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ROLE OF MINERAL NUTRITION ON CONTROLLING *Meloidogyne incognita* INFECTING OKRA PLANT UNDER GREENHOUSE CONDITIONS

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ABSTARCT

The impact of three mineral fertilizers and magnetic iron at three levels (5, 10, 15 g/plant) on *Meloidogyne incognita* infecting okra plant in comparsion with furadan were studied under greenhouse conditions (29 ± 3°C). Results indicated that all tested materials significantly ameliorated okra plant growth criteria and reduced tested nematode parameters as well. Zinc sulphate, magnesium sulphate and magnetic iron at the level of 15 g/ plant achieved better results than did other levels with values of 20.1, 44.3 and 46.6%; 21.8, 50.9 and 32.6%; and 39.0, 34.2 and 32.1% for plant length , total plant fresh weight and shoot dry weight, respectively, followed by that of 10g/ plant, and then the level of 5 g/ plant - except that of ferrous sulphate. A positive correlation between reduction percentage of nematode population in soil and increasing tested materials levels was evident. The level of 15g/ plant ranked first in diminishing number of nematode in soil with values of 83.9, 80.6, 82.9 and 79.4% respectively for zinc sulphate, magnesium sulphate, ferrous sulphate and magnetic iron, respectively. However, a negative correlation between levels of application of such materials and reduction percentages of galls and eggmasses was also observed except that of magnetic iron. As the level of such materials raised, reduction of galls and eggmasses number decreased except that of magnetic iron. However, the least values of these nematode criteria were recorded by zinc sulphate, magnesium sulphate, and ferrous sulphate treatments at the rate of 15g/plant. Furadan (5g/plant) gave considerable percentage increase values for plant growth parameters and ranked first in diminishing nematode criteria.

Keywords: *Meloidogyne incognita* , control, , okra plant, furadan, mineral fertilizers, magnetic iron.

INTRODUCTION

Okra (*Abelmoschus esculentus* Moench.) is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds and also rich in vitamin A and low in calories. (Rashid *et al.,* 2002). It is among the most heat- and drought-tolerant vegetable species in the world and will tolerate soils with heavy clay and intermittent moisture. Okra is infamous for its susceptibility to root-knot nematodes. Root knot nematode *(Meloidogyne* spp.) disease occurs in nearly all parts of the world and on most plant species. Although plant tolerance and resistance to pathogens are genetically controlled, they are significantly influenced by environmental nutrition factors. Mineral nutrients can increase or decrease resistance or tolerance to pathogens and pests. Plants receiving ample nutrition have higher resistance to diseases and higher tolerance. This is based on the fact that more vigorous plants have greater capacity to offset a loss of photosynthates, for instance, reduction in root and leaf surface area caused by infection by pathogens or poor nutrition (Simone *et al.*, 2013). Plant mineral nutrition can be considered an environmental nutrition factor that can be an important component in disease control, as well as a tool for adjusting phytonematodes. Therefore, the objective of the present work was to study the effect of certain plant mineral nutrition in comparison with furadan on root-knot nematode, *Meloidogyne incognita* infecting okra plant cv. Hyper Doki 1 under greenhouse conditions.

MATERIALS AND METHODS

Source of Nematodes:

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

Nematicide:

Furadan: 2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate; IUPAC: 2,3-dihydro-2,2-dimethylbenzofuran-7-yl methylcarbamate

Impact of three mineral fertilizers and magnetic iron at three levels on the root-knot nematode, *Meloidogyne incognita* infecting okra plant in comparsion with furadan under greenhouse conditions.(29 ± 3 °C)

A greenhouse experiment was conducted in order to evaluate the efffect of the following three mineral fertilizers, zinc sulphate($ZnSO_4$), magnesium sulphate ($MgSo_4$)and ferrous sulphate ($FeSo_4$)as well as magnetic iron at three levels i.e. 5, 10 and 15g /plant against *M. incognita* infecting okra plant (cv. Hyper Doki 1) as highly susceptible host in comparison with furadan under greenhouse conditions. Sixty plastic pots (15 cm-d) filled with 1 kg steam loamy sandy soil (1:1) (v:v) were planted with three okra seeds/pot and irrigated with tap water. Fifteen days from seed germination, seedlings were thinned into one seedling /pot. Fifty six pots (seedlings) were separately inoculated with 1000 juveniles of *M. incognita* and left four seedlings (pot) without nematode to serve as check. The tested materials were separately added to four seedlings each and mixed with soil one week after nematode inoculation, while four seedlings (pots) with nematode only were left without any treatment. Each treatment was replicated four times. Treatments were as follows:

