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INFLUENCE OF BIOGAS MANURE ON ROOT-KNOT NEMATODES AND GROWTH OF TOMATO

A.N. ESTEFANOUS[1], M.A. KHALIL[2] AND F.W. RIAD[2]

1 Soils, Water and Environment Research Institute. Arc, Giza, Egypt.
2 Plant Pathology Research Institute, Agricultual, Research Center,Giza, Egypt.

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Abstract

The influence of biogas manure produced from anaerobic digestion of fresh cattle dung on the recovery of root-knot disease and vegetative growth of tomato plants was investigated. The digested slurry (biogas slurry) was used directly or after being air dried (biogas manure). Dried biogas manure was incorporated into the soil 3 weeks before transplantation at the rate of 120 mg N kg-1 soil, while biogas slurry was added in two equal portions, 60 N kg-1 soil, at transplantation time and one month later.

The two types of biogas manures induce significant increase in the growth of tomato plants when compared with non-manured one. The highest NPK uptake was shown in the healthy manured plants. Biogas slurry have the most stimulative effect on the microbial counts and enrichment of the soil with ammonia than dried biogas manure.

Both types of biogas manures were effective in decreasing the number of galls induced by *Meloidogyne javanica*. However, biogas slurry was more effective, in reducing disease and in improving the chemical and biological properties of the soil, than dried biogas manure. This was attributed to the high content of biogas slurry of both easily decomposable organic matter and available nutrients.

Key words: Biogas manure, Root-knot nematode, Tomato plants.

INTRODUCTION

The important and beneficial effects of organic manures on soil fertility and plant growth have been recognized by many researchers (Luo and Sun, 1994 Lulakis and Petsas, 1995; Estefanous *et al.*, 1997). In recent years, considerable progress has been made in the utilization of waste materials as soil amendments for nematode control (Hoitink and Fahy, 1986; Akhtar and Alam, 1993; Reddy *et al.* 1995). Poultry manure has given significant reduction of *Meloidogyne incognita* populations on jute (Bora and Phukan, 1983) and tomato (Chindo and Khan, 1986) and also of other nematodes (Derrico and Maio, 1980). In one study, Johnson *et al.* (1967) demonstrated that, when mature dried residues of lespodeza, alfalfa, oats and flax were incorporated into field soil infested with *M.incognita*, the incidence of root knot of tomato (*Lycopersicon esculentum*) was significantly suppressed. A 10 ton/acre dose was more effective than a 5 ton/acre dose.

Increased microbial activity in the soil amended with organic manures causes enhanced enzymatic activities (Rodriguez-Kabana *et al.*, 1983 and 1987) and accumulation of decomposition end-products and microbial metabolites, which are deleterious to plant-parasitic nematodes (Mankau and Minteer, 1962). Organic additives also release nutrients that accelerate rapid root development and overall plant growth and thus help the plants to escape nematode attack.

Fermentation of organic residues under anaerobic conditions can provide farmers with native source of energy, namely "Biogas". The digested materials present a good source of organic manure rich in water soluble major and minor plant nutrients (Idnani and Varadarajan, 1974; Abdel-Aziz *et al.* 1982; Zohdy *et al.*, 1984; El-Shinnawi *et al.*, 1990; Balasubramanian and Kasturi Bai, 1992). There is not much information on the use of anaerobically digested cattle dung (i.e. after biogas production) in nematode control. In the present investigation, anaerobically digested cattle dung from a 28 m^3 biogas plant, located at Biogas Training Center at Moshtohor, Egypt, was used fresh or after being air dried, to study its effect on root-knot nematode and growth of tomatoes.

MATERIALS AND METHODS

Pot studies were conducted in 3 kg earthenware pots in the greenhouse at the Agricultural Research Center at Giza, Egypt for 3 months. The soil used was sandy, from cultivated area near Ismailia and had the following properties: organic carbon, 0.240%, total nitrogen, 0.026%, total phosphorus, 0.034%, W.H.C., 25.0%, pH, 8.12 and E.C. 0.72 dSm^{-1}. The soil was passed through a 2 mm sieve and sterilized, in the autoclave at 15 lb. /square inch for 2hrs. before use. The experiment was a completely randomized factorial with three replicates for each treatment. The soil treatments were 1- control, 2-air dried biogas manure and 3- biogas slurry. Each of the three treatments was applied to soil either infested with nematode or remained without infestation.

