Evaluation of Polymer- based Nematicidal Combinations against Root-knot infected sugar beet fields in West Nubaria district

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Abstract

The present study was conducted during two experienced growing seasons of 2016/ 17 and 2017/ 18 at West Nubaria Sector. The experiments were designed to evaluate certain management strategies for root-knot nematode, *Meloidogyne incognita*. The main studied factors were plowing depth and control treatment; there were three plowing depths and six treatments. Experimental design was a split plot randomized complete block design, split plot with plowing depth as main plot, strip-plot arrangement and treatments as subplot with four replicates. Single treatments and combinations of Abamectin, Nemastop, Mocap 10% G and potassium-based polymer yet were compared with untreated control. Analysis of variance for the combined data of the studied seasons significantly at $P \leq 0.05$ cleared out the effect of various treatments. Management strategy efficacy %., denoted that 30 cm-plowing depth scored the best At level of control treatments, the lead was due to (Nemastop + Polymers) followed by Polymers followed with (Abamectin + Polymers). Interaction effects on efficacy % revealed that the best results obtained were with 30 cm- plowing depth × (Abamectin + Polymers) followed by the same depth with Polymers followed by 30 cm- plowing depth with (Nemastop + Polymers). All treatments achieved positive impacts on root-knot nematode and sugar beet yield parameters when interacted with each other under deficit irrigation (DI) to level of 75 % of Irrigation water requirements (IWR)

Plowing depth of 30 cm achieved the most promising results for number of plants after thinning, at harvest and losses percentages in number of plants/ fed. in sugar beet field. Also, plowing depth of 30 cm scored the highest values for root yield and extractable white sugar yield. 50 cm-plowing depth recorded the best value for purity percentage followed by depth 30 cm. Plowing depths of 30 cm and 50 cm showed the lowest values for sodium (Na) percentage and potassium (K) percentage. Plowing depth of 50 cm scored the highest value for extractable white sugar percentage (ZB %) , with significant difference between it and the two other plowing depths of 30 and 40 cm at $P \leq 0.05$. The lowest number for root- knot nematodes number/g soil as affected by plowing depth was recorded at plowing depth of 30 and 50 cm. also, the lowest record for disease severity % recorded was for plowing depth of 30 and 50 cm. Drop rate % is another indicator for efficiency of management strategy. The most excellent drop rate % was achieved by plowing depth 30 cm,

consequently, the study recommends plowing depth of 30 cm and adequate nematicide seed treatments under deficit irrigation (DI) of 75 % water requirement is best combination to increase water use efficiency (WUE) as well as to improve the efficiency of modern integrated management strategies to control *M. incognita* in sugar beet infected fields without serious effects on crop performance which eventually results in augmented yield.

Keyword: sugar beet - root-knot nematodes –plowing depth - polymers – nematicides.

Introduction

In Egypt industrial demand for sugar beets is increasing, which provides a higher price, incentivizing many farmers to plant more beets (GAIN Report, 2019). Increased demand is attributed to new sugar beet processing plants, increasing demand for raw beets. Post expects area planted to increase and, subsequently, area harvested to rise by 11 percent or 25,000 ha, to reach 250,000 ha in May, 2019/20.

As sugar beet production increasing, problems increase, among these tackle in newly cultivated soils the root knot nematodes (RNK) are included within the genus *Meloidogyne* spp. and belong to a moderately small but important polyphagous grouping of particularly adapted obligate plant pathogens (Abad *et al*., 2003). Typically, they reproduce and feed within plant roots and induce small to large galls or root knots. These nematodes affect crop yields directly through the alteration of the morphology of the root system that results from their invasion and feeding on root tissues. The most obvious symptoms of RNK are galling on primary and secondary roots associated with stunted growth and wilting (Fortnum *et al*., 1991). Capable to cause immense losses in yield and quality of sugar beet crop (Gohar and Maareg, 2005) In intensive commercial production, where sequential cropping of one susceptible crop after another is practiced, the lack of effective RNK management strategies has led to total crop failure (Sikora and Fernández, 2005). Disturbance of soils caused by application of strategies for management of RNKs results in tremendous shifts in soil microbial communities and soil food-web dynamics (Neher and Darby 2006).

The application of chemical nematicide is one of the primary strategies of control against plant parasitic nematodes, but their risks to humans and animals may cause environmental pollution. In addition, these lead to an incremental attention in finding some safe alternatives for the control of plant-parasitic nematodes (Maareg *et. al*., 2014).

Use of treated seed can reduce chemical use by 99.4% compared to aerial applications and 88% compared to a banded in-furrow treatment (Frye, 2009). Thus, it considered among those ecofriendly root- knot nematode pest management strategies. Chemical seed treatment is only active in the photospheres of soil surrounding the root system of young plants and therefore reduces the risk of undesired accumulation. Furthermore, seed treatment is faster to handle than liquid or granular formulations, especially in areas where nematicide is incorporated into the soil and where labour is unskilled. Treating seeds directly reduces the high cost associated with all other application forms.

