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Impact of Ecological Friendly Treatments on *Meloidogyne incognita* Infected Ground Cherry

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ABSTRACT

The main efforts of scientists to reduce appliance of nematicides that are commonly found in the markets, led to an increase in the demand safety, effective and environment friendly alternatives. Hence, the present research aims to test three safety and effective substances (Potassium silicate; Furfural and Albendazole) single or in combination in the control of root-knot nematode, *Meloidogyne incognita* infecting ground cherry plants (*Physalis pruinosa* L.) under field conditions. The obtained results revealed that all tested materials decreased *M. incognita* J_2 population density. Individual treatments gave average reduction percentages of *M. incognita* J_2 as: Potassium silicate 39.4%; Furfural 55.9% and Albendazole 52.1%. The triple treatment (Potassium silicate + Furfural + Albendazole) gave the best results, as it led to decrease in the number of *M. incognita* J_2 by 72.3% more than that occurred by the chemical nematicide (Oxamyl 24%), which gave a reduction percentage of 65.6%. The triple treatment also led to decrease in the numbers of mature females; egg masses and root gall index by 96.5, 95.4 and 83.3%, respectively, while the Oxamyl 24% gave 86.9, 90.5 and 83.3 %, respectively. In addition, the triple treatment caused improvement in the vegetative and fruiting characteristics of treated plants. Thus, triple treatments can be recommended as a safety alternative for plants and humans instead of chemical nematicides in integrated nematode control programs.

Keywords: *Meloidogyne incognita*, Potassium silicate, Furfural, Albendazole, Ground cherry.

INTRODUCTION

Ground cherry , *Physalis pruinosa* L. (Family: Solanaceae) has economic and therapeutic importance as its fruit protected by an accrescent calyx and covered by a brilliant yellow peel and contains many important vitamins for the body, as it is rich in many beneficial elements for diabetics, strengthening the immune system and reducing high blood pressure (Kumagai et al., 2021; Puente et al., 2011). The root-knot nematode, *Meloidogyne* spp. is one of the most widespread genus and its host range is wide, as it parasites on many vegetables, fruit and field crops in addition to some ornamental plants and leads to a complete loss of yield (Saad et al., 2010). Root-knot nematodes attack the roots of *Physalis pruinosa* plants, causing damage and great economic loss (Abo-Korah, 2017).

Silicon (Si) considered as the second element after oxygen in the percentage of its presence in the earth's crust and reduces the toxic effect on plants caused by increased salinity; dehydration and exposure to heavy metals (Ye et al., 2013). Silicon increases the ability of plants to withstand temperatures and droughts; prevent the

penetration of fungi, bacteria and nematodes into the cortex of plants, as it is concentrated at the site of penetration of the pest and prevents it from income and thus reduce the incidence of diseases (Gad, 2019). It is considered to have a major role in increasing plant resistance to pests (Dannon and Wydra, 2004).

Furfural is an organic substance that is easily soluble and decomposed in water and the soil as well as is not polluting the environment. It has a negative effect on *Meloidogyne incognita* egg hatching, juveniles viability and root penetration rate. Accordingly, it must be taken into account that furfural is a suitable alternative to first-class nematicide (Fabiyi, 2020; Abdelnabby et al., 2016).

Albendazole is a medicine used for the treatment of a variety of zooparasitic nematode infestations and broad spectrum antinematodes. The principal mode of action is by its inhibitory effect on tubulin polymerization which results in the loss of cytoplasmic microtubules in the intestines of nematodes, ultimately causing energy depletion and death of the organism (Stephen et al., 2012).

This study aims to use safety and effective materials against root-knot nematode, *Meloidogyne incognita* that infecting ground cherry plants, to be used as substituent of chemical nematicides which cause damage to human health.

MATERIALS AND METHODS

Field naturally infested (175.0 m^2) was conducted at the experimental farm of the Faculty of Agriculture, Menoufia University, Shibin El-Kom, Egypt, to study the effectiveness of three safety treatments (Potassium silicate; Furfural and Albendazole) individually or solidarity on root-knot nematode, *M. incognita* infecting ground cherry plants in comparison with chemical nematicide Vydate (Oxamyl 24% L) and their impact on the vegetative and fruiting characteristics of the ground cherry plants.

