26.5	32.3^{a}	72.7
	6 g	31.3^{c}	18.1^{d}	49.5^{d}	113.4	20.5^{b}	12.2^{b}	32.7^{b}	100.6	5.6^{c}	64.7	35.7^{a}	90.9
Juniperus communis	2 g	21.3^{ij}	11.1^{ij}	32.4^{j}	39.7	12.2^{i}	7.3^{g}	19.5^{i}	19.6	4.1^{f}	20.6	23.0^{b}	23.0
	4 g	24.8^{g}	13.2^{g}	38.0^{h}	63.8	16.0^{ef}	9.5^{e}	25.5^{f}	56.4	4.5^{ef}	32.4	33.7^{a}	80.2
	6 g	35.0^{a}	21.4^{b}	56.4^{a}	143.1	22.0^{a}	13.3^{a}	35.3^{a}	116.6	6.4^{b}	88.2	37.1^{a}	98.4
Lepidium sativum	2 g	16.7^{k}	9.3^{k}	26.1^{k}	12.5	11.7^{i}	5.3^{i}	17.0^{j}	4.3	4.1^{f}	20.6	23.0^{b}	23.0
	4 g	23.2^{h}	12.0^{hi}	35.2^{i}	51.7	14.5^{g}	8.4^{f}	22.8^{g}	39.9	4.3^{ef}	26.5	32.3^{a}	72.7
	6 g	21.0^{j}	10.3^{j}	31.3^{j}	34.9	13.2^{h}	7.3^{g}	20.4^{i}	25.2	4.2^{f}	23.5	25.3^{b}	35.3
Raphanus sativus	2 g	28.0^{de}	15.3^{f}	43.3^{f}	86.6	16.7^{e}	10.3^{d}	27.0^{e}	65.6	4.7^{e}	38.2	34.0^{a}	81.8
	4 g	28.8^{d}	15.3^{f}	44.2^{ef}	90.5	18.5^{cd}	10.5^{d}	29.0^{d}	77.9	4.8^{e}	41.2	35.7^{a}	90.9
	6 g	33.5^{b}	20.4^{bc}	53.9^{b}	132.3	20.5^{b}	12.4^{b}	32.8^{b}	101.2	6.3^{b}	85.3	37.0^{a}	97.9
Sinapis alba	2 g	26.0^{f}	13.7^{g}	39.7^{g}	71.1	16.3^{e}	9.4^{e}	25.7^{ef}	57.7	4.4^{ef}	29.4	33.7^{a}	80.2
	4 g	32.0^{c}	20.3^{bc}	52.4^{c}	125.9	20.3^{b}	12.3^{b}	32.7^{b}	100.6	6.1^{b}	79.4	37.3^{a}	99.5
	6 g	32.3^{c}	18.2^{d}	50.5^{d}	117.7	19.2^{c}	11.4^{c}	30.6^{c}	87.7	5.4^{cd}	58.8	35.7^{a}	90.9
Krenkel	0.3 ml	22.2^{hij}	18.4^{d}	40.6^{e}	75.0	15.5^{ef}	7.9^{f}	23.4^{g}	43.6	4.5^{ef}	32.4	23.3^{a}	24.6
Only Nematode		14.2^{l}	9.0^{k}	23.2^{i}	---	9.8^{j}	6.4^{h}	16.3^{j}	---	3.4^{g}	---	18.7^{c}	---
Plant free		24.6^{g}	19.8^{c}	44.4^{e}	91.4	17.8^{d}	9.0^{e}	26.8^{ef}	64.4	5.2^{d}	52.9	24.0^{b}	28.3
$LSD_{P=5\%}$		6.118	4.901	7.512	---	2.872	3.473	5.011	---	0.299	---	3.24	---

Each treatment is an average of four replicates, percentage increase (Inc.%) = (Treatment – Only nematode)/ Only nematode ×100. Means in each column followed by the same letter(s) did not differ at P<0.05 according to Duncan's multiple-range test.