All pots received ammonium sulphate (20.5% N), calcium superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) at the rate of 0.45, 0.60 and 0.30g pot^{-1}, respectively. Dried biogas manure was incorporated into the soil 3 weeks before transplantation at the rate of 120 mg N kg^{-1} soil, while biogas slurry was added in two equal portions, 60 mg N kg^{-1} soil, while biogas slurry was added in two equal portions, 60 mg N kg^{-1} soil, at transplantation time and one month later. Table (1) shows the chemical analysis of biogas manures.

Table 1. Chemical analysis of biogas slurry and air dried biogas manure used in this study.

Parameters		Biogas slurry	Dried biogas manure
Total solids	%	8.300	77.820
Organic matter	%	4.550	42.660
Organic carbon	%	2.640	24.740
Total nitrogen	%	0.130	1.210
Ammoniacal nitrogen	ppm	642.000	166.000
Nitrate nitrogen	ppm	12.000	38.000
Total phosphorus	%	0.042	0.360
Available phosphorus	ppm	350.000	220.000
Total potassium	%	0.051	0.450
Available potassium	ppm	430.000	262.000
C/N ratio		20.310	20.450
pH		7,860	7.680

In each pot, 4 tomato seedlings (Super Marmand, 4 weeks old) were planted. One week later, they were thinned to 2 apparently healthy plants per pot. *Meloidogyne javanica* stock culture maintained on tomato was provided by Plant Pathology Research Institute, Agricultural Research Center. 1500 newly hatched nematode larvae from hand-picked egg-masses were used for inoculation, one week after thinning, by pouring the suspension into holes made around the base of the plant. Moisture content of the potted soil was kept throughout at 60% of the water-holding capacity.

Soil samples for mineral nitrogen estimation and microbial counts were taken at 0, 1, 2 and 3 months, while samples for nematode infection were taken at the end of the experiment. Tomato plants, 3 months old, were dried at 75°C and subjected to determinations of dry weight of roots and shoots, thereafter the shoots were ground for determing total N, P and K (Jackson, 1967).

Ammoniacal and nitrate nitrogen in the soil sample were determined as described by Page *et al.* (1982). The soil extract agar medium and Jansen's medium (Allen, 1953), were used for counting viable bacteria and Actinomycetes, respectively, while the fungal count was determined using rose bengal streptomycin agar medium as described by Martin (1950).

Results were statistically analyzed by the least significant difference (LSD) according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

It is clear from the data presented in Table (2) that growth of tomato plants responded positively to biogas manures additives. Plant growth in soil treated with biogas slurry revealed the highest increases in plants height, dry weight of roots and shoots and NPK contents followed by those grown in soil treated with air dried manure compared to those in non amended soil. The stimulating influence of biogas manures amendments on tomatoes vigor might be attributed to improving the microbial activities in soil and this probably improves the availability of the nutrients (Goyal *et al.*, 1992; Hannaa, 1994; Estefanous *et al.*, 1997).

Application of biogas manures was also effective in increasing the vegetative growth of the nematode infected plants. Data in Table (2) showed highly significant difference, in plant height and dry weight of root and shoots, between manured plant and those non-manured. It is also evident from data presented in Table (2) that gall formation cuased by *M.javanica* on roots of tomato affected plant height. This trend was clear when comparing the height of infected and non infected plants. This indicates that gall formation by nematode decreased the vegetative growth of the plant. On the other hand, the variation in the height was reflected on dry weight of shoots which showed significant differences between healthy and diseased plants.

With respect to NPK, it seems that the lowest NPK uptake was observed in diseased plants compared with healthy ones. This was attributed to the negative effect of the disease on plant uptake. On the other hand, the highest NPK uptake was in biogas slurry manured treatments. This is because of the richness of this manure with nutrients in available forms (El-Shinnawi *et al.*, 1990). Similar beneficial effects of the organic manure on plant growth have been described by Tarjan (1977) who observed that, when municipal solid waste compost was added to soil, citrus plant weight improved. These plants were infected with *Tylenchulus semipenetrans* or *Pratylenchus coffeae*.

Table 2. Plant height, dry weight of roots and shoots and NPK contents of tomato plants as influenced by addition of biogas manure and infected with root-knot nematodes.