Potassium silicate

Potassium silicate [K_2SiO_3 (SiO_2 25% & K_2O 10%)] was applied as foliar spray at 4000 ppm concentration. The application was started one week after planting the seedlings, then after one, two, three and four months, according to Abdel-Latif et al. (2019).

Furfural

Furfural (2 furancarbox aldehyde) is a naturally occurring aromatic aldehyde present in some foods, essential plant oils, and cosmetics. It was obtained from Sinopharm company, with a purity of 99.0%.. One week after seedling adaptation, Furfural was applied at a rate of 50 ml/plant as soil drench around the roots, the same rate was applied two months after planting, according to Fabiyi (2020).

Albendazole

Albendazole ($C_{12}H_{15}N_3O_2S$) is one of the most famous medicines for the treatment and disposal of zoo parasitic nematodes. It is produced by Pharma Cure for the pharmaceutical industries in the form of tablets and syrup.

Experimental laboratory (before field experiment):

A laboratory experiment was conducted to study the effect of Albendazole on root-knot nematode, *M. incognita* J_2. Nematodes were extracted from the soil before planting and different concentrations of albendazole (1;3;5 and 7 ml) were added by

micropipette on parasitic nematodes placed in Petri dish (5 cm diameter) and its activity was monitored under the microscope. It was found that the concentration of 3 ml led to a weak activity of the nematodes after two hours and after eight hours all the nematodes were died. Albendazole was applied to the soil around the roots of plants at a rate of 3 ml/plant and repeated every month.

Vydate 24% L., Oxamyl : (2-dimethylthio) glyoxal-0-methylcarbamoyl monoxime) was applied around the roots of plants at a rate of 2 ml/plant.

Experimental preparation and design:

At transplanting time of ground cherry seedlings cultivar Balady, the nine treatments were arranged in a completely randomized block design. Each treatment was replicated three times (three rows), each row consisted of was 4 meter long and one meter wide. The distance between each two ground cherry seedlings cv. Balady was 50cm. Normal agricultural practices were undertaken and treatments were as follows : 1. Potassium silicate; 2. Furfural; 3. Albendazole; 4. P. silicate + Furfural; 5. P. silicate + Albendazole; 6. Furfural + Albendazole; 7. P. silicate + Furfural + Albendazole; 8. Oxamyl 24% L and 9. Control.

Soil samples were taken before planting and nematode extraction was processed using modified Baermann funnels for 72 hours. Different plant parasitic nematode genera were identified and counted using Hawksely counting slide with the aid of Stereomicroscope. Key references of Mai and Lyon (1975) were consulted and found to be of the genus *Meloidogyne* and traces of other genera like *Pratylenchus* and *Helicotylenchus*. Monthly soil samples were taken from the rhizosphere area of ground cherry plants from each treatment for four months. Three replicates, each one of 100 g soil and roots were taken from each treatment to extract nematodes, counted and identified according to methods described by Southey (1970). At the end of the experiment, 120 days after treatments, plant roots were submerged, thoroughly washed in tap water, immediately stained with Phloxin-B solution (0.15 g/l tap water) for 20 minutes and egg masses were assessed according to Daykin and Hussey (1985). Plant roots were rinsed in water, some of root knot nematode females were counted with the help of a dissecting microscope and according to the perineal pattern, it was found that mostly types follow *M. incognita*. Number of galls were rated on scale of 0-5 (Table 1). Vegetative and fruiting measurements of plants were taken.

Table 1: Rating scale levels of galls numbers (Taylor and Sasser, 1978)

Number of galls/ root system	Gall index
0	0
1-2	1
3-10	2
11-30	3
31-100	4
>100	5

Statistical analysis

The obtained data were subjected to analysis of variance (ANOVA) using CoStat Software, Version 6.4 (2008). The mean differences were compared by Least Significant Difference (L.S.D. 5%).