The obtained results in Table (4) illustrated the application of grinded seed powders for six plants species as soil amendment, on nitrogen, phosphorus, potassium concentrations, chlorophyll, and phenol total contents in leaves of pepper infected with RKN at greenhouse. Overall, all tested materials increased the percentages of nitrogen, phosphorus, potassium concentrations and phenol contents as well as decreased the total chlorophyll percentages to certain extent. *R. sativus* seed powder (6g/plant) ranked the first of the tested applications and significantly ($P < 0.05$) increase percentage values of N (143.6 %), P (216.5 %) and K (101.9 %), followed by those of *B. rapa* and *E. sativa* seed powders (6g/plant) that averaged 124.8 & 117.1 %; 201.8 & 195.4 %, and 98.7 & 93.0 % for N, P, and K, respectively. On the other hand, *L. sativum* seed powder (6g/plant) ranked first and recorded significant ($P < 0.05$) improvement in total phenol concentration (198.27 %), followed by those of *J. communis* and *S. alba* seed powders that averaged 175.27 & 163.29, respectively.

However, *L. sativum* seed powder ranked first in decreasing total chlorophyll content (45.09 & 17.40 and 16.01 %) at the rate of 6 & 4 & 2g/plant, respectively, followed by *J. communis* seed powder (12.61%) at the rate of 4g/plant. It is valuable to reminder that Krenkel nematicide recorded increase percentages of N (86.3%), P (212.8%), K (63.3 %) and total phenol concentration (48.55 %) as compared with uninoculated, untreated, control pepper plants (Table, 4).

Table 4. Effect of seed powders of six plant species as soil amendment on nitrogen, phosphorus, and potassium concentrations as well as chlorophyll and total phenol in leaves of pepper infected with *Meloidogyne incognita* under greenhouse conditions.

Treatments	Rate	N mg/g	Inc. %	P mg/g	Inc. %	K mg/g	Inc. %	Chlorophyll content		Total chlorophyll mg/g	Dec. %	Total phenol	Inc. %
								A mg/g	B Mg/g				
Brassica rapa	2	2.14^{j}	82.9	0.299^{h}	174.3	2.5^{jk}	58.2	0.719^{e}	0.498^{j}	1.217^{g}	5.88	0.415^{r}	19.94
	4	2.45^{d}	109.4	0.311^{f}	185.3	2.94^{de}	86.1	0.714^{g}	0.514^{e}	1.228^{e}	5.03	0.536^{l}	54.91
	6	2.63^{b}	124.8	0.329^{d}	201.8	3.14^{b}	98.7	0.734^{b}	0.533^{b}	1.267^{c}	2.01	0.665^{h}	92.20
Eruca sativa	2	1.73^{o}	47.9	0.184^{n}	68.8	2.33^{l}	47.5	0.715^{f}	0.502^{h}	1.217^{g}	5.88	0.954^{b}	17.72
	4	1.92^{m}	64.1	0.209^{l}	91.7	2.65^{h}	67.7	0.701^{j}	0.504^{g}	1.205^{i}	6.81	0.421^{q}	21.68
	6	2.54^{c}	117.1	0.322^{e}	195.4	3.05^{c}	93.0	0.695^{k}	0.492^{k}	1.187^{j}	8.20	0.423^{q}	22.25
Juniperus communis	2	1.54^{q}	31.6	0.159^{p}	45.9	2.09^{n}	32.3	0.683^{m}	0.483^{l}	1.166^{k}	9.82	0.541^{k}	56.36
	4	1.62^{p}	38.5	0.171^{o}	56.9	2.17^{m}	37.3	0.659^{o}	0.471^{n}	1.130^{n}	12.61	0.668^{g}	93.06
	6	1.84^{n}	57.3	0.195^{m}	78.9	2.47^{k}	56.3	0.671^{n}	0.477^{m}	1.148^{m}	11.21	0.954^{b}	175.27
Lepidium sativum	2	1.26^{t}	7.7	0.122^{t}	11.9	1.67^{q}	5.7	0.639^{q}	0.447^{q}	1.086^{p}	16.01	0.716^{f}	106.94
	4	1.43^{r}	22.2	0.146^{q}	33.9	1.98^{o}	25.3	0.627^{r}	0.441^{r}	1.068^{q}	17.40	0.837^{d}	141.91
	6	1.35^{s}	15.4	0.135^{s}	23.9	1.8^{p}	13.9	0.494^{u}	0.316^{u}	0.710^{t}	45.09	1.032^{a}	198.27
Raphanus sativus	2	2.03^{l}	73.5	0.223^{k}	104.6	2.76^{g}	74.7	0.711^{h}	0.511^{f}	1.222^{f}	5.49	0.412^{s}	19.08
	4	2.35^{f}	100.9	0.302^{g}	177.1	2.97^{d}	88.0	0.721^{d}	0.522^{c}	1.243^{d}	3.87	0.475^{o}	37.28
	6	2.85^{a}	143.6	0.345^{b}	216.5	3.19^{a}	101.9	0.726^{c}	0.544^{a}	1.270^{b}	1.78	0.511^{n}	47.69
Sinapis alba	2	2.15^{i}	83.8	0.136^{r}	24.8	2.77^{g}	75.3	0.705^{i}	0.501^{i}	1.206^{h}	6.73	0.614^{j}	77.46
	4	2.40^{e}	105.1	0.264^{i}	142.2	2.92^{e}	84.8	0.684^{l}	0.465^{o}	1.149^{l}	11.14	0.794^{e}	129.48
	6	2.27^{g}	94.0	0.251^{j}	130.3	2.88^{f}	82.3	0.645^{p}	0.457^{p}	1.102^{o}	14.77	0.911^{c}	163.29
Krenkel	0.3 ml	2.18^{h}	86.3	0.341^{c}	212.8	2.58^{i}	63.3	0.598^{s}	0.375^{s}	0.974^{r}	24.67	0.514^{m}	48.55
control		1.17^{u}	---	0.109^{u}	---	1.58^{r}	---	0.772^{a}	0.521^{d}	1.293^{a}	---	0.346^{t}	---
Healthy Plant		2.11^{k}	80.3	0.346^{a}	217.4	2.51^{j}	58.9	0.585^{t}	0.349^{t}	0.934^{s}	27.76	0.456^{p}	31.79
$LSD_{P=5\%}$		0.005	---	3.415	---	0.036	---	2.936	2.076	4.642	---	0.002	---