1-N+ zinc sulphate (5g / pot), 2- N+ zinc sulphate (10g / pot),
3- N+ zinc sulphate (15g / pot), 4-N+ magnesium sulphate (5g / pot),
5- N+ magnesium sulphate (10g / pot), 6-N+ magnesium sulphate (15g / pot),
7- N+ ferrous sulphate (5g / pot), 8- N+ ferrous sulphate (10g / pot),
9- N+ ferrous sulphate (15g / pot), 10- N+ magnetic iron (5g / pot),
11- N+ magnetic iron (10g / pot), 12-N+ magnetic iron (15g / pot),
13- N+ furadan (5 g/plant), 14- N alone and
15- Plant free of N and any treatment.

Plastic pots were then arranged in a randomized complete block design on a bench of greenhouse at 29±3°C and irrigated with tap water as needed. Plants were harvested after 45 days from nematode inoculation. Data dealing with length and weights of fresh shoot and root; and shoot dry weight of each plant / pot were measured and recorded. Infected okra roots were washed in tap water and examined for the numbers of galls and egg-masses and 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 galls 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. *M. incognita* (J_2s) were separately extracted from 250 g. soil of each treatment / replicate by sieving and modified Baermann technique (Goodey, 1957), counted , recorded and then determined for the soil of each pot. 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 table (1) represented the plant growth parameters of okra plant cv. Hyper Doki 1 (susceptible host) i.e. plant length, whole plant fresh weight and shoot dry weight under the stress of *M. incognita* infection as influenced by zinc sulphate, magnesium sulphate, ferrous sulphate and magnetic iron at three levels (5, 10, 15 g/ plant) comparing with furadan under greenhouse conditions. Results indicated that all tested applications significantly improved okra plant tested characters. In the meantime, most treatments showed positive correlation between plant growth improvement and increment of application level. Plants receiving the level of 15 g/ plant of such tested materials, except that of ferrous sulphate, showed better results than other levels. For instance, plant receiving zinc sulphate, magnesium sulphate and magnetic iron at the rate of 15g / plant ranked first with the maximum increment values that averaged 20.1 , 44.3 and 46.6%; 21.8, 50.9 and 32.6%; and 39.0, 34.2 and 32.1% for plant length , total plant fresh weight and shoot dry weight, respectively comparing to nematode alone, followed by that of 10g/ plant which were amounted to 19.5 , 30.3, and 25.9%; 10.5, 42.6 and 16.1%; and 32.0, 25.7 and 27.5% for the same parameters, respectively. Moreover, plants treated by all materials at the level of 5 g/ plant - except that of ferrous sulphate- represented the last position with the minimum values of plant length (19.3, 7.2 and 26.8%); total plant fresh weight (24.6, 31.9 and 23.5%); and shoot dry weight (14.5, 9.3 and 13.5%), for zinc sulphate, magnesium sulphate and magnetic iron, respectively, whereas, ferrous sulphate as mineral fertilizer accomplished the modest increments of okra plant growth parameters at the tested three levels. Moreover, furadan (5g/plant) as a nematicide gave the considerable percentage increase values for plant length (43.7%) total plant fresh weight (28.5%) and shoot dry weight (25.9%), respectively. Meanwhile, plant free of nematode and untreated with any tested materials showed reasonable percentage increase values that averaged 29.5, 20.7 and 17.1% for plant length, total plant fresh weight and shoot dry weight, respectively, comparing to nematode alone (Table 1).

Table (1) Influence of three mineral fertilizers and magnetic iron on okra plant cv. Hyper Doki (1) in comparison with furadan under the stress of *Meloidogyne incognita* infection in the greenhouse (29±3°c).