Reduction percentages were counted according to the formula of Henderson and Tilton (1955); Fleming and Retnakaran (1985):

Reduction% =1-[No. of J2 in treated after treatment/ No. of J2 in treated before treatment x No. of J2 in check before treatment/ No. of J2 in check after treatment] x100

Increase or decrease % = Control – Treatment / Control x 100

RESULTS AND DISCUSSION

The application of the treatments led to a gradual decrease in the population density of root-knot nematode, *M. incognita* J_2 over a period of four months after planting (Tables 2 & 3). As for the individual treatments, the furfural gave the highest reduction percentage in *M. incognita* J_2 reaching 55.9%, followed by treatment with albendazole (52.1%) and the least effective treatment occurred with potassium silicate which gave 39.4%.

Table 2: Effect of certain safe materials applied singly or in combination on the population density of *Meloidogne incognita* infecting ground cherry plants under field conditions**.**

Treatments	Aver. no. of *Meloidogyne incognita* second stage juveniles/ 100 g soil					
	Pre-treatment	Months post-treatments				
		One month	Two months	Three months	Four months	Overall mean
Potassium silicate	1699.0 F	1516.0 B	1474.0 B	1302.0 B	1191.0 B	1370.8 B
Furfural	1705.0 F	1414.0 D	1009.0 E	861.0 E	642.0 E	981.5 E
Albendazole	1798.0 D	1476.0 C	1250.0 C	993.0 C	806.0 C	1131.3 C
P. silicate + Furfural	1687.0 G	1329.0 F	981.0 F	706.0 G	593.0 F	902.3 F
P. silicate + Albendazole	1723.0 E	1403.0 E	1167.0 D	924.0 D	723.0 D	1054.3 D
Furfural + Albendazole	1812.0 C	1417.0 D	1016.0 E	715.0 F	409.0 G	889.3 G
P. silicate + Furfural + Albendazole	1891.0 A	1294.0 G	844.0 H	395.0 I	107.0 I	660.0 I
Oxamyl 24% L	1853.0 B	1329.0 F	946.0 G	639.0 H	381.0 H	823.8 H
Control	1808.0 C	2093.0 A	2418.0 A	2576.0 A	2708.0 A	2448.8 A
LSD 5%	8.6	8.6	8.6	8.6	8.6	8.5

Means in each column followed by the same letter (s) are not significantly different at 5% level.

As for the combined treatments, Potassium silicate + Furfural + Albendazole gave the highest reduction percentage (96.2%) in the fourth month, with an average 72.3% along the four months. The chemical nematicide, Oxamyl, gave 86.3% reduction in the fourth month with an average 65.6%.

Table 3: Reduction percentages in the population density of root-knot nematode, *Meloidogyne incognita* infecting ground cherry plants treated with safe materials under field conditions.

Treatments	Reduction % of *M. incognita*				
	One month	Two months	Three months	Four months	Overall mean
Potassium silicate	22.9	35.1	46.2	53.2	39.4
Furfural	28.4	55.8	64.6	74.9	55.9
Albendazole	29.1	48.0	61.2	70.1	52.1
P. silicate + Furfural	31.9	56.5	70.6	76.5	58.9
P. silicate + Albendazole	29.7	49.4	62.4	72.0	53.4
Furfural + Albendazole	32.5	58.1	72.3	85.0	62.0
P. silicate + Furfural+Albendazole	40.9	66.6	85.3	96.2	72.3
Oxamyl 24% L	38.0	61.8	75.8	86.3	65.6

These results are in agreement with those obtained by Fabiyi (2020) who confirmed that furfural has a significant and negative effect on root-knot nematode *M. incognita* in soil and roots on *Arachis hypogaea* plant. Oka (2001) found that the furfural reduces root-knot nematode and the number of mature females in tomato roots and improves the vegetative and fruiting characteristics of the plants. Abdelnabby et al. (2016) found that furfural inhibited egg hatching after two days of application and eradicated *M. incognita* J2 after 12 hours, and it has a negative effect on the biology of the different stages of *M. incognita* growth. This occurred by dissolving the lipid layer of the egg shell or the cuticle responsible for the impermeability and thus the eggs and larvae become more permeable and die.

