J. Agric. Sci. Mansoura Univ., 26 (11): 7351 - 7370, 2001.

IMPROVING PRODUCTIVITY OF WASHINGTON NAVEL ORANGE AND WILLIAMS BANANA PLANTS GROWN IN NEMATODE INFESTED SOILS USING AGERIN® AND CERTAIN NEMATICIDES

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ABSTRACT

To improve the status and productivity of Washington navel orange and Williams banana plants grown in soil infested by citrus nematode, *Tylenchulus semipenetrans*, and root-knot nematode, *Meloidogyne javanica*, respectively, two field experiments were conducted during the two successive seasons (1999 and 2000) in west Nubaria region using 3 concentrations of the bioproduct, Agerin® and three common nematicides (Mocap® 10G, Temik® 10G and Vydate®L 24%). Agerin® and the tested nematicides proved to be effective in reducing the damage caused by nematodes, improving plants growth and their productivity. In the 1st season, Temik® and Agerin®50 g treatments gave the highest reduction in numbers of citrus nematode juveniles (92 and 89 %) and females (91 and 89 %), respectively, followed by Mocap 10G and Vydate L 24% with 83-84 % reduction. In the 2nd season, reduction % decreased. Temik and Agerin®50g were the most effective treatments giving 90.2 and 85.6 reduction, respectively. Temik®, Vydate®L and Mocap® gave the highest reduction of root-knot nematode juveniles infected banana roots (85.8-86.3 %) and number of eggs (87.8-89.2 %) followed by Agerin 50g with 81 and 84 % reduction of juveniles and eggs, respectively. Similarly, reduction % decreased with a low proportion in the 2nd season, Temik, Agerin®50 g and Mocap gave the highest reduction followed by Vydate L.

Temik and Agerin 50 g caused the lowest rate of reproduction (P_f/P_i) of citrus nematode J_2 and females in both seasons. Similar results were obtained on banana plants.

Both nematode population dynamics and monthly change percentages of nematode populations, in both crops, showed decreasing in numbers of citrus and root-knot nematode stages.

Agerin® and the tested nematicides resulted in a significant increase in the yield, fruit size, T.S.S, T.S.S/acidity, and vitamin C in navel orange. As well as, number of hands/bunch, number of fingers/bunch, and pseudostem height and girth of banana. The concentrations of N, P, K, Fe, Zn and Mn in leaves of navel orange and banana treated with the tested nematicides and Agerin® (50 and 40 g/plant) were significantly increased. Results indicated the possibility of using Agerin® as an environmentally friendly and safe alternative for controlling citrus and root-knot nematodes instead of the use of conventional hazardous chemicals.

Keywords: Bioproduct, biological control, Temik, Mocap, Vaydate L, citrus nematode, root-knot nematode, navel orange, banana, elements, fruit quality, yield.

INTRODUCTION

Washington navel orange and banana plants are considered among important horticultural fruit crops in the world as well as in Egypt. The world production reached 67.4 and 64.6 million tons in 2000, respectively. Orange and banana areas occupied about 240 and 54 thousand feddans in Egypt producing 1.44 and 0.73 million tons, respectively (MOALR, 1998 and FAO, 2000).

Plant-parasitic nematodes especially, citrus and root-knot nematodes are major agricultural pests worldwide, governing the success of such cultures. The citrus nematode, *Tylenchulus semipenetrans* Cobb attacks most of commercial citrus rootstocks causing slow decline (Cobb, 1913). Since its discovery in California, in 1912, on sour orange trees, the parasite was recorded on citrus roots all over the world (Oteifa and Shaarawi, 1962; O'Bannon and Esser, 1985; Davide, 1988; Osman and Hendy, 1989; El-Saedy *et al.*, 1993; Al-Qasem and Abu-Gharbieh, 1995; and Allam, 2000).

O'Bannon and Tarjan (1973) found that the citrus nematode fed on citrus roots causing growth reduction, debilitation and lower fruit yield.

Similarly, Banana *Musa* spp. suffers from numerous plant-parasitic nematodes especially root-knot nematodes, *Meloidogyne* spp. (Fademi and Bayero, 1993; Blomme *et al.* 1995; and Sundaram, 1997). Aboul-Eid and Ameen (1991), Yossef and Aboul-Eid (1996) and El-Nagdi (2001) reported that root-knot nematodes were the most common and probably the most damaging nematodes in banana plantations in Egypt.

The management of these pests relies mainly on the repeated use of the chemical nematicides, which maintain yield 50 % greater than that of untreated plantations (Timmer and French, 1979 on citrus and Gowen and Quénéhervé, 1990 on banana). However, the use of these chemical compounds has many drawbacks among which are the potential residues in fruits, ground water pollution, effect on non-target organisms, and their toxicity to workers. Therefore, alternative control strategies, with bioproducts and microorganisms, are urgently needed.

Several reports have been published on biocontrol agents of citrus and root-knot nematodes (Ibrahim *et al.* 1992; Aboul-Eid *et al.* 1993; Osman and Salem, 1995; Jansson and Rabatin, 1997; Warrior *et al.* 1999, Allam, 2000 and Heikal, 2001).