Means in each column followed by the same letter(s) did not differ at p<0.05 according to Duncan's multiple-range test.
Pi=1000 eggs of *M. incognita* *Each value is a mean of three replicates. N= Nitrogen, P= Phosphorus, K= Potassium,
Increase % $=\frac{\text{Treatment} - \text{N alone}}{\text{N alone}} \times 100$ ، Reduction % = (N alone – Treatment)/ N alone×100

Application of seed powders for the six plant species; *Brassica rapa, Eruca sativa, Juniperus communis, Lepidium sativum, Raphanus sativus, Sinapis alba* as soil amendment had a significant effect ($P < 0.05$) on nematode development and plant growing parameters with different degrees. The application of mustard, *S. alba* seed powder at the highest rate (6g/plant) overwhelmed other treatments and accomplished the highest reduction percentage of nematode parameters. The nematicidal impact of the tried mustard may conceivably be credited to their high substance of certain oxygenated intensifies which are portrayed by the lipophilic properties that empower them to break up the cytoplasmic film of nematode cells and their practical gatherings meddling with the compound protein structure (Knoblock *et al.,* 1989; Salem *et al.,* 2015). The present data agreed with Oka, 2010 who stated that treatment with plant grinded seed reduced the number of *M. incognita* in the soil due to the altered nutrient status of the soil after amendments with dried seeds or due to the toxic substances (allelochemicals) that were added to the soil either directly from the seeds or through their products of microbial degradation and due to the enhancement of the antagonistic organisms in the soil. Salem *et al.,* (2012) found that components of isothiocyanates from *Ammi visnaga*, *Sinapis alba*, and *Lepidium sativum* seeds, separately affected the degree of nematode reduction parameters and increase in weight of the plant. *Juniperus* species have been extensively investigated as a source of natural products with potential antibacterial, antifungal, and insecticidal activities (Tumen *et al.,* 2013).

Several researchers stated that plant species generally considered as biofumigation are belonging to the family Brassicaceae i.e., *Brassica rapa* (turnip), *Brassica oleracea* (broccoli, cauliflower), *Raphanus sativus* (radish), *Brassica napus* (canola, rapeseed), cv. AV Jade, *Eruca sativa* (salad rocket, arugula), cv. Nemat, *B. juncea* (Indian mustard) cv. Caliente 199, and various mustards, such as *Sinapis alba* (mustard) (Sarwar *et al.,* 1998; Hartz *et al.,* 2005; Everts *et al.* 2006; Monfort *et al.,* 2007; Lopez-Perez *et al.,* 2010; Kago *et al.* 2013; Edwards and Ploeg, 2014).

The instability of most isothiocyanates (ITCs) and other glucosinolates (GLS) hydrolysis products led to coining the term biofumigation to describe the suppression of soil-borne pests and pathogens by biocidal volatiles released from *Brassica* rotation and green manure crops or seed meal amendments incorporated into the soil (Smolinska *et al.* 1997; Angus *et al.* 1994; Matthiessen and Kirkegaard 2006).