Treatments	Level (g)	*Plant growth response*									
		Length (cm)		Total Length	**Inc %	Fresh weight (g)		Total Fresh weight	**Inc %	Shoot dry weight (g.)	**Inc %
		Shoot	Root			Shoot	Root				
Zinc sulphate ($ZnSO_4$)	5	65.6 g	25.3f	90.9i	19.3	61.3f	19.2 j	80.5 ij	24.6	22.1ef	14.5
	10	63.2 hi	27.9e	91.1hi	19.5	66.3d	17.9 k	84.2 gh	30.3	24.3c	25.9
	15	66.9 f	24.6gh	91.5h	20.1	67.9c	25.3e	93.2 c	44.3	28.3a	46.6
Magnesium sulphate ($MgSO_4$)	5	56.6 j	24.8g	81.7k	7.2	61.1fg	24.1f	85.2 g	31.9	21.1 de	9.3
	10	61.4 i	22.8h	84.2j	10.5	64.2e	27.9c	92.1d	42.6	22.4 d	16.1
	15	69.9 e	22.9h	92.8g	21.8	68.2b	29.3bc	97.5 j	50.9	25.6 b	32.6
Ferrous sulphate ($FeSO_4$)	5	66.4 f	28.9de	95.3f	25.1	69.1a	33.9a	103.0a	59.4	21.9 e	13.5
	10	67.2 d	33.9c	101.1c	32.7	59.2 gh	27.9c	87.1 e	34.8	23.7 cd	22.8
	15	64.3 h	31.4 cd	95.7ef	25.6	57.5 h	22.3h	79.8g	23.5	25.8 b	33.7
Magnetic iron	5	61.2 i	35.4b	96.6e	26.8	51.9 k	27.9c	79.8 j	23.5	21.9 e	13.5
	10	65.9 g	34.7bc	100.6d	32.0	59.9 g	21.3 g	81.2 i	25.7	24.6 c	27.5
	15	69.1 c	36.8a	105.9b	39.0	54.6 j	32.1b	86.7 f	34.2	25.5 b	32.1
Furadan (5g)		72.9 a	36.6ab	109.5a	43.7	56.6 i	26.4 de	83.0 h	28.5	24.3b c	25.9
N alone		55.3 k	20.9i	76.2l	--	49.3 m	15.3l	64.6 l	--	19.3 g	---
Check		69.3 bc	29.4 d	98.7d	29.5	50.7 l	27.3d	78.0 k	20.7	22.6 d	17.1

N=1000 J2 of *M. incognitan*
***Each value is a mean of four 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 × 100**
N alone

Data in table (2) showed the nematicidal properties of tested materials against *M. incognita* development on okra plant . Data revealed that tested components showed significantly protection performance in okra plant cv. Hyper Doki 1 against *M. incognita* infection in terms of reduction percentage of nematode population in soil , galls and eggmasses numbers. A positive correlation between reduction percentage of nematode population in soil and tested materials level was observed. Among levels of the tested materials, level of 15g/ plant ranked first in diminishing number of nematode in soil with values of 83.9, 80.6, 82.9 and 79.4% respectively for zinc sulphate, magnesium sulphate, ferrous sulphate and magnetic iron, respectively. However, a negative correlation between levels of application and reduction percentages of galls and eggmasses was observed, except that of magnetic iron, whereas, when the level of such material raised, reduction of galls and eggmasses number decreased. Plant receiving zinc sulphate, magnesium sulphate, and ferrous sulphate at the rate of 5g/plant showed the highest reduction percentage values of galls (60.1, 67.1 and 68.3%) and eggmasses (57.6, 64.3 and 69.1%) respectively, while the dose of 10g/plant recorded the modest values in this respect. However, the least values of these nematode criteria recorded by plant receiving zinc sulphate, magnesium sulphate, and ferrous sulphate treatments at the rate of 15g/plant (the high level) that were amounted to 53.6, 66.1 and 49.3%; 55.5, 59.2 and 46.2% for galls and eggmasses, respectively, comparing to nematode alone (Table 2). Magnetic iron significantly ascertained a gradual increase for those nematode criteria with increasing level from 5 to 15 g/ plant with values that averaged between (37.9 to 70.2%) and (40.2 to 70.5%) for reduction percentages of galls and eggmasses, respectively. Moreover, furadan as a nematicide ranked first over tested materials in percentage reduction of nematode population in soil (88.9%), galls (78.4%) and eggmasses number (85.1%), respectively. Likewise, considerable results were also observed between eggmasses and root galls indices of all tested applications and nematode alone where their values ranged between 3 to 4 for nematode galls and eggmasses each vs 5 of nematode alone (Table 2).