Aalten *et al.* (1998) found three *Pseudomonas fluorescens* bacterial strains and type strain *P. putida* CFBP 2066 inhibited invasion of banana roots by *Meloidogyne* spp. All strains also showed an *in vitro* repellent effect towards the nematodes. It was concluded that bacterial compounds affected nematode infectivity or the elicited strains induced systemic resistant plants. Daneel *et al.* (1998) tested the Biostart (group of *Bacillus* spp.) for controlling *Meloidogyne* spp. on banana plants. They found that Biostart can enhance banana growth, uptake of nutrients and reduced population of nematodes. Hammad (1999) found that the bioproduct, Nemaless® 10 % gave a significant reduction in number of galls, egg masses and eggs of *M. arenaria* on tomato and eggplant crops. Warrior *et al.* (1999) reported that the

bioproduct, Ditera resulted in significant reduction in populations of major nematode pests affected banana including root-knot nematodes. An overall increase in yield, comparable to that obtained with the current chemical standard, was obtained

Regarding the leaf mineral contents, Chitwood *et al.* (1952) detected distinct decrease in Fe in leaves of S-37 peach cultivar infected with *M. javanica* and *M. incognita*. El-Gindi *et al.* (1976) found that infection by citrus nematode caused remarkable decrease in Mn and Zn contents of rough lemon. Hassan (1985) found less N, P, K, Mn and Fe contents in leaves of sour orange infected by citrus nematode. Whereas, K and Mn decreased and P and Fe increased in leaves of cleopatra mandarin plants infected with citrus nematode. Zn content was not affected in bitter almond infected with *M. javanica* (Nasr *et al.,* 1980) and in cleopatra mandarin infected with *M. incognita* (Hassan, 1985).

The present investigation aimed to evaluate three concentrations of the bioproduct, Agerin® in comparison with three commonly used commercial nematicides on navel orange trees and Williams banana plants grown in nematode infested soils.

MATERIALS AND METHODS

This study was conducted during two consecutive seasons in 1999 & 2000 on Washington navel orange trees (*Citrus sinensis*, L. Osbeck) budded on sour orange (*C. aurantium*, L.) rootstock, 6-year-old and Williams banana (*Musa cavendishii*, Lamb.) plants, 4-year-old grown in a private orchard, near west Nubaria city, under drip irrigation system. The citrus trees, naturally infested with *Tylenchulus semipenetrans* were spaced 5 × 5 m apart, whereas banana plants, naturally infested with *Meloidogyne javanica* were spaced 3 × 3.5 m apart.

Source of Agerin® and nematicides:

Agerin®, a commercial formula of Egyptian isolate of *Bacillus thuringiensis* subsp. *aegypti* (Bt.C18) produced by Agricultural Genetic Engineering Research Institute (AGERI), ARC, Giza, Egypt; the nematicides, ethoprofos (Mocap® 10G) produced by *rP* Rhône-Poulenc Agrochimie, France; the aldicarb, Temik® 10G, produced by Rhône-Poulenc, USA; and oxamyl (Vydate® L 24%), produced by Dupont® de Nemorse, USA, were used.

Experimental treatments and design:

Navel orange trees (35) and Williams banana plants (70) were divided into 7 groups of five trees for navel orange and ten plants for Williams banana plants. The selected plants were nearly uniform in vigor and size. Agerin® was applied to the 1st, 2nd and 3rd groups at the rate of 25, 40 and 50 g per tree or hole, respectively. The 4th and 5th groups received the recommended doses (according to age and growth) of Temik® 10G and Mocap® 10G at the rate of 30 and 50 g/tree or hole, respectively, while the 6th group received Vydate®L 24% at the rate of 25ml/tree or hole. The 7th group was left

untreated to serve as check treatment. To evaluate the effectiveness of Agerin® against the three commonly used nematicides, all treatments were applied once on the 1st week of March 1999. Agerin® and the two tested granular nematicide doses were separately mixed with about 1 kg sand then applied in a circle of about 2 m in diameter from the trunk of orange trees and of 1.5 m from pseudostem of banana plants and 5 cm in depth, then covered with soil. Vydate®L was applied, as a soil drench, around trunk of orange trees or pseudostem of banana plants. The experimental treatments were arranged in a complete randomized block design. Treatments were replicated five and ten times in orange and banana plants, respectively.

Numbers of citrus and root-knot nematode juveniles:

The initial populations (P_i) of citrus nematode juveniles (CJ_2) and females (CF) as well as root-knot nematode juveniles (RJ_2) and eggs (RE) were recorded prior to application of Agerin® and chemical treatments at March 1999. Density of CJ_2 and RJ_2/ 250 cc soil and CF and RE/ 5 g root fresh weight were monthly determined using Peter's 1 ml eelworm counting slide from April to December 1999 except June and November (Mai and Lyon, 1975). The final populations (P_f) of CJ_2, RJ_2, CF and RE were determined at December 1999 and 2000. One kg of the rhizosphere soil of each tree or hole was collected at the drip line of feeder root zones. The CJ_2 and RJ_2 were extracted from 250 cc soil using sieving and Baerman pan technique (Ayoub, 1980). Also, five grams of roots, from each replicate, were cut into 1-2 cm long pieces comminuted in water for 20 seconds in Waring blender, then two sieves of 30 and 325 mesh were used to extract citrus nematode females, whereas 30 and 400 mesh for root-knot nematode eggs. Backwashing the retained materials, on 325 or 400 mesh sieves, collect females and eggs, respectively.

Reduction % of CJ_2, RJ_2, CF and RE populations resulted from different treatments was calculated in Dec. 1999 and Dec. 2000 using the equation:

$R\ \% = [(P_f \text{ of treatment} - P_f \text{ of check treatment}) / P_f \text{ of check treatment}] \times 100.$

The rate of reproduction or increase (P_f/P_i) of CJ_2 , RJ_2 , CF and RE, in each treatment, were calculated (Dropkin, 1980).