All the polymers, except poly (ethylene glycol), are synthesized by free-radical polymerization of the corresponding monomers. One of the necessary characteristics of these polymers is a high molar mass. Polyacrylamide (PAM) is one of the most widely employed soil conditioner. They have been shown to be most effective in improving the physico-chemical properties of soils. The effect of the polymeric soil conditioners on plant growth and crop yield has also been extensively studied. The rates of germination and emergence of a number of plants such as tomato, lettuce or maize increased markedly in the presence of the conditioner (Wallace and Wallace 1986). Other studies (Batyuk *et al.* 1973) have shown that the yield of (sugar beets) is increased while the requirements for irrigation decreased by the use of the conditioners. A number of reasons have been put forward to explain these observations: better soil aeration, thereby enhancing microbial activity; delaying dissolution of fertilizers; increasing sorption capacity or favouring the uptake of some nutrient elements by the plants.

The objective of this study was to test the effect of sugar beet seed treatments with Abamectin, Nemastop and Mocap nematicides along with plowing depths under utilization of deficit irrigation (DI) 75% from irrigation water requirements (IWR) and with aids of polymers in seedbed to maintain moisture surrounding the root system of young plants and hinder it for nematodes and reduce of early root penetration and damage rates of root-knot nematode, *Meloidogyne incognita* and sugar beet productivity.

Materials and Methods

2.1. **Experimental Location and Sugar beet Growing Conditions**. The experimental location was at Adam Village, Tiba Supervision, West Nubaria Sector (30°37'31.40"N, 29°58'9.26"E), and a history of Root-knot nematodes infestation. The soil type was sandy soil containing distinctly low percentage of organic matter (0.39 %), with a pH of 8.01. The average particle size distribution was 87.2 % sand, 6.5 % fine sand, 2.0 % silt and 4.3 % clay. The field had been cultivated in autumn by sugar beet for numerous seasons before initiating this study. The experiment included for replicates each one had three soil cultivation depths in strip tillage: 1. strip tillage at a depth of 30 cm, 2. strip tillage at a depth of 40 cm and 3. strip tillage at a depth of 50 cm. Tillage was preformed with a 4×4 drive wheel FIAT 130-90 tractor, with 130 hp engine powers. All plots received primary tillage by moldboard plowing at the last week of September. Plowing depth was controlled by the gauge wheel of moldboard plow in all experiment area. Secondary tillage operations consisted of disking and land leveling done for all plots at the same way before planting sugar beet in October. Conventional crop management was followed as recommended for sugar beet production in the region. All crop production practices were performed by the grower, and fertilization was based on soil nutrient analysis. Irrigation was drip irrigation system 50x20 cm. In the drip irrigation system, polyethylene drip lines of 16 mm in diameter had in-line type emitters. Deficit irrigation to level of 75% of Irrigation water requirements (IWR) was utilized to the management of root- knot nematode, *M. incognita* infection without significant reduction in sugarbeet yields as recommended by Maareg *et. al.* (2018)

2.2. **Experimental design** split plot randomized complete block design was used for this study. Statistical comparison was made at the *P*=0.05 level of significance split plot with plowing depth as main plot, strip-plot arrangement and treatments as subplot with four replicates. Each subplot consisted of six rows (50 cm spacing) by 7.0 m in length (3 m×7.0 m = 21.0 m^2). i.e. 1/200 Fed. The experimental setup was repeated for the following fall season of 2018.

2.3. **Planting of tested seeds of sugar beet *Beta vulgaris,* subsp. *vulgaris*** was Sahar polygerm commercial variety obtained from the certified group of sugar beet varieties own by Alexandria Sugar Company. Its origin Germany characterized as diploid × diploid (CECD 2019). Sugar beet, Sahar is susceptible to root-knot nematodes based on Canto-Saenz host suitability designations modified for sugar beet by Gohar *et. al*., 2013)

2.4. **Nematicides and substances used**:

2.4.1 **Abamectin®** as liquid formulation is a macrocyclic lactone derived from the soil bacterium *Streptomyces avermitilis* that has been shown to have nematicidal properties (Putter *et al.* 1981) and a different mode of action than the other currently available nematicides (Tuner and Schaeffer, 1989). The rate of application 40 ml $feddan^{-1}$

2.4.2. **Ethoprop** granules 10% (Mocap**®** 10% G) [0-ethyl S,S-dipropyl phosphorodithioate] is a non-systemic, non-fumigant nematicide and soil insecticide which has been registered since 1967 for use on tobacco in the United States. The rate of application was 1 kg a.i. feddan^{-1}.

2.4.3 **Nemastop®** as suspension formulation is a natural product consist of herb *Allium sativum* (garlic) extracts (thio- compounds - Allyl Disulfide + Allyl cysteine) 8% (Harris *et.al.* 2001) and natural organic matter effective in fighting nematodes. The rate of application 10 L feddan^{-1}.

2.4.4. **Polymer** is potassium-based polymer (Stockosorb AGRO F, manufactured by Stockhausen, Inc.) was applied at a rate of 1.0 kg feddan^{-1}. The polyacrylamide granules were applied directly in the seed furrow during planting (Yonts, 2006).

2.4.5. Soil management treatments were applied to individual plots. Five treatments plus an untreated control were established in a randomized complete plot design with four replicates per treatment at each location every season.

