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MANGEMENT OF *MELOIDOGYNE INCOGNITA* ON OKRA PLANTS USING NICKEL SULPHATE UNDER GREENHOUSE CONDITIONS.

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ABSTARCT

Impact of five nickel sulphate concentrations i.e. 1, 2, 4, 8 and 16 ppm as soil drench in comparison with oxamyl on plant growth parameters of okra plant *(Abelmoschus esculentus*) cv. Hyper Doki 1 infected with *Meloidogyne incognita* and its development was evaluated under greenhouse conditions at 30±3ºC. Results revealed that all tested treatments improved okra plant growth characters and reduced nematode criteria as well. In general, a gradual decline of plant growth increase was detected by the increase of tested nickel sulphate concentrations that accompanied with high percentage increase in reduction of nematode criteria. Among tested nickel sulphate applications, one ppm significantly overwhelmed other treatments in improving plant growth parameters with values of 31.0, 38.0 and 5.3% for total plant length, fresh weight of the whole plant and shoot dry weight, respectively. Moreover, plant receiving 16 ppm / plant accomplished the highest reduction percentage in tested nematode parameters that averaged 82.1, 67.6 and 70.7%, for juveniles in soil, galls and eggmasses numbers, respectively. Meanwhile, oxamyl ranked first in suppressing nematode parameters with values of 94.2, 90.2 and 94.9% for nematode population (J_2), galls and eggmasses numbers as well as fourth in the increment of plant growth criteria, respectively.
Keywords: Nickel sulphate, okra plant, oxamyl, *Meloidogyne incognita*

INTRODUCTION

Okra (*Abelmoschus esculentus* Moench.) is one of the warm season crops that is grown in the tropical and sub-tropical regions of the world (Rashid *et al.,* 2002). Okra is a popular health food due to its high fiber, vitamin C, folate content and antioxidants. Okra is also a good source of calcium and potassium. Soil nematodes, especially root-knot nematodes, *Meloidogyne* spp. are major soil-borne pests that damage crops and significantly diminish yields (Wang, 2006). Few reports have been published on the role of many microelements and heavy metals in nematode control (Nosrov and Korolchuck, 1975; Sholla, 1980; Ashoub, 1984; Korayem, 1993). Ferric sulphate Fe2 (SO4)3 is useful in controlling different nematodes, especially when added as soil drench (Osman, *et al*., 1993; El-Naggar and El-Nagar, 1995; Ismail, *et al*., 2010). However, no data is known about the influence of nickel as heavy metal on nematode development. Therefore, the objective of the present work was to elucidate the effect of nickel sulphate in comparison with oxamyl on plant morphology and root-knot disease in okra plant cv. Hyper Doki 1 infected with *M. incognita* under greenhouse conditions.

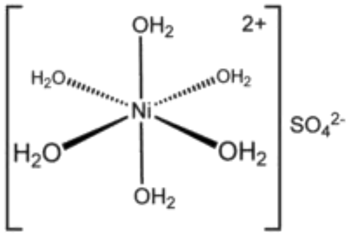
MATERIALS AND METHODS

Source of Nematodes:

Second stage juveniles (J2) of *M. incognita* (Kofoid & White) Chitwood, were obtained from a pure culture of *M. incognita* that was initiated by single eggmass and propagated on coleus plants, *Coleus blumei* in the greenhouse of Nematology Research Unit, Agricultural Zoology Department, Faculty of Agriculture, Mansoura University, Egypt, where this work was carried-out.

Nickel Sulfate

Nickel(II) sulfate, or just nickel sulfate, usually refers to the inorganic compound with the formula $NiSO_4(H_2O)_6$.



Impact of five concentrations of nicke sulphate on adjusting *Meloidogyne incognita* infecting okra plants in comparison with oxamyl under greenhouse conditions (30±3°C).

In order to study the impact of five concentrations of nickel sulphate i.e. 1, 2, 4, 8 and 16 ppm against *M. incognita* infecting okra plant cv. Hyper Doki 1 comparing to oxamyl under greenhouse conditions, thirty two plastic pots filled with 1 kg steam loamy sandy soil (1:1) (v:v) was planted with three okra seeds/pot and irrigated with water. Fifteen days from seed germination, seedlings/pot were thinned into one seedling /pot and twenty eight pot (seedling) was separately inoculated with 1000 juveniles of *M. incognita* and left four seedlings /pot without nematode to serve as check. The tested nickel sulphate concs were separately added to four seedlings (5ml /pot) each one week after nematode inoculation as well as 0.3 ml/seedling of oxamyl to another four seedlings, while four seedling (pots) with nematode only without any treatment were also included. Each treatment was replicated four times. Treatments were as follows:

1-N+ nickel sulphate (1 ppm),
2-N+ nickel sulphate (2 ppm),
3-N+ nickel sulphate (4 ppm),
4-N+ nickel sulphate (8 ppm),
5-N+ nickel sulphate (16 ppm),
6-N+ oxamyl (0.3 g/plant),
7-N alone and 8- Plant free of N and any treatment.