Amendments of brassica reduced the pathogenic agents. This reduction may be a cumulative effect of bio-toxic volatile compounds released during the decomposition of the residues at prevalent high soil temperatures (38 – 42ºC) and subsequent microbial antagonism. Sulfur-containing volatile substances are toxic to many fungi (Lewis and Papavizas, 1971). Reduction occurring of *M. incognita*, infecting tomato in a glasshouse, in soil amended with *M. chamomilla*, followed by soil treated with powdered seeds of *Ammi majus, Solanum nigrum, Ricinus communis*, and *Eucalyptus sp*. Was reported by Radwan *et al.* (2012). Amendments with seed meals in soil from varieties of *Brassica juncea, B. napus* and *S alba,* infected by *M. incognita* and *Pratylenchus penetrans* showed that *B. juncea* was by far the most suppressive against both nematode species. *B. napus* ‘‘Sunrise’’ was instead the least nematotoxic, while *S. alba* ‘‘Ida Gold’’ and *B. napus* ‘‘Dwarf Essex’’ showed an intermediate suppression of the nematodes (Zasada *et al.* 2009).

The present results could be clearly related to the different amounts and types of GLSs in the brassicaceous material: sinigrin (2-propenyl GSL) was the main component (99% of total GLS) in *B. juncea*, while the main GLSs in *B. napus* was 4-hydroxyglucobrassicin (4-hydroxy-3-indolylmethyl) and gluconapin (3-bute-nyl) respectively. Glucosinalbin (4-hydroxy-benzyl) was the predominant (96% of the total) GLS in *S. alba*. The same seed powder amendments provided no suppression of nematodes when added to infected soil after inactivation with hot water to degrade GLSs and volatilize decomposition products (Avato *et al.,* 2013).

Similarly, soil amendments using a synthetic formulation of defatted *B. carinata* seed meal, containing more than 98% of 2-propenyl GLS (sinigrin), have been found to significantly reduce the infestation of *M. incognita* in the greenhouse on zucchini and increasing the crop yield (Lazzeri *et al.,* 2009). The strong suppression against root-knot nematodes by *B. juncea* seed meal with a high sinigrin content further confirmed the nematotoxic potential of this phytochemical (Olivera *et al.,* 2011).

Seed meals (high in nitrogen) of various brassica crops have also been used to reduce plant parasitic nematode numbers in soil (Curto *et al.,* 2016; Meyer *et al.,* 2011). The major GSL compound differs greatly in different brassica crops, such as 4-hydroxy benzyl GSL (sinalbin) in *S. alba* (cv. Ida Gold), 2-propenyl GSL (sinigrin) in B. and 3-butenyl GSL in *B. napus* (Zasada *et al.,* 2009). *B. juncea* seed meals showed a relatively better suppressive effect on *Pythium* spp. and *Pratylenchus penetrans* populations in apple orchard compared to *B. napus* or *S. alba* seeds probably because *B. juncea* produces Allyl ITC in greater quantity of the other two (Mazzola *et al.,* 2007, 2009).

However, the consistent suppressive effect of seeds on nematode populations (regardless of GSL content) was also attributed to the nematicidal and nematostatic effect of ammonia liberated from seed amendments (Mazzola *et al.,* 2007, 2009). The role of seed particle size in influencing the nematotoxic effect cannot be ruled out. Ground *S. alba* seeds had a greater suppressive effect on *P. penetrans* than larger particles, indicating that smaller particles are evenly distributed in the soil profile while larger particles create pockets of toxicity to which not all nematodes are exposed, in comparison, *B. juncea* seeds showed greater nematode toxicity than *S. alba,* i.e., 2.5 and 10% S. alba (w/w) were required for 100% suppression of *M. incognita* and *P. penetrans* respectively, while 0.5% *B. juncea* is required for 100% suppression of both nematodes (Zasada *et al.,* 2009).

The present research indicated the potential of screened plant seed powders as organic amendments to control *M. incognita* under greenhouse conditions. However, further studies are needed under field conditions.

REFERENCES

Ahuja, I., J. Rohloff, A.M. Bones (2011). Defense mechanisms of Brassicaceae: implications for plant-insect interactions and potential for integrated pest management. In: Sustainable Agriculture, Volume 2. Springer, pp. 623–670.

Angus J. F., P. A. Gardner, J. A. Kirkegaard and J. M. Desmarchelier (1994) Biofumigation: isothiocyanates released from Brassica roots inhibit growth of the take-all fungus. Plant Soil 162:107–112.

