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NEMATICIDAL POTENTIALITY OF SOME ANIMAL MANURES COMBINED WITH UREA AGAINST *MELOIDOGYNE ARENARIA* AND GROWTH AND PRODUCTIVITY OF SUGAR BEET UNDER FIELD CONDITIONS

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Abstract

Three animal culture manures viz., cattle manure (CM), sheep manure (SM) and chicken manure (ChM) at three rates as organic substances, incombinination with urea as inorganic fertilizer, were tested for their action against root-knot nematode, *Meloidogyne arenaria* infesting sugar beet and plant growth, yield and total soluble sugars (TSS %) under new reclaimed sandy loam field. Results indicated that all treatments at their rates significantly ($p \leq 0.05$ and / or 0.01) reduced females, galls and egg-mass numbers as compared to un-amended plants. All rates of Ch M treatment gave best results in protecting sugar beet plants and diminishing the nematode population densities in various stages. But, SM treatment with their rates ranked statistically in the second category. However, the three levels of CM treatment achieved the third category in managing the nematode. All treatments significantly improved infected sugar beet growth including yield and TSS %. There were positive correlations between the evaluated concentrations and the obtained reduction in numbers of the nematode stages and also all plant growth parameters including root weight (yield) and total soluble sugars.

Sugar beet (*Beta vulgaris* L.) is a sugar cash crop cultivated in the temperate and cold zones of the world for sugar extraction. In Egypt, sugar beet comprises about 30% of total sugar production. Plant-parasitic nematodes, especially root-knot nematodes are a major problem in sugar beet production (Ibrahim, 1982; Janati *et al.*, 1982; Ismail *et al.*, 1996; Maareg *et al.*, 2005). Due to the high cost and toxic effects of nematicides alternate control measures have been used to control economically important plant-parasitic nematodes. The newly reclaimed sandy soils unfortunately are highly infested with nematodes. Application of organic matter to the soil is known to have beneficial effects on soil nutrition, soil physical conditions, soil biological activity and crop performance (Wade & Sanchez, 1983). Reductions in population densities of phytoparasitic nematodes in response to application of animal culture manures and their positive effects on host growth have been reported in many studies (Badra *et al.*, 1979; Montasser, 1991; Ismail & Youssef, 1997; Nakhla *et al.*, 1998; Ahmad & Siddiqui, 2009 Farahat *et al.*, 2010; El-Sherif *et al.*, 2010). The role of nitrogenous fertilizers especially urea in the hindrance of nematodes and improving the growth of treated plants is also reported (Glazaer & Orion, 1984; Brown, 1987; Hammad *et al.*, 1994; El-Sherif *et al.*, 2008; Ismail *et al.*, 2011). The interference and mutual interaction between urea and organic manures resulted in unknown effects between each others. Because of the mentioned encouraging results the present study was planned to determine the effects of some animal manures in combination with urea as a mineral fertilizer on sugar beet growth and the yield in a field infested with root-knot nematode *M. arenaria*.

Materials and Methods

A field experiment was carried out for one season in a newly reclaimed sandy loam soil at El-Emam Malek village located in El-Nubaria district, Behera governorate, Western Nile Delta region, Egypt. Physical and chemical properties of field soil are shown in Table 1. The selected experimental field was naturally infested with root-knot nematode *Meloidogyne arenaria*, ploughed, leveled and divided into fifty plots following the harvest of peanut cv. Giza 2. Each plot contained 5 ridges of 4 m in length, 0.5 m in width and 30 cm spaced hills. Three animal manures viz., cattle manure (CM), sheep manure (SM) and chicken manure (Ch M) air-dried, ground in combination with urea 46.5% N as mineral fertilizer at 200 g / plot (equal to 150 N unit / feddan) were broadcast in the form of powder as fertilizers on the side of the hill, covered and followed by drip irrigation at 0.5, 1 and 1.5 kg / m^2 equal to 2, 4 and 6 tons / feddan (= 4200 m^2). Seeds of sugar beet, *Beta vulgaris* cv. Toro were planted as host plant for *M. arenaria* at the beginning of September under drip irrigation system and thinned to one plant / hill. Five replicated plots for each of the ten treatments were arranged in a randomized complete block design. Other cultural operations and irrigation requirements were carried out as recommended. Three sub samples, each from the rhizosphere soil of a randomly selected plant, were taken with a hand trowel (6 cm diam. × 30 cm deep) and composited into a single sample at planting and harvest times. Nematodes were extracted from 250 g soil from thoroughly mixed sample using sieving and decanting technique (Barker, 1985). At the end of April, the percentages reduction or increase in nematode populations or plant growth parameters and total soluble sugars (TSS %) as compared to untreated plants were calculated. Also, roots were stained in hot acid fuchsin-lactophenol, cleared with lactophenol and nematode galls and egg-masses numbers were counted (Taylor & Sasser, 1978).