The obtained results in Table (4) show that potassium silicate led to a decrease in the percentage of mature females, egg masses and root gall index by 39.0, 51.1 & 33.3%, respectively. These results are in agreements with those obtained by Dannon and Wydra (2004) who confirmed that potassium silicate caused increase in plant resistance. Followed by furfural, which caused a decrease of 63.7, 70.1& 50.0%, respectively and albendazole by 56., 65.6 & 50.0%, respectively. But the tri treatment, Potassium silicate + Furfural + Albendazole is considered the strongest treatment, as it caused a decrease in the percentages of mature females, egg masses and root gall index reached 96.0, 95.4 and 83.3%, respectively, exceeded those of nematicide, Oxamyl which gave deficiency rates (86.9, 90.5and 83.3%, respectively).

Albendazole is considered a safety and inexpensive substance and has proven its effectiveness against root knot nematode, *M. incognita* parasitizing on the roots of the ground cherry plants. Kumsa et al. (2010) recorded that, this material works to eliminate nematodes, it performs this role through a lack of energy by reducing the

production of ATP energy molecules through the ability to destroy the micro-cytoplasmic tubes present in the intestines of worms, thus depriving. These worms are unable to obtain the glucose needed for energy, as well as cause a lack of other nutrients, which weakens the movement of nematodes and thus eliminates them.

Table 4: Effect of treating ground cherry plants with safe materials on *Meloidogyne incognita* mature females, egg masses and root gall index.

Treatments	Mature females/ 5g/root	No egg masses	Root gall index	Decrease %		
				Females	Egg masses production	Root gall index
Potassium silicate	15.3b b	21.3b b	4.0b B	39.0	51.1	33.3
Furfural	9.1 d	13.0 cd	3.0 C	63.7	70.1	50.0
Albendazole	11.0 c	15.0 c	3.0 C	56.2	65.6	50.0
P.silicate +Furfural	6.1 e	9.9 de	2.0 D	75.7	77.3	66.7
P.silicate+Albendazole	7.3 e	11.0 de	2.0 D	70.9	74.8	66.7
Furfural +Albendazole	4.0 f	8.4 e	2.0 D	84.1	80.3	66.7
P. silicate + Furfural + Albendazole	1.0 g	2.0 f	1.0 E	96.0	95.4	83.3
Oxamyl 24% L	3.3 f	4.1 f	1.0 E	86.9	90.5	83.3
Control	25.1 a	43.6 a	6.0 A	-	-	-
LSD 5%	1.7	3.3	0.2	-	-	-

Means in each column followed by the same letter (s) are not significantly difference at 5% level.

The obtained results in Table (5) show that, the ability of the treatments to improve the characteristics of the ground cherry plants, as furfural increased plant height; shoot weight; root weight and fruit weight (g)/plant by 42.4, 34.4, 51.7 & 92.9%, respectively, followed by albendazole with proportions of 35.8, 23.0, 30.3 & 65.1%, respectively. Potassium silicate came in the last rank of this respect (30.0%, 16.4, 58.4 & 45.9%) respectively. While tri treatment (Potassium silicate + Furfural + Albendazole) gave the best increments in these proportions (76.6, 99.4, 97.8 & 236.2%, respectively) compared with nematicide Oxamyl which gave 47.3, 43.7, 40.4 & 170.5%, respectively. These results are comfortable with Mamdouh et al.(2017); Abdel-Latif et al. (2019) hence they are confirmed that potassium silicate improves the physiological response of plant leaves while increasing the ability to photosynthesis, thus improving the ability to resist diseases and parasites, and improving the vegetative and fruiting characteristics of onion plants. Gad (2019) found that, treating the cotton plant with potassium silicate leads to the entry of silica into the structure of the cell walls and the formation of silicon-containing polymers that make the cell walls more rigid and thus be resistant to reniform nematode penetration, so the plant becomes resistant to a higher degree.

Table 5: Effect of treating ground cherry plants with safe materials to control *Meloidogyne incognita* vegetative and fruiting characteristics of plants.