Table (2) Percent reduction of nematode in soil, root galls and eggmasses numbers of *Meloidogyne incognita* infecting okra plant cv. Hyper Doki 1as influenced by three mineral fertilizers and magnetic iron in comparison with furadan under greenhouse conditions (29±3 C◦).

Treatments	Level (g)	*Nematode in soil	Red %	*No. of galls	Red %	RGI**	*No. of egg masses	Red %	EGI***
Zinc sulphate ($ZnSO_4$)	5	369.5 gh	81.6	42.6h	60.1	4	34.9e	57.6	4
	10	333.6j	83.3	47.1g	55.9	4	36.6d	55.5	4
	15	321.9k	83.9	49.6f	53.6	4	36.6d	55.5	4
Magnesium sulphate ($MgSO_4$)	5	531.2b	73.5	34.8 jk	67.4	4	29.4h	64.3	4
	10	436.2d	78.2	35.2j	67.1	4	30.2g	63.3	3
	15	387.9g	80.6	36.2i	66.1	4	33.6f	59.2	4
Ferrous sulphate ($FeSO4$)	5	361.8h	81.9	33.9k	68.3	4	25.4hi	69.1	3
	10	398.2f	80.1	51.9e	51.4	4	40.6c	50.7	4
	15	342.9i	82.9	54.2d	49.3	4	44.3bc	46.2	4
Magnetic iron	5	472.1c	76.4	66.4b	37.9	4	49.2b	40.2	4
	10	436.9de	78.2	56.3c	47.3	4	42.9bc	47.9	4
	15	412.3e	79.4	31.9l	70.2	4	24.3i	70.5	3
Furadan (5g)		221.8l	88.9	23.1m	78.4	3	12.3j	85.1	3
N alone		2002.9a	--	106.9a	--	5	82.3a	---	4

N=ck=1000 J2 of *M. incognita*
***Each figure represents the mean of four 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, results of the present investigation indicated that nematode parameters and host characters were both greatly affected by levels of mineral fertilizer and magnetic iron. Plant nutrients can directly or indirectly predispose plants to pathogen attack. They can reduce or increase disease severity, affect the environment to attract or deter pathogens and also induce resistance or tolerance in the host plant (Zambolim *et al.,* 2001; Agrios, 2005). Applying such fertilizer can, partially, offset nematode-induced damage by stimulating plant development (Ferraz *et al.,* 2010). The general rule is that, if a nutrient is essential to a plant species, it should be supplied in balanced proportion to other essential nutrients, since deficiency can aggravate disease, especially in short-cycle crops (Zambolim *et al.*, 2001). In 2003, Shaukat and Siddiqui reported that even when zinc alone was applied, it caused a decrease in the numbers of *M. javanica* and boosted increased growth in tomatoes. Simone *et al.,* (2013) confirmed that an increase in the antagonistic activity of rhizobacteria in the rhizobio group associated with the application of zinc. In another study, Siddiqui *et al.* (2002) confirmed that alterations in the soil when zinc was applied at 0.8 or 1.6 mg per one kg soil, whether alone or combined with *Pseudomonas aeruginosa* IE-6S+, significantly reduced the penetration of *M. javanica* into tomato roots.