Treatment symbols	Soil Treatment	Application
T_1	Abamectin®	Seed treatment
T_2	Ethoprop (Mocap® 10%G)	In the seed furrow at planting
T_3	Polymers	In the seed furrow at planting
T_4	Abamectin + Polymers	Seed treatment and in seed furrow at planting
T_5	Nemastop® + Polymers	Seed treatment and in seed furrow at planting
T_6	Control	Standard seed & free furrow of chemicals

2.4.6. Estimation of nematode population densities were performed from combined soil samples that taken from each plot just before sowing and applying the soil and/or seed treatments (P0) and after the treatments at planting (Pi) to estimate soil nematode buildup. On each sampling time, twelve soil cores were taken per plot using a vertical soil core sampler (2 cm diameter × 20 cm deep), and cores were corporate in a compound soil sample. Nematodes were extracted from subsamples of 250-g of soil by using a modified Bearman's tray method as described by Barker (1985), where at harvest, P_f was determined by taking composite soil samples excavated with a spade around the roots of 10 to 12 plants distributed randomly at each site. Nematodes were extracted from two 250 g sub-samples of using a modified Bearman's tray method as described by Barker (1985), and identified and counted under a compound microscope. To identify the *Meloidogyne* species, females were collected from infected roots under a stereo microscope. A minimum of 10 females per site was used to identify the RKN species in accordance with their perineal.

2.4.6. Efficacy % of tested nematodes management strategies against the root-knot nematode on sugar beet

To evaluate the efficacy % of experimented control strategies against root-knot nematode, the numbers of nematodes in the soil and disease severity % were determined. The nematode numbers in the soil were detected by Baermann funnel apparatus Barker (1985). A hold tightly rubber tube was placed beneath the funnel, and a piece of window screen (or similar material) was placed in the opening of the funnel; the funnel was placed into a holder; a tissue-paper wrapped soil sample was placed onto the screen material then add water to the funnel setup until the screen and soil sample were immersed; incubate overnight (or longer if desired). Finally, the first couple of drops of water from the bottom of the tube were gathered by slowly releasing the clamp on the tubing, and then the density of larvae was examined under the microscope. For the disease severity % detection, the gall indices we rerecorded at the termination of experiments on the scale rating used was as follows: 0 = no galls; 1 = 1 to 2 galls; 2 = 3 to 10 galls; 3 = 11 to 30 galls; 4 = 31 to 100 galls; and 5 = >100 galls per root system (**Maareg *et al*., 2005**). The six-control strategies efficacy was calculated as described by (Xue *et al.* 2009).

Disease severity, drop rate and control strategies efficacy were calculated as following:

Disease severity =

$$\left[\sum \frac{Class.frequancy \times Score.of.rating.class}{total.number.of.plants.investigated \times Maximal..disease.index} \times 100\%\right]$$

Drop rate =

$$\frac{the.number.of.J2.in.control.treatment - the.number.of.J2.in.strategy.management.treatment}{the..number.of.J2.in.control.treatment} \times 100\%$$

Biocontrol efficacy =

$$\frac{disease..severity.in.control.treatment - disease..severity.in.strategy.treatment}{disease..severity.in.control.treatment} \times 100\%$$

2.4.7. The impact of control strategies on the yield of o f sugar beet as roots and sugar ton/fed.

Data Recorded:

In each plot (sub- plot), the outer two ridges (1st and 6th) were considered as a belt, while, the 2nd and 5th ridges were devoted for plant growth sampling, the two central ridges to determine roots and top yields at harvest. The collected data in the two experiments involved the following traits:

Yield characters:

1- Number of plants/ fed. after thinning.
2- Number of plants/ fed. at harvest.
3- Losses percentages in number of plants/ fed.
4- Root yield (tons/ fed).
5- Extractable white sugar yield (ton/ fed.)

Extractable white sugar percentage (ZB %). Correct sugar content (white sugar%) of beet was determined in Sugar Nile Company calculated by linking the beet non- sugars, K, Na and α-amino- N (expressed as milliequivalents/100 g beet roots) according to **Harvey and Dutton (1993)** as follows:

$ZB = Pol - \{0.345 (K + Na) + 0.094\ \alpha\text{- amino- } N + 0.29\}$

2.4.8. Statistical analysis:

Data of the two experienced growing seasons of 2016/ 17 and 2017/ 18 were subjected to Bartlett's test (Snedecor and Cochran, 1989) to check their homogeneity of variances before combined for analysis of variance (ANOVA) according to Steel and Torrie (1981) using MSTAT version 4 (1987), followed by testing significant differences among the means of different treatments were separated by Duncan's Multiple Range Test at 0.05 probability according to Duncan (1955).

Results and discussion:

Findings in Table (1) demonstrated effects of some root- knot nematodes control strategies on root- knot nematodes number/g soil, knot disease severity % and drop rate % in sugar beet in sugar beet by combine analysis of 2016/ 17 and 2017/ 18 growing seasons. The lowest number for root- knot nematodes number/g soil as affected by plowing depth was 2.32 larvae for each plowing depth 30 and 50 cm. also, the lowest record for disease severity % recorded for plowing depth 30 and 50 cm (17.06 and 19.64 %, respectively). The most excellent drop rate % was achieved by plowing depth 30 cm (55.26 %) followed by plowing depth 50 cm (53.66 %) with significant difference between them at $P \leq 0.05$. At level of control treatments, T_5 = Nemastop + Polymers recorded the lowest number of root- knot nematodes number/g soil (1.7 larvae) followed by T_3= Polymers (2.0 larvae / g soil), all values had significant difference at $P \leq 0.05$. Also, knot disease severity % as affected by control treatments, it can be noticed T_5 = Nemastop + Polymers and T_3= Polymers had the lowest percentages (13.1 and 14.7 knot disease severity %, respectively) with obvious significant differences among all tested treatments at $P \leq 0.05$. Regarding effect of control treatments on drop rate %, the best scores achieved by T_5 = Nemastop + Polymers and T_3= Polymers (70.5 and 65.4 %) with clear significant differences among all tested treatments at $P \leq 0.05$.