Annual bulletin (2019). Statistical crop area and plant production 2016/2017, central agency for public mobilization of statistics in Egypt.

Anwar, S. A. and M. V. McKenry (2010). Incidence and reproduction of *Meloidogyne incognita* on vegetable crop genotypes. Pakistan Journal of Zoology 42: 135-141.

Avato, P., T. D'Addabbo, P. Leonetti, and M. P. Argentieri (2013). Nematicidal potential of Brassicaceae. Phytochem Rev. (12) 791–802.

Byrd, D. W., T. Kirapatrick, and K. Barker, (1983). An improved technique for clearing and staining plant tissues for detection nematodes. J. Nematol., 15(3)142-143.

Castagnone-Sereno, P., E. G. J. Danchin, L. Perfus-Barbeoch and P. Abad (2013). Diversity and evolution of root-knot nematodes, genus *Meloidogyne*: new insights from the genomic era. Annual Review of Phytopathology 51: 203-220.

Cetintas, R., M. Kusek and S. A. Fateh (2018). Effect of some plant growth promoting rhizobacteria strains on root-knot nematode, *Meloidogyne incognita*, on tomatoes. Egyptian Journal of Biological Pest Control 28: 7.

Chitwood, D. J. (2002). Phytochemical based strategies for nematode control. Annual Review of Phytopathology 40: 221-249.

Costat Software, (2005). Microcomputer program analysis, CoHort software, Version 6.303, Monterey, CA, USA.

Cuadra R., J. Ortega, O. L. Morfi, L. Soto, M. D. I. A. Zayas (2008) Effect of the biological controls Trifesol and Nemacid on root-knot nematodes in sheltered vegetable production. Rev. Protección Veg 23: 59-62.

Curto, G., E. Dallavalle, R. Matteo, L. Lazzeri (2016). Biofumigant effect of new defatted seed meals against the southern root-knot nematode, *Meloidogyne incognita*, Ann. Appl. Biol. (169) 17–26.

Edwards, S. and A. Ploeg (2014). Evaluation of 31 Potential biofumigant Brassicaceous plants as hosts for three *Meloiodogyne* species. Journal of Nematology 46: 287-295.

Everts, K. L., S. Sardanelli, R. J. Kratochvil, D. K. Armentrout, and L. E. Gallagher (2006). Root-knot and root lesion nematode suppression by cover crops, poultry litter, and poultry litter compost. Plant Disease 90: 487-492.

Goodey, J. B. (1957). Laboratory methods for work with plant and soil nematodes. Tech. Bull.No.2 Min.Agric.Fish Ed. London pp.47.

Goodwine, T. W. (1965). Countative analysis of the chloroplast, Pigments. Academic press, London and New York.

Hafez, S. L. and P. Sundararaj (2001). Life cycle of duration of *Meloidogyne incognita* and host status of Brassicaceae and Capparaceae selected for glucosinolate content. Nematology 7:203–212.

Hartz, T. K., P. R. Johnstone, E. M. Miyao, and R. M. Davis (2005). Mustard cover crops are ineffective in suppressing soil-borne disease or improving processing tomato yield. Hortscience 40: 2016-2019.

Hussey, R. S. and K. R. Barker (1973). A comparison of methods of collecting inocula of *Meloidogyne* spp. including a new technique. Pl. Dis. Reptr., 57: 1925-1928.

Jones, J. T., A. Haegeman, E. G. J. Danchin, H. S. Gaur, J. Helder, M. G. K. Jones, T. Kikuchi, R. Manzanilla-López, J. E. Palomares-Rius, W. M. L. Wesemael, and R. N. Perry (2013). Top 10 plant parasitic nematodes in molecular plant pathology. Mol. Plant Pathol. 14:946-961.

Jones, J., B. J. B. Wolf, and H. A. Mills (1991). Plant analysis Handbook: A Practical Sampling, Preparation, Analysis, and Interpretative Guide. Micro-Macro Publishing, Athens, Ga.

Kago, E.K., Z. M. Kinyua, P. O. Okemo, and J. M. Maingi (2013). Efficacy of Brassica Tissue and Chalim TM on Control of Plant Parasitic Nematodes. Journal of Biology 1: 32-38.

Kamali, N., E. Pourjam and N. Sahebani (2015). Elicitation of defense responses in tomato against *Meloidogyne javanica* and *Fusarium oxysporum* f. sp. *lycopersici* wilt complex. J. Crop Prot., 4 (1): 29-38.