To study the fluctuation of CJ_2, RJ_2, CF and RE, during the experiment periods (March 1999-December 1999 and December 2000), nematode population dynamics were monthly recorded. Also, change percentages (MH %) of CJ_2, RJ_2, CF and RE due to the application of different treatments were recorded monthly and calculated as follows:

$MH\ \%\ of\ April = (P_{f\ (April)} - P_{i\ (March)}) / P_{i\ (March)} \times 100.$

Yield and fruit quality:

A-Washington navel orange:

Number and weight of fruits per tree were recorded in both seasons at harvest. To determine fruit quality, ten fruits were randomized chosen and used from each replicate. Average fruit weight, size and juice weight percentages were determined. In fruit juice, total soluble solids (T.S.S.) were

determined by using a Carl Zeis hand refrectometer while total acidity and vitamin C contents were estimated titrimetrically according to the A.O.A.C (1980).

B-Williams banana plants:

The weight of Williams banana bunch (kg), number of hands and fingers/bunch were recorded in both seasons at harvest. In addition, pseudostem height and girth (cm) were measured.

Leaf mineral analysis:

A- Washington Navel orange:

Twenty new spring non-fruiting shoots from the outer tree canopy were labeled at March 1999 and 2000. A sample of 60 leaves representing the 3rd, 4th and 5th leaf from shoot apex were collected at the 3rd week of September in both seasons. The leaf samples were washed with tap water followed by distilled water and oven dried to a constant weight at 70 °C, then ground into a fine powder, digested with sulphuric acid and hydrogen peroxide according to Evenhuis and Dewaard (1980). Suitable aliquots were taken for the determination of N, P, K, Fe, Zn and Mn. Nitrogen and phosphorus contents were colorimetrically determined according to Evenhuis (1976) and Murphy and Riley (1962), respectively. Potassium was determined against a standard using flame photometer, whereas, Fe, Zn, and Mn were determined using Perkin Elemer atomic absorption spectrophotometer.

B- Williams banana plants:

Banana leaf samples were taken at September 1999 and 2000 from the 3rd leaf from the top of the plants. Pieces 10 × 10 cm , were taken from the middle part of the blade as recommended by Hewitt (1955) and adopted by Abou-Aziz *et al.* (1987). Analysis and determination of N, P, K, Fe, Zn, and Mn contents was done as in case of navel orange.

Statistical Analysis:

Data were analyzed using analysis of variance (ANOVA) by using the statistical analysis system (SAS) software (SAS Institute, 1988). Means of treatments were compared using revised LSD (Snedecor and Cochran, 1973).

RESULTS AND DISCUSSION

Applications of Agerin® and the tested nematicides reduced numbers of citrus and root-knot nematode stages in growing seasons 1999 and 2000 (Tables 1-6 and Figs 1-8).

Results of navel orange indicated that Temik® 10G gave the highest reduction of CJ_2 (92%) and CF (91%) in December 1999 followed by Agerin®50 (89 and 89 %), Agerin®40 (85 and 86 %) and Mocap® 10G (84 and 84 %) (Table 1). While, Vydate® L 24 % and Agerin®25 resulted in 83 & 83 %

and 80 & 82 % reduction, respectively. Similar results were obtained in the 2nd season, Temik® 10G caused the highest reduction of CJ_2 and CF (90.2 and 90.2 %) followed by Agerin®50 and Mocap® with 85.3 to 85.8 % reductions for CJ_2 and CF. Agerin®40 and Vydate® L ranked the 3rd position with 78.9 to 82.7 % reductions (Table 1).

Table 1: Mean numbers of *Tylenchulus semipenetrans* juveniles/ 250 cc soil (CJ_2) and females/ 5 g root fresh weight (CF) and their reduction % on navel orange trees on December 1999 and 2000 as affected by Agerin®, Mocap®, Temik® and Vydate® L 24 %

Treatment	1999		2000	
	CJ_2	CF	CJ_2	CF
Check	4900 a	480 a	5920 a	612 a
Agerin 25	970 b *(80)**	87 b*(82)*	1290 b *(78.2)*	128 b *(79.1)*
Agerin 40	720 cd*(85)*	67 bcd*(86)*	1080 c *(81.8)*	106 c *(82.7)*
Agerin 50	540 de*(89)*	54 cd*(89)*	850 d *(85.6)*	87 d *(85.8)*
Mocap 10G	760 bcd*(84)*	76 b*(84)*	870 d *(85.3)*	87 d *(85.8)*
Temik 10G	380 e*(92)*	43 d*(91)*	580 e *(90.2)*	60 e *(90.2)*
Vydate L 24%	850 bc*(83)*	82 b*(83)*	1250 bc *(78.9)*	122 bc *(80.1)*

Data are average of 5 replicates. Means followed by the same letter(s), in each column, are not significantly different at *p*= 0.05.

*** Data between brackets are reduction %= [number of nematode stage in treatment – number of nematode in check / number of nematode in check] × 100.**

In case of Williams banana plants, Temik®, Vydate®L and Mocap® gave the highest reduction ranged from 85.8 to 86.3% for RJ_2 and from 87.8 to 89.2 % for RE followed by Agerin®50 with 81 and 84 % reduction, respectively, and Agerin®40 with 71 and 79 % reduction in 1999 season. In the 2nd growing season, all treatments still effective, Temik®, Agerin®50 and Mocap® gave the highest reduction followed by Vydate®L and Agerin®40 (Table 2).

Data of reproduction rates (P_f/P_i) of citrus nematode (Table 3) supported the previous results. Temik®10G caused the lowest rate of reproduction (0.19 and 0.22) for CJ_2 and CF, respectively, in December 1999 followed by Agerin®50 (0.26 and 0.26), Agerin®40 (0.33 and 0.29), Mocap® (0.36 and 0.37) and Agerin®25 (0.4 and 0.35), respectively. However, Vydate®L gave the highest rate of reproduction (0.43 and 0.41), respectively.