Statistical analysis: All obtained data were subjected to statistical analysis by using F test and the means were compared according to L.S.D. test between the raw data of all nematodes, plant growth parameters and the control plants (Gomez & Gomez, 1984). Correlation analysis were also used to determine the relationships between doses of animal manures and the reductions in galls, egg-masses and gall index, increases in the plant growth parameters and TSS %.

Table 1. Some physical and chemical properties of El-Nubaria soil.

Particle size distribution							
Sand %	Silt %	Clay %	Soil Texture			Field capacity%	
75.8	20.6	3.6	Sandy loam			22.1	
Chemical properties							
EC dsm^{-1}		pH (1:2.5)		$CaCO_3$ %		O.M. %	
0.12		7.7		3.77		0.44	
Soluble cations (meq L^{-1})				**Soluble anions(meq L^{-1})**			
Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
2.1	1.9	0.155	1.50	0.0	1.22	0.34	3.88
Available (mg/100g)			**Available micronutrients (ppm)**				
Total N	P	K	Fe	Mn	Zn	Cu	
13.1	12.8	24.7	3.44	2.55	1.37	3.47	

Results

Data in Table 2 showed that the nematode development and reproduction were significantly ($p \leq 0.05$ and / or 0.01) reduced by all treatments. The data suggest that all the tested substances suppressed nematode development or did not allow the nematode to complete its life cycle by the end of the experiment. Newly hatched J_2 were found only from non-treated soil (Table 2). Statistically significant differences in the nematode stages were observed between and within treatments. Also, the numbers of the nematodes in different stages reduced gradually with an increasing dose of the tested organic additives combined with urea. The greatest reduction in numbers of *M. arenaria* females was caused at application of three rates of chicken manure, followed by sheep manure and cattle manure. Chicken manure treatment caused a significantly greater ($p \leq 0.01$) reduction in numbers of galls and galling index than any other substances. Similar trends were observed with nematode egg-masses (Table 2). There were positive significant correlations ($p \leq 0.05$) between reductions in numbers of females, galls, egg-masses and doses of all the organic substances (r = 0.98368, 0.94615 and 0.90828 for females), (r = 0.97916, 0.92994 and 0.92479 for galls) and (r = 0.94894, 0.98674 and 0.97087), respectively. On the other hand, there were negative significant correlations ($p \leq 0.05$) between GI% (total number of galls and egg-masses on the root system / their corresponding number in the control) and doses of all the organic substances (r= - 0.96797, - 0.97755 and 0.87676, respectively).

As for the effect of different animal manures combined with urea on sugar beet growth, yield and total soluble sugars (TSS %), Table 3 shows that all rates of the tested materials significantly ($p \leq 0.05$ and / or 0.01) increased all plant growth parameters with few exceptions as compared to unamended plants. Statistically significant differences in all plant growth parameters were observed between and within treatments. Also, the values of these criteria increased gradually with an increasing dose of the tested organic additives combined with urea. Clearly, the greatest increase in most plant growth parameters and TSS % was caused at application of three rates of cattle manure, followed by chicken manure and sheep manure as compared with control (Table 3). There were positive significant correlations ($p \leq 0.05$) between the increase in length and fresh weight of either shoot or root, TSS and doses of all the organic substances (r = 0.92105, 0.89655 and 0.93203 for shoot length), (r = 0.97724, 0.99624 and 0.98408 for shoot fresh weight), (r = 0.94805, 0.98065 and 0.97478 for root length), (r = 0.94503, 0.99848 and 0.97367 for root fresh weight) and (r = 1.0, 0.96153 and 0.90323 for TSS).

Discussion

The antagonistic action of the tested animal manures combined with urea against *M. arenaria* infested sugar beet caused remarkable reduction in the nematode development stages in both soil and roots and their reproduction and consequently all substances showed improvement in all plant growth parameters and TSS % as compared to unamended plants. These findings agreed with the results of Alam *et al.*, (1979); Ismail *et al.*, (1996) and Farahat *et al.*, (2010).They reported that the efficacy of organic manures against phytonematodes may be due to stimulation of specific microorganisms that are capable of parasitizing eggs or other developmental stages of plant parasitic nematodes. Also, amendments may accelerate proliferation of the microbial forms that are capable of synthesizing and producing substance (s) toxic to nematodes.