Table 1. Effect of some root- knot nematodes control strategies on root- knot nematodes number/g soil, knot disease severity % and drop rate % in sugar beet in sugar beet by combine analysis of 2016/ 17 and 2017/ 18 growing seasons.

Varieties	Plowing depth	Treatments						Mean
		T_1	T_2	T_3	T_4	T_5	T_6	
Root- knot nematodes number/g soil	**30**	3.0	2.9	1.9	1.8	2.0	5.2	**2.32**
	40	4.2	3.6	2.2	3.8	1.3	6.1	**3.02**
	50	4.0	3.8	2.0	3.4	1.8	6.5	**2.32**
Mean		**3.7**	**3.5**	**2.0**	**3.0**	**1.7**	**5.9**	**2.78**
Knot disease severity %	**30**	22.8	22.2	15.2	14.8	10.3	**17.06**	**17.06**
	40	31.0	23.3	15.1	26.0	13.0	58.6	**21.68**
	50	25.0	23.2	13.8	20.3	15.9	32.5	**19.64**
Mean		**26.3**	**22.9**	**14.7**	**20.4**	**13.1**	**60.5**	**19.48**
Drop rate %	**30**	42.3	43.5	63.4	65.4	61.7	0.0	**55.26**
	40	31.4	41.0	63.3	37.7	78.3	0.0	**50.34**
	50	39.2	41.1	69.3	47.1	71.6	0.0	**53.66**
Mean		**37.7**	**41.9**	**65.4**	**50.1**	**70.5**	**0.0**	**53.21**

T_1= Abamectin, T_2= Mocap, T_3= Polymers, T_4 = Abamectin + Polymers, T_5= Nemastop + Polymers and T_6= Control

$L.S.D_{0.05}$	Root- knot nematodes number/g soil	Knot disease severity %	Drop rate %
Plowing depth (P)	**0.031**	**0.065**	**0.063**
Treatments (T)	**0.033**	**0.137**	**0.1135**
P x T	**0.032**	**0.239**	**0.237**

Concerning interaction effects of plowing depth × control treatment on root- knot nematodes number/g soil, knot disease severity % and drop rate %, it can outlined that The best scores were due to 40 cm-plowing depth × T_5 = Nemastop + Polymers (1.3) followed by the same treatment at 50 cm-plowing depth (1.8) and 30 cm-plowing depth with T_4 = Abamectin + Polymers with same value (1.8) followed by 30 cm-plowing depth with T_3= Polymers (1.9 larvae/ g soil) with frequent significant differences among combinations. Interaction effect of combined treatment on knot disease severity % verified that 30 cm-plowing depth with T_5 = Nemastop + Polymers scored better percentage in comparison with other treatments (10.3 %) followed by the same treatment (T_5) at 40 cm-plowing depth (13.0 %) followed by 50 cm-plowing depth with T_3= Polymers (13.8 %) followed by T_4 = Abamectin + Polymers at 30 cm-plowing depth (14.8 %) with significant differences among them at $P \leq 0.05$. Whereas, effect of interaction on drop rate % 40 cm-plowing depth with T_5 = Nemastop + Polymers had the lead (78.3 %) followed by the same treatment at 50 cm-plowing depth (71.6 %) followed by 50 cm-plowing depth with T_3= Polymers (69.3 %). Generally, T_5 and T_3 when combined with any of tested plowing depth gave the best results for drop rate %; significant differences were existed among combinations at $P \leq 0.05$ (Table, 1).

Findings demonstrated in Table (1) about effects of certain root- knot nematodes control strategies on root- knot nematodes number/g soil, knot disease severity % and drop rate % in sugar beet, revealed that the potential effects were due 30 and 50 cm-plowing depth n reducing root- knot nematodes number/g soil and knot disease severity % confirmed by these statements that nematode density was further enhanced by tillage in amended soils, nematode and protozoan densities were lower in the 5-25 cm layer (Zasada *et. al*. 2008). Also, Tillage depth and intensity alter the soil physical and chemical properties that affect plant growth vigor and crop yields (Strudley *et. al*. 2008).

Under field condition, Gohar *et. al.* (2014) showed that nematode parameters i.e. gall index and reproduction factor, proved that Nemastop seed treatment followed by Abamectin seed treatment pulled off the lowest values for gall index and reproduction factor. Also, Gohar *et. al.* (2012) proved that reduction in galls number/ root system, gall ratings, egg-masses numbers/root system, eggs/ egg-mass was associated with Ethoprop (Mocap) plots. As well great reduction in the number of juveniles/ plant, juvenile/ 200 g soil and mature females' number/ roots system was associated with application of Ethoprop (Mocap).

Adding synthetic compounds, such as polyacrylamide (Polymers), to the soil is a method being explored to enhance plant emergence by retaining soil water near the seed and/or reduce soil crusting (Yonts, 2006). This study was under deficit irrigation (DI) to level of 75% of Irrigation water requirements (IWR), so that; polymer makes water between the soil's granules available to the plant and is vacant to nematodes i.e. a suppressive condition to nematodes where polymer exists. Maareg *et. al*. (2018) stated that deficit irrigation (DI) practices can be a beneficial technique to increase crop yield production per cubic water unit, and to reduce nematode infection. Logically and practically as experienced in this study the interaction effect of the distinguish elements of the two studied factors had significant positive results on nematode's parameters under study.