In Dec. 2000, rate of reproduction increased but still lower than the rate in check treatment. Temik® gave the lowest rate of reproduction of CJ_2 and CF (0.29 and 0.30) followed by Agerin®50 (0.40 and 0.41) and Mocap® (0.41 and 0.42). Agerin®40 resulted in the rate of 0.49 and 0.46, respectively. Similarly, the highest rate of reproduction, in comparison with the other treatments, was recorded with Vydate®L treatment (0.63 and 0.61), respectively (Table 3).

Table 2: Mean numbers of *Meloidogyne javanica* juveniles/ 250 cc soil (RJ2), eggs/ 5g root fresh weight (RE) and their reduction % on banana plants on December 1999 and 2000 as affected by Agerin®, Mocap®, Temik® and Vydate® L 24%

Treatment	1999		2000	
	RJ_2	RE	RJ_2	RE
Check	903 a	3610 a	1220 a	3995 a
Agerin 25	463 b*(49)**	1720 b *(52)*	530 b *(56.6)*	2170 b *(45.7)*
Agerin 40	260 c*(71)*	750 c*(79)*	487 b *(60.1)*	1539 d *(61.5)*
Agerin 50	173 d*(81)*	580 cd*(84)*	270 d *(77.9)*	744 e *(81.4)*
Mocap 10G	128 de*(85.8)*	420 d*(88)*	289 d *(76.3)*	646 ef *(83.4)*
Temik 10G	123 e*(86.3)*	390 d*(89.2)*	246 d *(79.8)*	569 f *(85.8)*
Vydate L 24%	123 e*(86.3)*	440 d*(87.8)*	421 c *(65.5)*	1820 c *(54.4)*

Data are average of 10 replicates. Means followed by the same letter(s), in each column, are not significantly different at *p*= 0.05.

***Data between brackets are reduction %= [number of nematode stage in treatment – number of nematode in check / number of nematode in check] × 100.**

Table 3: Effect of Agerin®, Mocap®, Temik® and Vydate® L 24% on citrus nematode juveniles and females final populations (P_f), and rate of reproduction (P_f/P_i) on navel orange trees, 1999 & 2000

Treatment	No. of citrus nematode juveniles / 250 cc soil			*Rate of reproduction (P_f/P_i)*		No. of citrus nematode females / 5 g root fresh weight			*Rateof reproduction (P_f/P_i)*	
	P_i March 99	P_f Dec. 99	P_f Dec. 2000	*Dec. 1999*	*Dec. 2000*	P_i March 99	P_f Dec. 99	P_f Dec. 2000	*Dec. 1999*	*Dec. 2000*
Check	2580 a	4900 a	5920 a	1.9	2.29	252 a	480 a	612 a	1.9	2.43
Agerin® 25g	2420 a	970 b	1290 b	0.40	0.53	246 a	87 b	128 b	0.35	0.52
Agerin® 40 g	2200 a	720 cd	1080 c	0.33	0.49	232 a	67 bcd	107 c	0.29	0.46
Agerin® 50 g	2100 a	540 de	850 d	0.26	0.40	210 a	54 cd	87 d	0.26	0.41
Mocap® 10G	2100 a	760 bcd	870 d	0.36	0.41	204 a	76 b	87 d	0.37	0.42
Temik® 10G	1980 a	380 e	580 e	0.19	0.29	198 a	43 d	60 e	0.22	0.30
Vydate® L 24%	1980 a	850 bc	1250 bc	0.43	0.63	200 a	82 b	122 bc	0.41	0.61

Data are average of 5 replicates (trees).

P_i= Juvenile or female initial population (before control application, March 1999).

P_f= Juvenile or female final population.

Rate of reproduction = P_f / P_i.

In Williams banana experiments, Temik® gave the lowest rate of increase in the 1st season 1999 for RJ_2 and RE (0.16 and 0.13) followed by Mocap® (0.16 and 0.15) and Vydate®L (0.17 and 0.17), respectively. Agerin®50 and 40 ranked the 3rd and 4th position with (0.22 and 0.21) and (0.35 and 0.32), respectively (Tables 4). Results obtained in Dec. 2000 indicate that Temik® gave the lowest rate of increase for RJ_2 (0.3) and RE (0.19) followed by Agerin50 (0.34 and 0.27) and Mocap (0.38 and 0.24), respectively (Table 4).

Table 4: Effect of Agerin®, Mocap®, Temik® and Vydate® L 24% on root-knot nematode juvenile and egg final populations (P_f), and its increase (P_f/P_i) on Williams banana, 1999& 2000

Treatment	No. of root-knot nematode juveniles / 250cc soil			*Rate of reproduction (P_f/P_i)*		No. of eggs / 5 g root fresh weight			*Rate of reproduction (P_f/P_i)*	
	P_i March 99	P_f Dec. 99	P_f Dec. 2000	*Dec. 1999*	*Dec. 2000*	P_I March 99	P_f Dec. 99	P_f Dec. 2000	*Dec. 1999*	*Dec. 2000*
Check	658 a	903 a	1220 a	*1.43*	*1.85*	2490 a	3610 a	3995 a	*1.45*	*1.6*
Agerin® 25g	560 a	463 b	530 b	*0.83*	*0.95*	2460 a	1720b	2170 b	*0.70*	*0.88*
Agerin® 40 g	750 a	260 c	487 b	*0.35*	*0.65*	2380 a	750 c	1539 b	*0.32*	*0.65*
Agerin® 50 g	793 a	173 d	270 d	*0.22*	*0.34*	2750 a	580cd	744 e	*0.21*	*0.27*
Mocap® 10G	760 a	128de	289 d	*0.16*	*0.38*	2730 a	420 d	646 ef	*0.15*	*0.24*
Temik® 10G	818 a	123 e	246 d	*0.16*	*0.30*	3070 a	390 d	569 e	*0.13*	*0.19*
Vydate® L 24%	718 a	123 e	421 c	*0.17*	*0.59*	2550 a	440 d	1820 c	*0.17*	*0.71*

Data are average of 10 replicates (trees).
P_i= Juvenile or female initial population (before control application, March 1999).
P_f= Juvenile or female final population.
Rate of reproduction = P_f / P_i.