Plastic pots were then arranged in a randomized complete block design on a bench of greenhouse at 30±3°C, irrigated with tap water as needed. Plants were harvested after 60 days from starting the experiment.

Data dealing with length and weights of plant fresh shoot and root; and shoot dry weight as well were measured and recorded. Infected okra roots / replicate/ treatment were washed in tap water and examined for the numbers of galls and egg-masses (Byrd *et al.*, 1983). *M. incognita* (J_2s) were separately extracted from 250 g. soil of each replicate treatment by sieving and modified Baermann technique (Goodey, 1957), counted and recorded. This process was repeated three times and the average of J2 / 250 g. soil was recorded. The root gall index (RGI) and egg mass index (EI) were estimated according to the scale given by Taylor and Sasser (1978) as follows: 0= no galling or egg-masses, 1= 1-2 galls or egg-masses, 2= 3-10 galls or egg-masses, 3= 11-30 galls or egg-masses, 4= 31-100 galls or egg-masses and 5= more than 100 galls or egg-masses. Statistically, the obtained data were subjected to analysis of variance (ANOVA) (Gomez and Gomez, 1984) followed by Duncan's multiple ranges to compare means (Duncan, 1955).

RESULTS AND DISCUSSION

Data in Tables (1&2) documented the impact of five concs of nickel sulphate i.e. 1, 2, 4, 8 and 16 ppm against *M. incognita* infecting okra plant cv. Hyper Doki 1 in comparison with oxamyl on plant growth response; and nematode development and reproduction under greenhouse conditions. Obviously results indicated that all tested treatments improved plant growth parameters and reduced nematode criteria as well. In general, a gradual decline of plant growth increase was detected by increasing of nickel sulphate concentrations. Among tested nickel sulphate concentrations, one ppm significantly overwhelmed other treatments in improving plant growth parameters with values of 31.0, 38.0 and 5.3% for total plant length, fresh weight of the whole plant and shoot dry weight, respectively, followed by that of 2 ppm for the same plant criteria with values of 29.6, 35.0 and 5.3%, respectively. However, the two concs 4 and 8 ppm of nickel sulphate gave the intermediate values in this respect, which were amounted to 28.9, 34.4 and 4.7%; 28.8, 29.4 and 4.3% for total plant length, fresh weight of whole plant and shoot dry weight as well, respectively. Like wise, the same trend was noticed in the case of conc. of 16 ppm with slight increase percentages in total plant length (26.4%) and total fresh weight (26.8%), and shoot dry weight (2.9%) respectively, comparing to nematode alone. Moreover, Oxamyl as a nematicide showed considerable values in improving plant growth criteria which averaged 27.4, 37.4 and 5.1% for the same plant characters, respectively, comparing to nematode alone (Table 1).

It is worthy to note that phytotoxicity of okra plant growth characters was evident as the concentrations of nickel sulphate increased from one to 16 ppm comparing to the uninoculated and untreated plants(Table 1).

Data presented in Table (2) showed nematode population in soil and number of galls and egg-masses on okra plant infected with *M. incognita* as affected by the tested five concs of nickel sulphate in comparison with oxamyl under greenhouse conditions. It was evident that nematode criteria were also significantly influenced by all tested treatments comparing to nematode alone. Appositive correlation was recorded between reduction of nematode criteria and the increase of nickel sulphate concentrations. The application of nickel sulphate at the high concentration 16 ppm accomplished the highest reduction percentage in tested nematode parameters that averaged 82.1, 67.6 and 70.7%, for juveniles in soil, galls and eggmasses numbers, respectively that accompanied with the lowest values of increasing plant growth parameters, followed by that of 8 ppm application with value of 81.1, 61.8 and 68.7% for the same parameters, respectively (Table 1&2)

Table (1): Impact of five concentrations of nickel sulphate in comparison with oxamyl on growth response of okra cv. Hyper Doki 1 infected with *Meloidogyne incognita* under greenhouse conditions (30±3 ºC).