Table 2. Efficacy % of some root- knot nematodes control strategies in sugar beet by combine analysis of 2016/ 17 and 2017/ 18 growing seasons.

Varieties	Plowing depth	Treatments T_1	T_2	T_3	T_4	T_5	T_6	Mean
Efficacy %	**30**	74.75	75.42	83.17	83.61	80.95	0.0	**79.58**
	40	47.10	60.24	74.23	55.63	79.01	0.0	**63.242**
	50	23.05	28.59	57.52	37.52	58.45	0.0	**41.026**
Mean		**48.30**	**54.75**	**71.64**	**58.92**	**72.80**	0.0	**61.282**

T_1= Abamectin, T_2= Mocap, T_3= Polymers, T_4 = Abamectin + Polymers, T_5= Nemastop + Polymers and T_6= Control

$L.S.D_{0.05}$	Efficacy %
Plowing depth (P)	0.067
Treatments (T)	0.139
P x T	0.240

Efficacy % of some root- knot nematodes control strategies in sugar beet by combine analysis of 2016/ 17 and 2017/ 18 growing seasons considered the most suitable assessment for how far successfulness of tested control strategy. Table (2) illustrated the effect of treatments individually or/ and in combinations on efficacy %. At the level of plowing depth, 30 cm-plowing depth scored the best efficacy (79.58 %) followed by 40 cm-plowing depth (63.24 %) with significant difference at $P \leq 0.05$. At level of control treatments, the lead was due to T_5 = Nemastop + Polymers (72.80 %) followed by T_3= Polymers (71.64 %) followed with T4 = Abamectin + Polymers (58.92 %) with obvious significant differences among them at $P \leq 0.05$. As regards of interaction effects on efficacy %, the best results obtained with 30 cm-plowing depth × T_4 = Abamectin + Polymers (83.61 %) followed by the same depth with T_3 = Polymers (83.17 %) followed by 30 cm-plowing depth with T_5 = Nemastop + Polymers (80.95 %) with clear significant differences among them at $P \leq 0.05$. The second combinations as power of effect were all control treatments with 40 cm-plowing depth with average 63.24 % efficacy.

The entire studied elements that were employed in this investigation proved enhancements as illustrated by obtained results in root-knot nematode management or/and in sugar beet yield and quality parameters, along with confirmations by other authors (Lehrsch *et. al.* 2005; Yonts, 2006; Agami *et. al.* 2010; Gohar *et. al.*, 2012; Gohar *et. al.* 2014; Maareg *et. al.* 2018; Michalska-Klimczak *et. al.* 2018; Mioduszewska *et. al.* 2018). Percentage of efficacy of nematode control strategies in sugar beet fields under study is an outcome of the efficiency and success of each of the elements used in the study and their impact on root-knot nematode or/and sugar beet yield parameters.

Results in Table (3) illustrate the findings by combine analysis for two successive seasons after experiencing innovative strategy to control root-knot nematodes in sugar beet fields. Combinations of two factors, the first are Treatments which were combinations consisted from nematicides and organic polymers whereas the second factor was plowing depth. The two mentioned factors had effects on number of plants after thinning, at harvest and losses percentages in number of plants/ feddan in sugar beet field. 30 cm-plowing depth recorded the highest values for the survived plant after thinning and at harvest (31080.0 and 29506.7 plant/fed., respectively). Effect of plowing depth of 40 cm had the lower value for loss % in number of plant/ fed. (4.61 %) followed by 30 cm-plowing depth (5.04 %) but without significance between them at $P \leq 0.05$. At level of management treatments, T_1= Abamectin and T_5= Nemastop + Polymers achieved the most preservation for the numbers of plant after thinning and at harvest (32777.8 and 31244.4 plant/fed., respectively) outperformed the other tested treatment significantly at $P \leq 0.05$. Also, for loss % in number of plants /fed., the same abovementioned treatment had the superiority in comparison this context whereas they recorded the lowest values (3.56 % for T_5 and 5.14 % loss for T_1) without significance between them at $P \leq 0.05$.

Regarding effect of interaction for plowing depth × management treatments, T_1= Abamectin × 30 cm-plowing depth has the lead for the three parameters of number of plants /fed, whereas the distinguished values were 36400.0, 35533.3 plant /fed. and 2.38 % loss, orderly. The second ranked interaction effect on those parameters was at the same treatment T_1= Abamectin × 40 cm-plowing depth (35000.0, 33866.7 plant /fed. and 3.21 % loss, respectively).

Notably, management treatment of T_5= Nemastop + Polymers individually or in combination with plowing depth of 30 cm at significance with $P \leq 0.05$ gave the second rank as positive influence on plant number after thinning or at harvest or in loss% in number of survived plants (Table, 3).

Table 3. Effect of some root- knot nematodes control strategies on number of plants after thinning, at harvest and losses percentages in number of plants/ feddan in sugar beet by combine analysis of 2016/ 17 and 2017/ 18 growing seasons.