The obtained results were in agreement with many investigators (Ibrahim *et al*., 1992; Timmer and French, 1973 & 1979; Hassan *et al*., 1992; Osman and Salem, 1995; Warrior *et al.*, 1999; Allam, 2000; and Osman *et al*., 2000). They found that Temik® and Vydate®L have been found effective in reducing citrus and root-knot nematodes. Timmer and French (1973) found that Temik application reduced CJ_2 by about 70-90%. Likewise, Osman and Salem (1995) working on the bioproduct, Sincosin-AG™ and Allam (2000) and Osman *et al*. (2000) on Agerin® showed that these bioproducts were effective against citrus nematode on navel orange trees and root-knot nematodes, *M. incognita* and *M. arenaria* on tomato and eggplant. The application of Agerin® after the onset of nematode infestation controlled about 90% of the nematodes, while application of Agerin® to the soil before planting and nematode infestation completely protected plants from nematode attack. Agerin® (Bt.C18) produced a variety of toxin proteins during vegetative and sporulated phases of growth against lepidepteran, dipteran and coleopteran insect larvae. Moreover, its spore-crystal complex showed nematicidal activity against root-knot and citrus nematodes. Genetic analysis of Bt.C18 detected two genes encoding for nematicidal activity of this bacterium (Osman *et al.,* 2000).

Population dynamics of citrus nematode on navel orange and root-knot nematode on banana and monthly change percentages were illustrated in Figs 1-4 and 5-8, respectively. Population dynamics of CJ_2 and CF indicated that all the tested treatments reduced nematode populations, compared with that in March 1999, during the growing seasons of 1999 and 2000. Temik®10G and Agerin®50 caused the lowest numbers of citrus nematodes (Figs 1 and 2). Citrus nematode population was decreased gradually with different control treatment applications till Sept.- Oct. 1999 then started to increase in a low rate than that of check treatment.

Banana plants of control treatments showed the lowest RJ_2 and RE populations in August 1999, increased gradually till Oct. 1999, then decreased in Dec. 1999 and increased again in Dec. 2000 (Figs 3 and 4). Temik®, Mocap®, Vydate®L and Agerin®50 resulted in the lowest numbers of root-knot nematode stages.

Monthly change of nematode populations (MH %) indicated that citrus nematode population increased in check treatment and the lowest MH % was recorded in August and Dec. 1999 for CJ_2 and in July, August and Dec. 1999 for CF. Whereas, the highest MH % was recorded in April, May, Sept. 1999 and Dec. 2000 for CJ_2 (Fig. 5) and April, Oct. 1999, and Dec. 2000 for CF (Fig. 6). Temik® and Agerin®50 had the lowest MH% of CJ_2 and CF then started to increase in Oct. 1999 while with the other treatments increase began in Sept. 1999 except with Vydate®L, which started at August 1999 for CF (Figs. 5 & 6).

In case of Williams banana, root-knot nematode population MH % increased in check treatment in May, Sept. 1999 and Dec. 2000 for RJ_2 and the lowest MH % was recorded in July and Dec. 1999 (Fig. 7). Whereas, the highest MH % for RE was recorded at April, Sept. 1999 and Dec. 2000 and the lowest was recorded in August and Dec. 1999 (Fig. 8). While, MH % for RJ_2 started to increase in August 1999 in Agerin®25 and 40 treatments and in Sept. 1999 for the other treatments (Fig. 7). Monthly change % of RE started to increase in July 1999 in case of Agerin®25 and in August for the other tested treatments (Fig. 8).

The rate of reproduction and consequently the population present at any given time are related to the general condition of the root system at that time. The nematode population will be again building up depending on rate of the initial application (Reynolds and O'Bannon, 1963). These monthly fluctuations might be attributed to monthly changes of temperatures, competition for feeding sites and/or root activity, i.e., source of food (Dropkin, 1980). Davis (1984) found that the nematode population of grapefruit peaked in April and declined to the lowest level in August and September. However, Al-Sayed *et al.* (1993) found that number of CJ_2 peaked in May and September and was lowest in July and August. On the other hand, the highest number of CJ_2 on navel orange trees was recorded in May while the lowest number in November (Allam, 2000).

Navel orange yield and physiochemical properties of fruits in relation to Agerin®, Mocap®, Temik® and Vydate®L treatments were illustrated in Table (5). Orange yield was, significantly, increased with Agerin® and nematicide treatments except Agerin®25 treatment in both seasons and Agerin 40 in the 1st season (Table 5). Temik® gave the highest yield (57.5 kg/tree) with 119.5 % increase of the untreated treatment, followed by Mocap® and Agerin®50 with 84.4 and 70% increase, respectively. In the 2nd season, the highest yield (63 kg/tree) was recorded by Temik®, which represent 136 % over the untreated treatment followed by Mocap® (120 % increase) and Agerin® 50 (99.6 %). Also, data showed that Temik®, Mocap®, Agerin®50 and Vydate®L significantly increased fruit weight and size, T.S.S,

fig

fig

T.S.S/acidity and vitamin C content in both growing seasons except T.S.S/acidity (in the 1st season) and T.S.S (in the 2nd season) for Vydate®L treatment. However, Agerin®40 induced a significant increase in fruit weight in the 2nd season. On the other hand, juice weight percentages and total acidity did not affected by all the tested nematicides and Agerin treatments.