The present findings are in agreement with Ismail *et al.*, 2010 who reported that the low bio-NK (BC) rate surpassed magnetic iron ore (MIO)and metal compound fertilizer ((MCF) three times by controlling *M. incognita* populations in both soil and roots of grapevine cv. Superior through two successive seasons. However, the high rate of MIO and BC was superior for two experimental periods, as well as the recommended and high rates of MCF. The low rate of MCF was the best formulation for soil and roots of grape cv. Thompson seedless. As for the tested four inorganic fertilizers with three levels each on okra plants under the stress of *M. incognita* infection in comparison with furadan proved their role in improving plant growth of such crop and in diminishing nematode criteria in the present study. Moreover, these mineral nutrients play a vital role in bio- and physiological activities in such plants. On the other hand, these nutrients may either increase or decrease resistance or tolerance in plants to nematode attack. In this present study, nematode population in all cases were diminished by ranging from 73.5 to 83.9%. The highest nematode population reductions were accomplished by the levels of 15 g/plant for zinc sulphate (83.9%) magnesium sulphate (80.6%) ferrous sulphate (82.9%) and magnetic iron (79.4%), respectively. The present findings are in agreement with those reported by Kheir *et al.*, (2009) in respect to MnSo4 , MgSo4 and NH4CL at the highest concentration level on *M*. *incognita* infecting soybean and that of Shalaby (2012) in respect to CaCl2 and Mnso4 at the high levels and ZnSo4 at the modest level for controlling *M*. *incognita* on tomatoes, respectively. Moreover, in certain cases an increase in nematode galls and eggmasses numbers against the levels tested in this study may be occurred that is due to a negative effects of heavy metals on some of their antagonists (Georgieval *et al.,* 2002). In conclusion, proper and good nutritional status of plants could enhance and magnify their defense systems against such nematode pathogens. As a whole, it can be concluded from the obtained results that all tested materials used improved plant growth of okra and suppressed nematode population and development with various degree. However, more research is needed to be done under field conditions before final recommendations can be made.

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دور التغذيــة المعدنيــة فــي مكافحــة نيمــاتودا تعقــد الجــذور ***Meloidogyne incognita*** التي تصيب نبات الباميا تحت ظروف الصوبة الزراعية

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تم دراسة تأثير ثلاث مستويات من الأسمدة المعدنيـة (كبريتـات الزنـك ، كبريتـات المغنسـيوم ، كبريتات الحديدوز) والحديد المغناطيسي بمعدلات (5 ، 10 ، 15 جم / نبـات) فـي مكافحـة نيمـاتودا تعقد الجذور *M. incognita* تحت ظروف الصوبة الزراعية مقارنة بالمبيد النيماتودي فيوردان (5 جم / نبات) عند درجة حرارة 29 ± 3 م º وقد اوضحت النتائج مايلي:-

1. أدت جميع المعاملات المختبرة الي تحسن كبير في مقاييس نمو نباتات الباميا وخفض معدل تكـاثر النيماتودا.
2. حققت المعاملة بكبريتات الزنك ، كبريتات المغنيسيوم و الحديد المغناطيسي عند مستوى 15 جم / نبـات أفضل النتـائج مقارنـة بالمستويات الأخرى بقيم 20.1 ، 44.3 و 46.6 ٪، 21.8 ، 50.9 و 32.6 ٪، و 39.0 ، 34.2 و 32.1 ٪ لكل من طـول النبـات، مجمـوع وزن النبـات الرطب والوزن الجاف الخضري على التوالي ، يليها في ذلك نفس المعاملات السابقة بمعدل (10 جم / نبات) واخيرا بمعدل (5 جم / نبات) فيما عدا المعاملة بكبريتات الحديدوز .
3. كان هناك ارتباط إيجابي بين نسبة الخفض فـي تعداد النيمـاتودا فـي التربـة وزيـادة معدل اضـافة المواد المختبـرة حيـث حقق مسـتوي 15 جـم / نبـات فـي كل المعـاملات المختبـرة اعلـي معـدلات الخفض لتعداد النيماتودا في التربـة بقيم 83.9 ، 80.6 ، 82.9و 79.4 ٪ علـى التـوالي لكـل من كبريتـات الزنـك ، كبريتـات المغنيسـيوم ، كبريتـات الحديـدوز و الحديـد المغناطيسـي ، علـى التوالي
4. .وتم رصد ارتباط سلبي بين الجرعات المستخدمة ونسبة الخفض في عدد العقد النيمـاتوديـة وكتـل البيض فيما عدا معاملة الحديد المغناطيسي . حيـث سجلت اقل معـدلات الخفض لكـل مـن عـدد كتل البيض والعقد عند مستوي (15 جم / نبات) لكل من كبريتات الزنك ، كبريتـات المغنيسـيوم ، كبريتات الحديدوز.
5. .أعطى معاملة مبيد الفيوردان (5 جم / نبات) زيادة واضحة في المقاييس النباتية المختبرة واحتل المركز الاول في خفض مقاييس النيماتودا المختبرة بقيم 88.9 ، 78.4، 85.1% لكل من اعداد النيماتودا في التربة ، عدد العقد ، عدد كتل البيض علي التوالي.

قام بتحكيم البحث

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