Treatments	**Plant growth response*									
	Length (cm)		Total Length	**Inc %	Fresh weight (g)		Total Fresh weight	**Inc %	Shoot dry weight (g.)	**Inc %
	Shoot	Root			Shoot	Root				
NS (1ppm)	66.3 b	29.3 b	95.6 b	31.0	52.5 a	16.9bc	69.4b	38.0	21.26 b	5.3
NS (2ppm)	66.0 b	28.6 b	94.6 bc	29.6	52.3 a	15.6bc	67.9bc	35.0	21.25 b	5.3
NS (4ppm)	65.5 b	28.3 b	94.1 bc	28.9	52.1 a	15.5bc	67.6bc	34.4	21.14bc	4.7
NS (8ppm)	65.0 b	29.0 b	94.0 bc	28.8	51.2 b	13.9cd	65.1cd	29.4	21.05 c	4.3
NS (16ppm)	66.0 b	26.3 c	92.3 d	26.4	51.9 ab	11.9d	63.8d	26.8	20.77 d	2.9
Oxamyl	65.0 b	28.0 c	93.0 c	27.4	52.0 a	17.1ab	69.1b	37.4	21.21 b	5.1
N alone	53.0 c	20.0 d	73.0 e	------	52.2 a	18.1ab	50.3ab	-----	20.19bc	------
Check	88.0 a	30.0 a	118.0 a	61.6	52.3 a	20.1a	72.4a	43.9	21.41a	6.0

N=1000 J2 of *M. incognita*
NS = Nickel Sulphate
***Each value is a mean of three replicates. Means in each column followed by the same letter(s) did not differ at p<0.05 according to Duncan multiple-range test.**
**** Increase % = Treatment - N alone (Untreated) / N alone (Untreated) × 100**

The relative lowest reduction percentages of this nematode criteria were resulted by treatment of (1 ppm) with value of 66.8, 54.9 and 65.7 % for juveniles in soil, galls and eggmasses numbers, respectively as compared with nematode alone, (Table 2).

Concerning root galling, a significant reduction in number of galls on okra roots was achieved by all tested treatments, comparing to nematode alone since their indices ranged from 2 to 4 vs 5 for the tested nickel sulphate concs and oxamyl, vs the nematode alone (Table 2).

Similar trend was noticed in reduction of egg-mass numbers since their indices ranged from 2 to 4 vs 5 respectively comparing to the nematode alone.

Moreover, oxamyl as a systemic nematicide ranked first in suppressing nematode parameters with values of 94.2, 90.2 and 94.9% for nematode population (J2), galls and eggmasses numbers, and fourth in the increments values of plant growth characters, respectively. (Table 1&2)

Table (2): Number of root galls, eggmasses, and juveniles in soil of *Meloidogyne incognita* infecting okra cv. Hyper Doki 1 as influenced by five concentrations of nickel sulphate in comparison with oxamyl under greenhouse conditions (30±3 ºC).

Treatments	Juveniles in soil	Red %	No. of galls	Red %	RGI**	No. of egg masses	Red %	EGI***
NS (1ppm)	365.3 b	66.8	46.0 b	54.9	4	34.0 b	65.7	4
NS (2ppm)	322.7 bc	70.7	43.0 b	57.8	4	32.0 bc	67.7	4
NS (4ppm)	298.7 c	72.9	41.0 b	59.8	4	31.0 bc	68.7	4
NS (8ppm)	208.0 d	81.1	39.0 bc	61.8	4	29.0 c	70.7	3
NS (16ppm)	197.3 d	82.1	33.0 c	67.6	4	29.0 c	70.7	3
Oxamyl	64.0 e	94.2	10.0 d	90.2	2	5.0 e	94.9	2
N alone	1100.2 a	-----	102.0 a	-----	5	99.0 a	----	4

N=ck=1000 J2 of *M. incognita*
NS = Nickel Sulphate
***Each figure represents the mean of three replicates.**
***Means in each column followed by the same letter did not differ at P< 0.05 according to Duncan's multiple range tests.**
***The root gall index (RGI) and egg mass index (EI) were estimated according to the scale given by Taylor and Sasser (1978) as follows: 0= no galling or egg-masses, 1= 1-2 galls or egg-masses, 2= 3-10 galls or egg-masses, 3= 11-30 galls or egg-masses, 4= 31-100 galls or egg-masses and 5= more than 100 galls or egg-masses.**