In case of Williams banana, data in Table (6) showed that Agerin®50 and 40, Mocap®, Temik® and Vydate®L caused significant increase in bunch weight, number of hands per bunch, number of fingers per bunch, pseudostem height and girth. On the other hand, number of fingers per bunch in Agerin®40 treatment in both seasons and pseudostem height and girth with Vydate®L treatment in the 2nd season were not affected (Table 6). In the 1st season, Mocap® gave the highest yield (24.8 kg/tree), with 136 % increase than the untreated plants, followed by Temik® and Vydate®L and Agerin 50 with 131.4, 126.5, and 116.2 %, respectively. In the 2nd season, the highest yield (25.2 kg/tree) was obtained by Temik®, with 186.4 % increase than the untreated plants followed by Mocap® (168.2 %) and Agerin® 50 (167 %). Vydate®L and Agerin®40 resulted in 104.5 and 87.5 % increase, respectively.

Similar findings were previously reported by many investigators (Timmer and French, 1973; Badra and Caveness, 1983; Hassan, 1985; Hassan *et al.*, 1992; Crozzoli and Martinez-Rivas, 1995; Osman and Salem, 1995; Allam, 2000). Timmer and French (1973) showed that Temik increased the average yield of grapefruit by about 100 %. Timmer (1977) showed that Vydate®L 24% increased the average yield of grapefruit by 42 %. Hassan (1985) found that the yield of navel orange was increased by Temik and Vydate L applications. Badra and Caveness (1983) found that banana yield increased by about 90 % and 70 % using Temik and oxamyl in plants infected by *M. javanica*, respectively. Davide and Marasigan (1985) reported that banana fruit bunch weight reduced to 45.4% in plants infected with *M. incognita*. Abou-Eid *et al.* (1993) and Osman and Salem (1995) reported that the bioproduct, Sincosin-AG™ significantly reduced root-knot nematode populations and increase yield. Also, Daneel *et al.* (1998) using Biostart and Warrior *et al.* (1999) using Ditera, found that application of these bioprodcuts on banana plants infested with root-knot nematode decreased parasite population and increased the yield.

Regarding fruit properties, similar results were obtained by Allam (2000) who found that fruit size, juice volume and V.C. of navel orange fruits were increased with Agerin application while T.S.S and T.S.S/ acidity were not affected. Timmer and French (1979) reported that Temik treatment increased the fruit size due to reducing rust mite damage.

Concentrations of leaf minerals, i.e., N, P, K, Fe, Zn and Mn of navel orange significant increase with Agerin®50, Mocap®, Temik® and Vydate®L treatments in both growing seasons except Mn with Agerin 50 in the 1st season and N with Vydate® L treatment in the 2nd season that did not affected (Table 7). However, Agerin®40 induced significant increase in P and K in the 1st season and N, K and Mn in the 2nd season. Also, P was increased in the 1st season with Agerin®25 treatment (Table 7).

من الأصل5

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Similarly, concentrations of leaf mineral, i.e., N, P, K, Fe, Zn and Mn in Williams banana leaves were increased in all treatments in both growing seasons except with Agerin®25 treatment, giving a significant increase in N, Fe and Mn only in the 1st season. Concentration of P was not affected with Vydate®L treatment in the 1st season (Table 8).

Similar reports by several authors (Chitwood *et al.,* 1952; Owens and Novotny, 1960; El-Gindi *et al.,* 1976; and Hassan, 1985) indicated that citrus nematode infection resulted in reducing the concentration of N, P, K, Mn, and Fe.

The above mentioned results showed the possibilities of using biologically based products for reducing nematode populations, enhancing plant growth and nutrients uptake and consequently increasing yield quality and quantity. Therefore, the present results recommend the success of using Agerin® as an environmentally safe alternative to nematicides in controlling nematode diseases, decreasing the level of nematode infestation, improving the status of plants, increasing yield and yield properties.

Table 8: Effect of Agerin®, Mocap® 10G, Temik® 10G and Vydate® L 24% on some elements of Williams banana leaves, seasons 1999 and 2000

Treatment	1999						2000					
	%			µg/ml			%			µg/ml		
	N	P	K	Fe	Zn	Mn	N	P	K	Fe	Zn	Mn
Check	٢,١	٠,٢٠	٢,٨	٩٠	٤٥	٥٠	١,٩٥	٠,١٧	٢,٢	٨٠	٤٥	٤٨
Agerin 25 g	٢,٦	٠,٢٠	٣,١	١٠٠	٥٠	٦٠	٢,٤٠	٠,١٨	٢,٨	٩٠	٤٥	٥٥
Agerin 40 g	٣,١	٠,٢١	٤,٢	١٠٥	٦٠	٦٥	٣,٠٠	٠,١٧	٣,٨	٩٥	٥٨	٦٢
Agerin 50 g	٣,٤	٠,٢٤	٤,٥	١١٥	٧٠	٧٨	٣,٢٠	٠,٢٤	٣,٨	١١٠	٧٠	٧٥
Mocap 10G	٣,٢	٠,٢٣	٤,٢	١١٠	٦٥	٧٠	٣,٠٠	٠,٢٤	٣,٧	١٠٥	٦٢	٦٨
Temik 10 G	٣,٣	٠,٢٤	٤,٣	١١٥	٧٠	٧٥	٣,٢٠	٠,٢٤	٣,٨	١١٠	٦٨	٧٠
Vydate L 24%	٢,٩	٠,٢٢	٣,٩	١١٠	٦٠	٧٠	٢,٨٠	٠,٢١	٣,١	٩٥	٥٠	٥٥
L.S.D. 0.05	٠,٣٨	٠,٠٢	٠,٤	٨	٦	٧	٠,٥١	٠,٠٣	٠,٦	١٠	٨	٩

Data are average of 10 plants.