In the present study, the chicken manure combined with urea gave best results in controlling *M. arenaria* followed by sheep manure and cattle manure combined with urea. The efficient role of chicken manure amendments as a nematicide has been previously documented in literature (Badra *et al.*, 1979; Mian & Rodriguez-Kabana, 1982; Al-Rehyani *et al.*, 2001; Farahat *et al.*, 2010). Nematode toxicity resulting from the production of ammonia freed from decomposition of the urea probably contributes to the suppression of nematode population levels (Rodriguez-Kabana, 1986; Brown, 1987; Hammad *et al.*, 1994; Farahat *et al.*, 2010).

Table 2. Numbers of *Meloidogyne arenaria* galls, egg-masses and gall index (GI %) per root system of sugar beet as influenced by different treatments under field conditions.

Treatments / Fadden	No. of J_2	No. of females	No. of galls	No. of egg-masses	GI%
Cattle manure					
2 tons	--	200	209	160	79.7
		(15.4)	(17.4)*	(23.8)	
4 tons	--	163	174	143	68.5
		(30.9)	(31.2)	(31.9)	
6 tons	--	93	100	80	38.9
		(60.6)	(60.5)	(61.9)	
Correlation Coefficient (r)		0.983	0.979	0.948	0.96
Sheep manure					
2 tons	--	108	108	76	39.7
		(57.3)	(57.3)	(63.8)	
4 tons	--	77	77	51	27.7
		(69.6)	(69.6)	(75.7)	
6 tons	--	71	71	37	23.3
		(71.9)	(71.9)	(82.4)	
Correlation Coefficient (r)		0.946	0.929	0.986	0.97
Chicken manure					
2 tons		87	87	59	30.2
	--	(65.6)	(65.6)	(71.9)	
4 tons	--	81	81	53	30.2
		(68.0)	(68.0)	(74.8)	
6 tons		45	45	38	17.9
	--	(82.2)	(82.2)	(81.9)	
Correlation Coefficient (r)		0.908	0.924	0.970	0.87
Control	698	236	253	210	100
LSD 5%	--	8.6	35.4	12.3	--
LSD 1%	--	11.6	47.3	16.5	--

Each value is the mean of five replicates; * Figures indicate percentage nematode reduction over control; GI%= Total number of galls and egg-masses on the root system / their corresponding number in the control.

Table 3. Effect of some animal manures combined with urea on growth and productivity of sugar beet.

Treatments / Fadden	Shoot system		Root system		TSS %
	Length (cm)	Fresh wt (g)	Length (cm)	Fresh wt (g)	
Cattle manure					
2 tons	29.6 (22.3)*	324 (62.0)	6.6 (3.1)	682 (4.0)	15.1 (24.8)
4 tons	35.6 (47.1)	624 (212.0)	38.2 (40.1)	1720 (162.2)	15.7 (29.8)
6 tons	36.6 (51.2)	760 (280.0)	41.2 (59.7)	1980 (201.8)	16.2 (33.8)
Correlation Coefficient(r)	0.921	0.977	0.948	0.945	1.0
Sheep manure					
2 tons	26.6 (9.9)	218 (9.0)	34.4 (25.0)	820 (25.0)	12.6 (4.1)
4 tons	26.8 (10.7)	280 (40.0)	39.6 (53.5)	1116 (70.1)	13.8 (14.1)
6 tons	29.2 (20.7)	364 (82.0)	42.0 (62.8)	1480 (125.0)	17.6 (45.5)
Correlation Coefficient(r)	0.896	0.996	0.980	0.998	0.961
Chicken manure					
2 tons	26.2 (8.3)	212 (6.0)	29.8 (15.5)	670 (2.1)	16.5 (36.4)
4 tons	30.2 (24.8)	282 (41.0)	34.0 (31.8)	1048 (59.8)	16.6 (37.2)
6 tons	31.0 (28.1)	416 (108.0)	35.6 (27.5)	1208 (84.2)	17.9 (47.9)
Correlation Coefficient(r)	0.932	0.984	0.974	0.973	0.903
Control	24.6	200	25.8	656	12.1
LSD 5%	4.5	102.9	3.8	313.3	----
LSD 1%	6.1	137.6	5.1	419.1	----

Each value is the mean of five replicates; * Figures indicate percentage plant increase over control.

The action of organic amendments on phytonematodes may be due to the release of volatile organic acids and the ammoniacal nitrogen during microbial decomposition of the organic materials in soil (Badra & Shafiee, 1979; Mian & Rodriguez-Kabana, 1982). As a result of microbial activity, the pH value increases, stimulating processes of nitrification and production of nitrates which then convert into ammonia and nitrites. Such compounds are toxic to nematodes; and also become toxic to plants at high levels of accumulation. On the other hand, Rodriguez-Kabana (1986) reported that the action of effective organic amendments against plant parasitic nematodes may be due to the stimulation and selection of microflora capable of decomposing specific proteins or other materials that make up cuticle or structures of the nematodes.

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