Kihika, R., L. K. Murungi, D. Coyne, A. Hassanali, P. E. A. Teal and B. Torto (2017). Parasitic nematode *Meloidogyne incognita* interactions with different *Capsicum annum* cultivars reveal the chemical constituents modulating root herbivory. Scientific Reports 7: 2903.

Knoblock, K., N. Weis and R. Weigant (1989). Mechanism of antimicrobial activity of essential oils. p. 5-9. 37th Annual Congress Medicinal Plant Research. Braunschweig.

Lazzeri, L., G. Curto, E. Dallavalle, L. D'Avino, L. Malaguti, R. Santi and G. Patalano (2009). Nematicidal efficacy of biofumigation by defatted Brassicaceae meal for control of Meloidogyne incognita (Kofoid and White) Chitwood. on a full field Zucchini crop, J. Sustain. Agric. 33: 349–358.

Lazzeri, L., G. Curto, O. Leoni and E. Dalla Valle (2004). Effects of glucosinolates and their enzymat ic hydrolysis products via myrosinase on the root-knot nematode *Meloidogyne incognita* (Kofoid and White) Chitwood. Journal of Agriculture and Food Chemistry 52: 6703-6707.

Lewis, J. A., and G. C. Papvizas (1971). Effect of sulfur-containing compounds and vapors from cabbage decomposition on Aphanomyces euteiches. Phytopathology 61:208-214.

Lopez Perez, J.A., T. Roubtsova, M. D. Garcia, and A. Ploeg (2010). The Potential of five winter grown crops to reduce root-knot nematode damage and increase yield of tomato. Journal of Nematology 42: 120-127.

Matthiessen J. N., and J. A. Kirkegaard (2006) Biofumigation and enhanced biodegradation: opportunity and challenge in soilborne pest and disease management. Crit Rev Plant Sci 25:235–265.

Mazzola, M., J. Brown, A. D. Izzo and M. F. Cohen (2007). Mechanism of action and efficacy of seed meal-induced pathogen suppression differ in a Brassicaceae species and time dependent manner, Phytopathology 97: 454–460.

Mazzola, M., J. Brown, X. Zhao, A. D. Izzo, and G. Fazio (2009). Interaction of Brassicaceous seed meal and apple rootstock on recovery of Pythium spp. and Pratylenchus penetrans from roots grown in replant soils, Plant Dis. 93: 51–57.

McSorley, R., P. A. Stansly, J. W. Noling, T. A. Obreza and J. M. Conner (1997). Impact of organic soil amendments and fumigation on plant-parasitic nematodes in Southwest Florida vegetable fields. Nematropica 27:181–189.

Meyer, S. L. F., I. A. Zasada, S. B. Orisajo, M. J. Morra (2011). Mustard seed meal mixtures: management of *Meloidogyne incognita* on pepper and potential phytotoxicity, J. Nematol. (43) 7–15.

Monfort, W.S., A. S. Csinos, J. Desaeger, K. Seebold, T. M. Webster and J. C. Diaz-Perez (2007). Evaluating brassica species as an alternative control measure for root-knot nematode (*M. incognita*) in Georgia vegetable plasticulture. Crop Protection 26: 1359-1368.

Nicol, J. M., S. J. Turner, D. L. Coyne, L. D. Nijs, S. Hockland and Z. T. Maafi (2011). Current Nematode Threats to World Agriculture. In: Jones, J., Gheysen, G., Fenoll, C. (eds.) Genomics and molecular genetics of plant-nematode interactions, Springer, London.

Oka, Y. (2010). Mechanisms of nematode suppression by organic soil amendments – a review. Appl Soil Ecol. 44:101–115.

Oliveira, R. D. L., O. D. Dhingra, A. O. Lima, G. N. Jham, M. A. Berhow, R. K. Holloway, S. F. Vaughn (2011). Glucosinolate content and nematicidal activity of Brazilian wild mustard tissues against Meloidogyne incognita in tomato, Plant Soil 341: 155–164.

Onkendi, E. M., G. M. Kariuki, M. Marais and L. N. Moleleki, (2014). The threat of root- knot nematodes (*Meloidogyne spp.*) in Africa: a review. – Plant Pathology 63: 727-737.

Palomares-Rius, J. E., C. Escobar, J. Cabrera, A. Vovlas and P. Castillo (2017). Anatomical alterations in plant tissues induced by plant-parasitic nematodes. Frontiers in plant science 8: 1987.