Varieties	Plowing depth	Treatments						Mean
		T_1	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	
number of plants/ feddan after thinning	**30**	36400.0	33133.3	20766.7	31500.0	33600.0	23266.7	**31080.0**
	40	35000.0	27000.0	24966.7	26600.0	26600.0	21566.7	**28033.3**
	50	26933.3	29566.7	18066.7	24600.0	31366.7	19833.3	**26106.7**
Mean		**32777.8**	**29900.0**	**21266.7**	**27566.7**	**31300.0**	**21555.6**	**28562.2**
number of plants/ feddan at harvest	**30**	35533.3	31266.7	19366.7	28933.3	32433.3	19633.3	**29506.7**
	40	33866.7	25900.0	23800.0	24733.3	27766.7	19033.3	**27213.3**
	50	24333.3	27000.0	16200.0	20400.0	30400.0	17366.7	**23666.7**
Mean		**31244.4**	**28055.6**	**19788.9**	**24688.9**	**30200.0**	**18677.8**	**26795.6**
losses % in number of plants/ feddan	**30**	2.38	5.66	5.54	8.14	3.47	15.58	**5.04**
	40	3.21	4.15	4.56	6.98	4.13	11.73	**4.61**
	50	9.83	9.17	10.70	17.07	3.08	12.46	**9.97**
Mean		**5.14**	**6.33**	**6.94**	**10.73**	**3.56**	**13.26**	**6.50**

T_1= Abamectin, T_2= Mocap, T_3= Polymers, T_4 = Abamectin + Polymers, T_5= Nemastop + Polymers and T_6= Control

$L.S.D_{0.05}$	**number of plants/ feddan after thinning**	**number of plants/ feddan at harvest**	**losses % in number of plants/ feddan**
Plowing depth (P)	358.5	401.3	0.81
Treatments (T)	828.1	793.2	1.34
P x T	1300.4	1245.8	2.32

Generally, management treatments maintained higher number sugar beet plants/fed. even after thinning or at harvest or loss percentage in plant number/fed. in comparison with control treatment, these finding in constancy with those found by Gohar *et. at*. (2009) confirmed that the studied agents acted against nematodes resulted in maintaining a higher number of survival plants / treated plots as compared to untreated plots. All findings in Table (3), concerning components the two studied factors i.e. management treatments and plowing depth individually or in combination, denoted to distinguish effects of some on survived plants rather than others, among those, Abamectin, Nemastop, polymer, Mocap and 30 or 40 cm-plowing depth this in agreement with those found by Gohar *et. al*. (2014) revealed that there were variations in germination seeds parameters i.e. germination percentage, germination index and germination rate index, the nematicide, Nemastop achieved the highest germination % (76.3%) followed by Abamectin (71.7%). results of plowing depth individually or in combinations with other treatments in consistency with those stated by Agami *et. al.* (2010) that the best agronomical performance to sugar beet crop obtained with plowing depths of 40 and 30 cm among other agricultural practices and in harmony with those found by Mioduszewska *et. al*. (2018) stated that field emergence capacity of sugar beet was only satisfactory in the systems where the soil was cultivated at depths of 25, 30 and 35 cm. this study was initiated under deficit irrigation to level of 75% of IWR therefore polymers prospected to have potential role. Polymers in water applied to soil surfaces may increase aggregate stability and reduce aggregate slaking, thus minimizing crusting and increasing sugar beet *(Beta vulgaris* L.) emergence. Lehrsch *et. al.* (2005) found that organic polymer Nalcolyte 8102 significantly increased emergence, averaged across three field sites, of sugar beet from crusted soils, compared to controls, Treatment organic polymer 8102-3 increased emergence 1.22-fold (from 53.6 to 65.5%, significant at $p < 0.001$).The application of Ethoprop (Mocap) at planting reduced the severity of the roots knot nematode–*Fusarium* wilt disease complex in sugar beet and maintained good rate of survival plants/fed**.** (Gohar *et. al*., 2012).

Effect of some root- knot nematodes control strategies on root yield and extractable white sugar yield (ton/ fed.) in sugar beet in by combine analysis of 2016/ 17 and 2017/ 18 growing seasons shown in Table (4) revealed that plowing depth 30 cm scored the highest values for root yield and extractable white sugar yield (20.2, 3.01 tons/fed., respectively). Effects of management treatments on the same mentioned parameters were distinguish for two outstanding treatments, the first T_1= Abamectin, whereas recorded 24.177 and 3.913 ton/ fed. for root yield and extractable white sugar yield (ton/ fed.), respectively. Second impact on these parameter was for treatment T_5= Nemastop + Polymers as recorded values of 19.382 and 3.049 ton/ fed, orderly, with significance at $P \leq 0.05$. The followed effects on these parameters were due to T_2= Mocap and T_4 = Abamectin + Polymers without significance between them at $P \leq 0.05$ for related parameters.