Apparently, the importance searching for alternative cheap technique for the management of phytonematodes in various agricultural crops was essential**..** However, results of the present work proved this phenomenon in suppressing *M. incognita* development associated with relative ameliorating plant growth parameters of infected okra cv. Hyper Doki 1 using the concs of nickel sulphate under greenhouse conditions. In the meantime, the concentration of one ppm significantly overwhelmed other treatments in improving plant growth parameters with a reasonable reduction percentages values of nematode criteria eventhough the concentration of 16 ppm ranked first in suppressing nematode criteria as well, a situation which supported by the findings of Gad and Ismail (2011) who reported that all cobalt doses significantly (p≤ 0.05 and / or 0.01) reduced juveniles, females, galls, egg-masses and eggs per egg-masses numbers as compared to un-treated plants. Also, the obtained results indicated that all cobalt treatments significantly increased the growth, and yield of roots, as well as sugar yield and root mineral composition (except Fe content). Moreover, results of this investigation proved the phenomenon of utilizing nickel sulphate in protecting vegetable crops against such pathogenic nematode, a situation which agreed with the findings of Gad and Ismail (2011) who reported that increase in cobalt activity against *M. arenaria*, may be due to reduction in pH solution value of 6.1 that resulting from its dissolved in irrigation water (Youssef, *et al*., 2001; Nadia Gad and Kandil, 2008). The relation between biological activity of some compounds and their pH was recorded by Gradis and Sutton, 1981; Lukens, 1969, whereas the activity of captan fungicide was reduced in alkaline solutions. On the other hand, Tawfik and El-Sisi, 1987 found that oil activity increased as pH decreased and the pH value of spray oils play a role in their toxicity against the scale insect, *Parlatoria ziziphus*. In 1984, Korayem assumed that presence of an electrophilic agent (E+) on the other used element may change to a positive ion, since its amide group are known to be nucleophilic (Hendrickson, *et al*., 1976), attracting the electrophilic agent to the oxygen atom (electronegative), provoking the positive ion. Therefore, nickel ions may form with soil particles a positive ion, which may have a more potency for cholinesterase inhibition in nematodes and also may be easily absorbed by plant roots. However, results of the present investigation showed the possibilities of using nickel sulphate at moderate concentration (8 ppm/plant) with values of 81.0, 61.8 and 70.7% for reduction percentages (J_2) in soil, galls and eggmasses numbers on okra roots, in addition to certain minerals i.e. NPK fertilizers to compensate the plant growth parameters. In this respect, additional research program under field conditions may be needed before drawing such recommendation of nematode control.

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مكافحة نيماتودا *Meloidogyne incognita* علي نبات الباميا باستخدام سلفات النيكل تحت ظروف الصوبة الزراعية

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تم دراسة تقييم خمسة تركيزات من سلفات النيكل 1 ، 2 ، 4 ، 8 ، 16 جزء بالمليون مقارنة بمبيد الاوكساميل عند الجرعة الموصي بها (0.3 مل / نبات) علي المقاييس النباتية والاصابة بمرض تعقد الجذور النيماتودي علي نبات الباميا صنف هيبر دوقي 1 تحت ظروف الصوبة الزراعية . **وقد أشارت النتائج الي:**

1. ان جميع المعاملات المختبرة أدت الي تحسن النمو الخضري وخفض تعداد النيماتودا مقارنة بمعاملة النيماتودا منفردة.
2. حققت معاملة تركيز واحد جزء بالمليون تفوق واضح بدرجة معنوية عن جميع المعاملات الآخري في زيادة النمو الخضري بمعدلات 31.0 ، 38.0 ، 5.3 % لكلا من الطول النباتي والوزن الرطب الكلي للنبات والجاف للمجموع الخضري ، يليها معاملة بتركيز 2 جزء بالمليون بقيم 29.6 ، 35.0 ، 5.3 % للمقاييس النباتية السابقة علي الترتيب.
3. أعطت المعاملة بتركيز 16 جزء بالمليون اعلي معدلات الخفض في تعداد النيماتودا في التربة (82.1%) ، عدد العقد (67.6%) عدد كتل البيض (70.7%) علي الترتيب يليه المعاملة بتركيز 8 جزء بالمليون بقيم 81.1 ، 61.8 ، 70.7% لنفس المقاييس النيماتودية المختبرة السابقة علي الترتيب.
4. أحتلت المعاملة بالاوكساميل المركز الاول في خفض تعداد النيماتودا بقيم 94.2 ، 90.2 ، 94.9% لكلا من تعداد النيماتودا في التربة ، عدد العقد ، كتل البيض علي الترتيب.

قام بتحكيم البحث

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