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تحسين إنتاجية أشجار البرتقال أبو سرة ونباتات الموز صنف وليامز النامية فى أرض ملوثة بالنيماتودا باستخدام المركب الحيوى أجرين وبعض المبيدات النيماتودية

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تم تنفيذ هذه الدراسة على أشجار البرتقال أبو سرة ونباتات الموز صنف وليامز نامية فى أرض ملوثة بشدة بنيماتودا المولح ونيماتودا تعقد الجذور على الترتيب وذلك خلال عامى ١٩٩٩ ، ٢٠٠٠ بهدف تحسين إنتاجية هذه النباتات باستخدام المركب الحيوى أجرين بثلاثة تركيزات مختلفة هى ٢٥ ، ٤٠ ، ٥٠ جم/شجرة أو جورة وكذلك ثلاث مبيدات نيماتودية هى تميك ١٠% ، موكاب ١٠% بمعدل ٣٠ ، ٥٠ جم/شجرة أو جورة على الترتيب والمبيد السائل فايدات بمعدل ٢٥ سم٣/شجرة أو جورة ، وأظهرت النتائج ما يلى :

1- أدى استخدام المركب الحيوى أجرين والمبيدات النيماتودية المختبرة إلى خفض معنوى لأعداد النيماتودا ، وتسبب مبيد التميك والمركب الحيوى أجرين تركيز ٥٠ جم/شجرة فى أعلى انخفاض لأعداد اليرقات (٩٢ و ٨٩ %) والإناث (٩١ و ٨٩ %) لنيماتودا المولح فى تربة وجذور أشجار البرتقال أبو سرة فى السنة الأولى على الترتيب ، وفى السنة الثانية كانت نسبة الخفض فى اليرقات (٩٠,٢ و ٨٥,٦ %) و (٩٠,٢ و ٨٥,٨ %) للإناث على الترتيب ، أما فى نباتات الموز فقد تسببت المبيدات النيماتودية التميك ، فايدات والموكاب فى أعلى خفض فى أعداد اليرقات (٨٥,٨-٨٦,٣ %) والبيض (٨٧,٨-٨٩,٢ %) فى نهاية السنة الأولى يليهم المركب الحيوى أجرين بتركيز ٥٠ جم / جورة بنسب خفض ٨١ % لليرقات و ٨٤ % للبيض ، أما فى نهاية السنة الثانية فنتج أعلى انخفاض فى أعداد يرقات نيماتودا تعقد الجذور (٧٩,٨ و ٧٧,٩ %) والبيض (٨٥,٨ و ٨١,٤ %) نتيجة لتطبيق المبيد الكيماوى تميك والمركب الحيوى أجرين بتركيز ٥٠ جم/جورة على الترتيب .

2- اتضح من دراسة معدل تكاثر النيماتودا أن كل من مبيد التميك والمركب الحيوى أجرين تركيز ٥٠ جم/شجرة أو جورة تسببا فى أقل معدل زيادة سواء لليرقات أو إناث نيماتودا المولح على أشجار البرتقال أبو سرة وكذلك يرقات وبيض نيماتودا تعقد الجذور على نباتات الموز .

3- أظهرت دراسة تذبذب أعداد النيماتودا خلال موسمى النمو أن كل المعاملات المستخدمة أدت إلى خفض معنوى لأعداد يرقات وإناث نيماتودا المولح فى تربة أشجار البرتقال أبو سرة سواء لليرقات والإناث حتى شهر سبتمبر وأكتوبر ١٩٩٩ على الترتيب وبدأت الأعداد تزداد بعد ذلك ولكن بنسب منخفضة ، أما بالنسبة لنيماتودا تعقد الجذور على الموز فقد أدت المعاملات الى خفض أعداد اليرقات والبيض حتى شهر أغسطس ١٩٩٩ ثم بدأت الأعداد فى الزيادة بعد ذلك ولكن بنسب بسيطة أيضاً . أما فى النباتات الغير معاملة سواء بالنسبة للبرتقال أو الموز فقد زادت أعداد اليرقات والإناث والبيض شهرياً ، وبالنسبة لإناث نيماتودا المولح فقد قل عددها فى شهر ديسمبر ١٩٩٩ ثم زادت مرة أخرى فى شهر ديسمبر ٢٠٠٠ .

4- أوضحت دراسة تذبذب أعداد اليرقات والإناث شهرياً (نسبة الزيادة أو النقصان) فى تربة أشجار البرتقال غير المعاملة زيادة نسبة أعداد اليرقات خلال أشهر أبريل ومايو وسبتمبر ١٩٩٩ وديسمبر ٢٠٠٠ وانخفاضها فى أغسطس وديسمبر ١٩٩٩ وزادت مرة أخرى فى ديسمبر ٢٠٠٠ ، أما الإناث

فازدادت فى اشهر أبريل و أكتوبر ١٩٩٩ وديسمبر ٢٠٠٠ ، أما بالنسبة للأشجار المعاملة فقد انخفضت أعداد الإناث شهرياً حتى شهر سبتمبر ١٩٩٩ وبدأت الأعداد فى الزيادة بعد ذلك .