Table 4. Effect of some root- knot nematodes control strategies on root yield, extractable white sugar yield (ton/ fed.) and sucrose percentage in sugar beet by combine analysis of 2016/ 17 and 2017/ 18 growing seasons**.**

Varieties	Plowing depth	Treatments						Mean
		T_1	T_2	T_3	T_4	T_5	T_6	
Root yield (ton/ fed	**30**	23.236	22.530	13.925	21.198	20.350	4.611	**20.2**
	40	22.288	19.197	10.622	19.708	17.911	7.044	**17.9**
	50	27.008	15.554	5.987	16.526	19.883	12.748	**17.0**
Mean		**24.177**	**19.094**	**10.178**	**19.144**	**19.382**	**8.135**	**18.40**
Extractable white sugar yield (ton/ fed.)	**30**	3.746	3.297	2.011	2.864	3.122	0.580	**3.01**
	40	3.781	2.749	1.440	2.727	2.759	0.866	**2.691**
	50	4.210	2.415	0.828	2.488	3.265	1.666	**2.781**
Mean		**3.913**	**2.820**	**1.426**	**2.693**	**3.049**	**1.037**	**2.641**
Extractable white sugar percentage (ZB %)	**30**	16.11	14.63	14.42	13.47	15.32	12.49	**14.79**
	40	16.95	14.29	13.54	13.83	15.36	12.26	**14.79**
	50	15.57	15.50	13.75	15.05	16.37	13.04	**15.25**
Mean		**16.20**	**14.80**	**13.91**	**14.12**	**15.69**	**12.60**	**14.94**

T_1= Abamectin, T_2= Mocap, T_3= Polymers, T_4 = Abamectin + Polymers, T_5 = Nemastop + Polymers and T_6 = Control

$L.S.D_{0.05}$	Root yield (ton/ fed	Extractable white sugar yield (ton/ fed.)	Extractable white sugar percentage (ZB %)

Plowing depth (P)	0.383	0.065	0.11
Treatments (T)	0.745	0.127	0.15
P x T	1.288	0.220	0.26

Regarding interaction effect of plowing depth × management treatments on for root yield and extractable white sugar yield (ton/ fed.), results in Table (2) revealed that the highest effect on root yield ton/fed. was for 50 cm-plowing depth × T_1= Abamectin (27.088 ton/fed.) followed the same treatment (T_1) × 30 cm-plowing depth (23.236 ton/fed.) followed by 30 cm-plowing depth × T_2= Mocap (22.530 ton/fed.) then followed by 30 cm-plowing depth × T_4 = Abamectin + Polymers (21.198 ton/fed.) with occasionally significance among them at $P \leq 0.05$. Interaction effect on extractable white sugar yield (ton/ fed.) confirmed that the highest effects achieved values above 3.0 ton/fed. in he lead was T_1= Abamectin × 50 cm-plowing depth (4.210 ton/fed.) followed by the same treatment at 40 cm-plowing depth (3.781 ton/fed.) followed by the same treatment (T_1) at 30 cm-plowing depth (3.746 ton/fed.).

The weakest impact on the parameters was due to polymer alone or with plowing depths. But polymer with Abamectin or Nemastop especially at 30 cm-plowing depth achieved distinguish results for all studied parameters at $P \leq 0.05$ (Table, 4).

As found in Table (4) results confirmed the findings in Table (4), the potential of impact on root yield, extractable white and sugar yield (ton/ fed.) were due to the same elements of study plus effect of Mocap this verified by Gohar et. al. (2014) stated that the sugar and root yields differed with different nematicide seed treatments, but it was comparable to the highest sugar and root yields achieved under Nemastop seed treatment followed by Abamectin. Interaction effects related promising elements i.e. T_5 = Nemastop + Polymers, 30 cm-plowing depth × T_4 = Abamectin + Polymers and T_1= Abamectin with all plowing depths achieved on all listed parameters in Table (4) depend on the most effective single element on nematodes like Abamectin and Nemastop or plowing depths as stated by Gohar *et al.* (2014) and Agami *et al*. (2010). Also, there was contribution for polymer to achieve enhancements even if it alone at plowing depth of 30 cm or/and with others whereas. Adding synthetic compounds, such as polyacrylamide (polymers), to the soil is a method being explored to enhance plant emergence by retaining soil water near the seed and/or reduce soil crusting Yonts (2006), and hence improving all related yield components.

Regarding effect of control treatments on extractable white sugar percentage (ZB %), the highest score obtained by T_1= Abamectin (16.20 %) and T5 = Nemastop + Polymers (15.69 %) with significant difference at $P \leq 0.05$ (Table, 4).

Concerning interaction effect of combined treatments on extractable white sugar percentage (ZB %), 40 cm-plowing depth × T_1= Abamectin scored highest value (16.95 %) followed by 50 cm-plowing depth × T_5 = Nemastop + Polymers (16.37 %) followed by 30 cm-plowing depth × T_1= Abamectin (16.11 %) -Table (4). As denoted previously, the components of two studied factors individually or in combination had notable effects on recorded parameters. So that, extractable white sugar percentage (ZB %) in sugar beet affected by those factors as presented above, this confirmed by other authors like Michalska-Klimczak *et. al*. (2018) declared that the use of primed seeds resulted in a higher technological white sugar yield with higher sugar content and lower content of α-amino nitrogen in the roots. Also, seed priming increased the technological value of the roots by a lower share in the root yield fractions of the root weight less than 300 g, characterized by lower sugar content and a higher content of α-amino nitrogen.

Conclusions and Recommendations:

Efficacy percentage of some root- knot nematodes control strategies in sugar beet by combine analysis of 2016/ 17 and 2017/ 18 growing seasons considered the most authentic mean to conclude and recommend successful tested control strategy.