Peters, I. S., B. Combs, I. Hoskins, I. Iarman, M. Kover Watson, and N. Wolf (2003). Recommended Methods of Manure Analysis. Univ. of Wisconsin, Cooperative extension Publ., Madison.

Pinkerton J. N., K. L. Ivors, M. L. Miller and L. W. Moore (2000) Effect of solarization and cover crops on population of selected soil borne plant pathogens in Western Oregon. Plant Disease 84: 952- 960.

Radwan, M. A., S. A. A. Farrag, M. M. Abu-ELamayem and N. S. Ahmed (2012). Efficacy of dried seed powder of some plant species as soil amendment against *Meloidogyne incognita* (Tylenchida: Meloidogynidae) on tomato. Archives of phytopathology and plant protection, 1–6.

Riga, E., H. Mojtahedi, R. Ingham, and A. M. McGuire (2004). Green manure amendments and management of root knot nematodes on potato in the Pacific Northwest of USA. Pp. 151–158 in R. C., Cook and D. J. Hunt eds. Nematology Monographs and Perspectives. Proceedings of the Fourth International Congress of Nematology. 2nd edition, Leiden, The Netherlands. Brill Academic Publishers, Inc.

Salem, M. F., and M. E. Mahdy (2015). Suppression of root-knot nematode through innovative mustard biofumigation. Future of Food: Journal on Food, Agriculture and Society 3(2): 41-50.

Salem, M. F., Y. O. Gamalat, S. E. Hasab El – Nabi and F. M. A. Khalaf (2012). Effect of certain medicinal plant natural products on *Meloidogyne incognita* management on tomato under greenhouse conditions. J. Plant Prot. and Path., Mansoura Univ., Vol. 3 (10): 1041 – 1050.

Sarwar, M., J. A. Kirkegaard, P. T. W. Wong and J. M. Desmarchelier (1998). Biofumigation potential of brassicas. III. In vitro toxicity of isothiocyanates to soil-borne fungal pathogens. Plant and Soil 201: 103-112.

Sharon E., M. Bar-Eyal, I. Chet, A. Herrera-Estrella and O. Kleifeld (2001) Biological Control of the Root-Knot Nematode *Meloidogyne javanica* by *Trichoderma harzianum*. Phytopathology 91: 687-693.

Slinkard, J. and V. L. Singleton (1977). Total phenol analysis: automation and comparison with manual methods. Am. J. Enol. Viticult; 28: 49–55.

Smant, G., J. Helder and A. Goverse (2018). Parallel adaptations and common host cell responses enabling feeding of obligate and facultative plant parasitic nematodes. The Plant Journal 93: 686-702.

Smolinska U, M. J. Morra. G. R. Knudsen and P. D. Brown (1997) Toxicity of glucosinolate degradation products from Brassica napus seed meal towards Aphanomyces euteiches f. sp. pisi. Phytopathol 87:77–82.

Taylor, A. L. and J. N. Sasser (1978). Biology, identification and control of root-knot Nematodes (*Meloidogyne spp*.) Coop. pub. Dept. plant pathol. North Carolina State Univ. and U.S. Agency Int. Dev. Raleigh, N.C. 111 pp.

Tumen I., J. E., Fred, A. C. Carol and A. T. Jeffery (2013). Antifungal activity of heartwood extracts from three Juniperus species, BioResource 8: 12-20.

Underhill, E. W. (1980). Glucosinolates. Pp. 493–511 in Bell, E.A. and Charlwood, B. V. eds. Secondary plant products. Encyclopedia of Plant Physiology. New Series 8: Berlin, Germany Springer-Verlag.

Vallejo, F., A. Gil-Izquierdo, A. Pe´rez-Vicente, C. Garcı´a-Viguera (2004). In vitro gastrointestinal digestion study of broccoli inflorescence phenolic compounds, glucosinolates, and vitamin. C. J. Agric. Food Chem. 52, 135–138.

Wittstock, U., E. Kurzbach, A. Herfurth, E. Stauber and S. Kopriva (2016). Glucosinolate Breakdown. Advances in Botanical Research. Academic Press, pp. 125–169.

Xiang, N., K. S. Lawrence, J. W. Kloepper, P. A. Donald, J. A. McInroy and G. W. Lawrence (2017). Biological control of *Meloidogyne incognita* by spore-forming plant growth promoting rhizobacteria on cotton. Plant Disease 101: 774-784.