5- أوضحت دراسة تذبذب أعداد النيماتودا شهرياً لكل من يرقات وبيض نيماتودا تعقد الجذور على نباتات الموز أن أعلى نسبة زيادة فى أعداد اليرقات كانت فى النباتات غير المعاملة فى أشهر مايو وسبتمبر ١٩٩٩ ، وفى ديسمبر ٢٠٠٠ ، وأشهر أبريل وسبتمبر ١٩٩٩ وديسمبر ٢٠٠٠ للبيض ، أما بالنسبة *للنباتات المعاملة فقد بدأت التغيرات الشهرية فى الزيادة ابتداءً من أغسطس ١٩٩٩ بالنسبة للمعاملة بواسطة أجرين ٢٥ ، ٤٠ جم / جورة ومن شهر سبتمبر ١٩٩٩ لباقى المعاملات الأخرى .

6- تسببت المعاملة بالمركب الحيوى أجرين أو المبيدات النيماتودية المستخدمة إلى زيادة المحصول وحجم الثمار والمواد الصلبة الكلية والحموضة وفيتامين C فى البرتقال أبو سرة.

7- ازداد محصول الموز نتيجة للمعاملة بالمركب الحيوى أجرين أو المبيدات النيماتودية ، وزادت أعداد أصابع الموز فى السباطة وعدد الكفوف لكل سباطة وطول النباتات وسمكها .

8- أظهر التحليل الكيماوى للأوراق زيادة محتواها من النيتروجين والبوتاسيوم الفوسفور والحديد والزنك والمنجنيز فى أوراق أشجار البرتقال أبو سرة المعاملة بالمبيدات موكاب والتميك والفايدات السائل والمركب الحيوى أجرين ٥٠جم/شجرة فى الموسمين ١٩٩٩ و ٢٠٠٠ .

9- زاد محتوى أوراق الموز من النتروجين والفوسفور والبوتاسيوم والحديد والزنك والمنجنيز فى كلا الموسمين نتيجة المعاملة بالمبيدات موكاب والتميك والفايدات السائل والمركب الحيوى أجرين بمعدل ٤٠ و ٥٠ جم/ جورة .

Table ٦. Effect of Agerin®, Mocap® 10G, Temik® 10G and Vydate® L 24% on yield properties of Williams banana plants, seasons 1999 and 2000

Treatment	١٩٩٩						٢٠٠٠					
	Bunch weight (kg)	Yield Increase %	No. of hand / bunch	No. of finger/ bunch	Pseudostem height (cm)	Pseudostem girth (cm)	Bunch weight (kg)	Yield Increase %	No. of hand / bunch	No. of finger/ bunch	Pseudostem height (cm)	Pseudostem girth (cm)
Check	١٠,٥	٠,٠	٩,٥	١٢٥	٢٣٠	٦٥	٨,٨	٠,٠	٩	١١٨	٢٢٣	٥٩
Agerin 25 g	١٢,٨	٢١,٩	١٢,٠	١٢٨	٢٤٠	٧٠	١٢,٨	٤٥,٥	١٢	١٢٥	٢٣٥	٦٨
Agerin 40 g	١٥,٢	٤٤,٨	١٢,٩	١٥٠	٢٦٠	٨٠	١٦,٥	٨٧,٥	١٤	١٤٥	٢٥٥	٨٠
Agerin 50 g	٢٢,٧	١١٦,٢	١٣,٥	٢١٠	٢٧٠	٩٠	٢٣,٥	١٦٧,٠	١٥	٢٠٥	٢٧٠	٩٥
Mocap 10 G	٢٤,٨	١٣٦,٢	١٢,٨	٢٢٥	٢٦٨	٩٩	٢٣,٦	١٦٨,٢	١٤	٢٢٥	٢٧٠	١٠٤
Temik 10 G	٢٤,٣	١٣١,٤	١٤,٠	٢٣٠	٢٧٥	٩٥	٢٥,٢	١٨٦,٤	١٦	٢٢٠	٢٧٨	١٠٠
Vydate L 24 %	٢٣,٨	١٢٦,٥	١٢,٥	٢٣٠	٢٦٥	٨٥	١٨,٠	١٠٤,٥	١٤	١٨٠	٢٤٥	٧٥
L.S.D. *0.05*	٣,٠٢		٢,٨	٣٨	٢٥	١٤	٤,٤		٣,٢	٣٠,٥	٢٣	١٦

Data are average of 10 plants.

Table 7: Effect of Agerin®, Mocap® 10G, Temik® 10G and Vydate® L 24% on some elements in leaves of Washington navel orange, seasons 1999 and 2000

Treatment	1999						2000					
	%			μg/ml			%			μg/ml		
	N	P	K	Fe	Zn	Mn	N	P	K	Fe	Zn	Mn
Check	1.75	0.155	1.65	70	30	35	1.70	0.130	1.50	60	28	30
Agerin 25 g	1.90	0.160	1.70	75	32	38	2.10	0.155	1.60	70	30	32
Agerin 40 g	1.95	0.160	1.85	80	35	40	2.20	0.155	1.80	70	30	40
Agerin 50 g	2.35	0.180	1.90	90	40	42	2.50	0.185	2.10	90	45	45
Mocap 10G	2.40	0.210	1.95	90	40	45	2.70	0.210	2.10	95	40	45
Temik 10 G	2.65	0.215	1.90	95	45	48	2.70	0.210	2.00	95	50	50
Vydate L 24 %	2.05	0.205	1.85	85	42	45	1.95	0.200	1.75	80	38	40
L.S.D. 0.05	0.45	0.025	0.12	13	7.5	8	0.40	0.030	0.15	15	6.5	7.5

*** Data are average of 5 trees.**