- In regard of plowing depth, plowing depth 30 cm achieved the most promising results for number of plants after thinning, at harvest and losses percentages in number of plants/ fed. in sugar beet field. Also, plowing depth 30 cm scored the highest values for root yield and extractable white sugar yield. the highest value for and extractable white sugar percentage (ZB %) – 15.25 % with significant difference between them at $P \leq 0.05$ from 30 and 40 cm-plowing depths (14.79 % for the two plowing depths). The lowest number for root- knot nematodes number/g soil as affected by plowing depth was at plowing depth 30 and 50 cm. also, the lowest record for disease severity % recorded was for plowing depth 30 and 50 cm. The most excellent drop rate % was achieved by plowing depth 30 cm, drop rate % s another indicator for efficiency management strategy.
- Concerning efficacy %., 30 cm-plowing depth scored the best At level of control treatments, the lead was due to (Nemastop + Polymers) followed by Polymers followed with (Abamectin + Polymers).
- Considering of interaction effects on efficacy %, the best results obtained with 30 cm-plowing depth × (Abamectin + Polymers) followed by the same depth with Polymers followed by 30 cm-plowing depth with (Nemastop + Polymers).
- All outstanding studied elements gave additive positive impacts on root-knot nematode and sugar beet yield parameters when interacted with each

other under deficit irrigation (DI) to level of 75 % of Irrigation water requirements (IWR)

Hence, the study recommends plowing depth of 30 cm and adequate nematicide seed treatments with deficit irrigation (DI) of 75% water requirement is suitable to increase water use efficiency (WUE) as well as to improve the efficiency of modern integrated management strategies to control *M. incognita* in sugar beet infected fields without serious effects on crop performance which eventually results in augmented yield.

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تقييم توليفات من المبيدات النيماتودية بمساعدة البوليمرات لمكافحة نيماتودا تعقد الجذور التى تصيب حقول بنجر السكر في منطقة غرب النوبارية .

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أجريت تجربتين تحت ظروف نمو محصول بنجر السكر بمنطقة غرب النوبارية في موسمي 2017/2016 – 2018/2017 لتقييم إستراتيجيات محددة لمكافحة نيماتودا تعقد الجذور، ميليدوجين إنكوجنيتا. وكانت العوامل الرئيسية المدروسة (أعماق الحرث مع معاملات المكافحة، ثلاث أعماق حرث وستة معاملات مكافحة) وكان تصميم التجربة ذو القطعة المنشقة مرة واحدة ذو القطع كاملة العشوائية. المعاملات تحت التقييم أو إستراتيجيات المكافحة عبارة عن توليفات مختلفة مكوناتها من الأبامكتين والنيماستوب والموكاب المحبب 10% والبوليمر البوتاسي بالمقارنة مع معاملة الكنترول. أجري تحليل التباين للبيانات التي تم دمجها للموسمين بإحتمال معنوية قدره P ≤ 0.05 والذي أوضح جلياً تأثير المعاملات المختلفة. وجد فرق معنوي بين عمقي حرث 30 و 40 سم. عند إحتمال قدره P ≤ 0.05 وأقل قيمة تحققت لعدد النيماتودا / جم تربة كانت عند عمق حرث 30 سم و50 سم. أما معدل الخفض % فأحسن قيمة له تم تحقيقها عند عمق حرث 30 سم وهي تعتبر مؤشر أخر لمدي كفاءة إستراتيجية المكافحة. النسبة المئوية لكفاءة إستراتيجية المكافحة أشارت إلى أن عمق حرث 30 سم سجل أحسن سجل على مستوي معاملة المكافحة، وكان في المقدمة معاملة (نيماستوب + البوليمر) تبعها البوليمر على عمق حرث 30 سم تبعها معاملة (الأبامكتين + البوليمر). أما تأثير التفاعل، علي الكفاءة النسبية أوضح أن أحسن النتائج المتحصل عليها كانت مع عمق 30 سم × (أبامكتين + البوليمر) تبعها البوليمر مع نفس عمق الحرث (30سم) تبعها عمق 30 سم حرث × (نيماستوب + بوليمر).

عمق الحرث 30 سم حقق أكثر النتائج الواعدة بالنسبة لتعداد النباتات في الحقل سواء بعد الخف أو عند الحصاد وكذلك النسبة المئوية للفقد في عدد النباتات/فدان. أيضاً عمق الحرث 30 سم حقق أعلى القيم لمحصول الجذور ومحصول السكر الأبيض القابل للإستخلاص. عمق الحرث 50 سم حقق أعلى قيمة للنسبة المئوية للنقاوة وتبعه في ذلك عمق حرث 30 سم . عمق حرث 30 سم و 50 سم كانت لهما أقل قيم لنسبة الصوديوم والبوتاسيوم. عمق 50 سم سجل أعلى قيمة لنسبة السكر الأبيض القابل للإستخلاص مع (ZB%).

وأعطت جميع العناصر المدروسة المتميزة تأثيرات إيجابية مضافة على نيماتودا تعقد الجذور ومحصول الجذور لبنجر السكر عند تفاعلها مع بعضها البعض تحت الري الناقص (DI) إلى مستوى 75 ٪ من متطلبات مياه الري (IWR).

وبالتالي توصي الدراسة بعمق الحرث 30 سم مع المبيد المناسب لمعاملة البذور تحت نظام الري الناقص عن الإحتياجات المائية ب 75 % وهو مناسب لرفع كفاءة إستخدام المياه وكذلك تحسين إستراتيجيات مكافحة نيماتودا تعقد الجذور ميليدوجين إنكوجنيتا في حقول بنجر السكر المصابة بدون تأثير كبير على آداء محصول بنجر السكر.