Treatments	Plant height (cm)	Shoot weight (g)	Root weight (g)	Fruit weight (g) /plant	Increase %			
					Plant height	Shoot weight	Root weight	Fruit weight
Potassium silicate	80.6 F	21.3 E	14.1 d	217.5 g	30.0	16.4	58.4	45.9
Furfural	88.3 D	24.6 D	13.5 d	287.5 e	42.4	34.4	51.7	92.9
Albendazole	84.2 E	22.5 E	11.6 f	246.0 f	35.8	23.0	30.3	65.1
P. silicate+Furfural	96.1 C	31.0 Bc	16.5 b	317.0 d	55.0	69.4	85.4	112.7
P. silicate +Albendazole	94.9 C	29.5 C	15.0 c	294.0 e	53.1	61.2	68.5	97.3
Furfural + Albendazole	103.0 B	32.1 B	16.9 ab	384.5 c	66.1	75.4	89.8	158.1
P. silicate + Furfural + Albendazole	109.5 A	36.5 A	17.6 a	501.0 a	76.6	99.4	97.8	236.2
Oxamyl 24% L	91.3 D	26.3 D	12.5 e	403.0 b	47.3	43.7	40.4	170.5
Control	62.0 G	18.3 F	8.9 g	149.0 h	-	-	-	-
LSD 5%	3.4	1.7	0.9	8.6	-	-	-	-

Means in each column followed by the same letter (s) are not significantly difference at 5% level

Initially, Albendazole is uniquitous and inimitable as a human nematode exterminator (Stephen et al., 2012). In the present study it was introduced as a first trial not only in Egypt but also globally as exterminator against root- knot nematode in agricultural pest control. Its solidarity with both of furfural as organic nematicide and potassium silicate which promote ground cherry growth properties as stemifol nutritional supplement against *M. incognita* infection. In the present study tri treatments gave amazing results with highly nematode reduction percentage exceeded that occurred by nematicide Oxamyl appliance. Finally, forthright on the bases of safety, aptly, forceful, cheapest, competency and environmentally friendly alternatives of these exterminators qualified in hence forward as substituent of chemical nematicide in integrated nematode control program.

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الملخص العربي

تأثير بعض المعاملات الصديقة للبيئة على نيماتودا تعقد الجذور *Meloidogyne incognita* التى تصيب نباتات الحرنكش

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يتجه العلماء حاليا إلى تقليص إستخدام المبيدات النيماتودية الكيميائية والشائعة التواجد في الأسواق وتبعاً لذلك زاد الطلب على بدائل آمنه وفعاله وصديقة للبيئة ، ومن ثم جاءت فكرة هذا البحث بتطبيق ثلاث مواد آمنة وفعالة ضد نيماتودا تعقد الجذور *Meloidogyne incognita* والتي تصيب نباتات الحرنكش تحت الظروف الحقلية وهذه المواد هي (Potassium silicate; Furfural ; Albendazole) فردي أوثنائي او ثلاثي مقارنة بالمبيد النيماتودى الاوكساميل.

أظهرت نتائج التجربة الى أن جميع المعاملات التي تم تطبيقها أدت إلى نقص الكثافة العددية لنيماتودا *M. incognita* وقد تفاوتت المعاملات الفردية في نسب نقص أعداد هذه النيماتودا مسجلة (سليكات البوتاسيوم 39.4٪ & الفورفيورال 55.9٪ & الابندازول 52.1٪). بينما سجلت المعاملة الثلاثية من المواد الثلاثة أعلى نسب موت للديدان النيماتودية تحت الدراسة وصلت إلى (72.3 ٪) متفوقة على المبيد النيماتودي الكيميائي الاوكساميل والذي أعطى نسبة موت وصلت إلى (65.6 ٪) فقط وعلية فقد سجلت المعاملة الثلاثية نقصاً ملحوظاً في أعداد كلا من الإناث البالغة وعدد كتل البيض والعقد الجذرية بنسب نقص وصلت إلى (96.5 ٪ & 95.4 ٪ & 83.3 ٪) على التوالي بينما كانت نتائج المبيد النيماتودي الاوكساميل أقل بنسب (86.9 ٪ & 90.5 ٪ & 83.3 ٪) على التوالي.

علاوة على ما سبق كان للمعاملة الثلاثية السبق في تحسين كل من الصفات الخضرية والثمرية لنباتات الحرنكش، وبالتالي يمكن الاعتماد على هذة المعاملة الثلاثية كبديل آمن للإنسان والنبات من تطبيق المبيدات النيماتودية في برامج المكافحة المتكاملة للنيماتودا المتطفلة على النبات.