Youssef, R. M., K. H. Kim, S. A. Haroon and B. F. Matthews (2013). Post transcriptional gene silencing of the gene encoding aldolase from soybean cyst nematode by transformed soybean roots. Experimental Parasitology 134: 266-274.

Zasada, I. A., S. L. F. Meyer and M. J. Morra (2009). Brassicaceous seed meals as soil amendments to suppress the plant-parasitic nematodes *Pratylenchus penetrans* and *Meloidogyne incognita*, J. Nematol. 41: 221–227.

Zrybko, C.L., E.K. Fukuda and R.T. Rosen, (1997). Determination of glucosinolates in domestic and wild mustard by high-performance liquid chromatography with confirmation by electrospray mass spectrometry and photodiode-array detection. J. Chromatogr. 767, 43–52.

النشاط السمى لمسحوق بذور بعض النباتات ضد نيماتودا تعقد الجذور "ميليدوجيني انكوجنيتا" التي تصيب نباتات الفلفل تحت ظروف الصوبة.

محمود مفيد شلبي [1] ، سمير برهام جاد [2] ، أشرف السعيد خليل [3] و أحمد جمال الشريف [2]

[1] قسم الحيوان الزراعي – كلية الزراعة – جامعة دمياط.

[2] وحدة بحوث النيماتولوجي – قسم الحيوان الزراعي – كلية الزراعة – جامعة المنصورة.

[3] معهد بحوث أمراض النباتات – مركز البحوث الزراعية – الجيزة – مصر.

أجريت هذه الدراسة لتقييم فاعلية مسحوق بذور ستة نباتات هي اللفت ، الجرجير ، العرعر ، حب الرشاد ، الفجل ، الخردل ؛ بثلاث جرعات هي 2 و 4 و 6 جرام/نبات، في مكافحة نيماتودا تعقد الجذور "ميليدوجيني انكوجنيتا" التي تصيب نباتات الفلفل تحت ظروف الصوبة (29±3ºم) ، وكانت النتائج على النحو التالي:أوضحت النتائج أن كل المعاملات أدت إلي زيادة في تحسن الصفات النباتية مع خفض أطوار النيماتودا المختبرة بنسب مختلفة.سجلت معاملة المسحوق الجاف لبذور نبات الخردل أعلي المعاملات في خفض المقاييس النيماتودية بنسب 93.09 و 93.94 و 95.75 ٪ لكل من المجموع الكلي لتعداد النيماتودا وعدد العقد وكتل البيض علي التوالي بمعامل تكاثر (0.15) ومعدل زيادة تعداد النيماتودا (-0.85) عند أعلي جرعة (6جرام/نبات).في حين حققت المعاملة بالمسحوق الجاف لبذور كل من نبات حب الرشاد ونبات العرعر (6جرام/نبات) في خفض المقاييس النيماتودية بعد معاملة الخردل ، بنسب (92.45 و90.74 و 95.07٪) و (90.96 و 90.58 و 94.73٪) علي التوالي لنفس المقاييس السابقة. حققت المعاملة بالمسحوق الجاف لبذور نبات اللفت أفضل النتائج في زيادة كل من المجموع الكلي لطول النبات (143.1٪) ووزن النبات الرطب (118.4٪) وكذلك الوزن الجاف للمجموع الخضري (100.0٪) وعدد الأوراق علي النبات (99.5٪) عند أعلي تركيز 6جرام/نبات علي الترتيب. سجل المبيد الكيماوي (كرينكل) نسبة خفض في المجموع الكلي للنيماتودا (92.95٪) وعدد العقد (91.01٪) وعدد كتل البيض (95.07٪) بمعامل تكاثر (0.15). أدت زيادة الجرعة المختبرة من 4 جرام إلي 6 جرام/نبات في كل من المعاملة بمسحوق بذور الخردل وحب الرشاد إلي خفض في المقاييس النباتية. كما أدت جميع الجرعات لمسحوق البذور للنباتات المختبرة إلي زيادة نسب النيتروجين والفوسفور والبوتاسيوم وكذلك المحتوي الكلي للفينولات وتقليل المحتوي الكلي للكلوروفيل إلي حد ما، حيث سجلت معاملة المسحوق الجاف لبذور نبات الفجل أعلي القيم (143.6 و 216.5 و 101.9 ٪) لكل من النيتروجين والفوسفور والبوتاسيوم علي التوالي. سجلت معاملة المسحوق الجاف لبذور نبات حب الرشاد أعلي نسبة زيادة في المحتوي الكلي للفينول (198.27٪) مقارنة بالنيماتودا فقط.