Treatments		Plant height (cm)	Dry Weight (gm) root	Dry Weight (gm) shoot	mg N	mg P	mg K
Control	+ Nem	22.40	0.63	1.36	22.20	12.25	26.35
	-Nem	28.67	0.78	2.50	55.11	28.29	40.32
	Mean	25.54	0.71	1.93	38.66	20.27	33.34
Dried biogas	+ Nem	27.53	1.80	5.79	67.84	47.91	120.22
manure	-Nem	31.03	1.97	7.17	129.09	70.62	135.11
	Mean	29.28	1.89	6.48	98.47	59.27	127.67
Biogas slurry	+ Nem	30.73	2.04	7.11	116.05	50.60	138.28
	-Nem	37.23	2.86	8.31	147.74	81.28	156.03
	Mean	33.98	2.45	7.71	131.9	65.94	147.16
L.S.D 1%							
Infection (I)		9.94	NS	1.15	25.54	9.95	19.08
Manure (M)		6.05	0.61	1.40	31.28	12.19	23.37
I+M		8.55	0.86	1.99	44.24	17.24	19.08
L.S.D 5%							
Infection (I)		3.52	NS	0.82	18.22	7.10	13.61
Manure (M)		4.31	0.61	1.00	22.32	8.70	16.67
I+M		6.10	0.86	1.42	31.56	12.30	23.58

+ Nem = Infected with nematodes.
- Nem = Non-infected with nematodes

Determinations of root-knot galls, egg-masses, the number of eggs per egg-mass and the number of *M.javanica* larvae per 250 g soil, (Table 3) indicated that the highest infection was in the control treatment (non manured). This suggests that manured root had a negative effect on the development of *M.javanica* on roots of tomato. This might be a reflection of the effect of the organic additives on nutrients release that accelerate rapid root development and overall plant growth and thus help the plants escape nematode attack. On the other hand, biogas slurry was also more effective in reducing the disease than did air-dried biogas manure. This also might be due to the richness of biogas slurry with easily decomposable organic materials and nutrient in available form (Zohdy *et al.*, 1984; El-Shinnawi. 1990). In this respect, many researchers reported the utilization of waste materials as soil amendments for nematode control (Alam, 1990; Reddy *et al.*, 1995).

Table 3. Development and repoduction of root-knot nematode (*M.javanica*) on infected tomato plants fertilized with biogas manure.

Treatments*	No. of galls/plant	No. of egg-masses per plant	No. of eggs per egg-mass	No. of larva 250 g soil
Control	116.0	49.0	280.0	200.0
Dried biogas manure	47.0	21.0	53.0	73.0
Biogas slurry	29.0	19.0	47.0	40.0

* No values recorded for the non infected treatments.

The addition of biogas manures to the soil increased its ammoniacal nitrogen in the first period of the experiment (Fig. 2). The high increase observed at the time of application of biogas slurry is due to the high content of this manure in ammoniacal nitrogen (Table 1). This is in accordance with Idnani and Varadarajan (1974) and Zohdy *et al.* (1984). The recoveries of nitrate nitrogen, (Fig. 2), were in parallel with the rate of disappearance of ammonia. The high effect of biogas slurry in reducing root-knot nematode disease may be attributed to the harmful effect of ammonia on *M.javanica*. Heald and Burton (1968) noted that organic nitrogen in the form of activated sewage sludge was more effective than ammonium nitrate in reducing the population of *Belonolaimus longicaudatus* in turf grass.

Addition of biogas manures to the sandy soil clearly increased the densities of microbial counts (Fig. 1). This increase appeared in infested and non infested soils.

However, the biogas slurry increased the microbial population more than did the dried biogas manure. The stimulating effect of organic manuring on the count of micro organisms, experieneed in this investigation, was clearly noted by Filip and Muller (1984) El-Huseiny *et al.* (1986), Luo and Sun (1994) and Estefanous *et al.* (1997) who reported that this enhancement might be due to the introduction of a large amount of living microorganisms and readily-utilizable carbon sources. In this concern, Rodriguez-Kabana *et al.* (1983) reported that the increase of microbial activity in soil amended with organic matter causes enhanced enzymatic activities and accumulation of decomposition end-products and microbial metabolites, which are deleterious to plant-parasitic nematodes (Mankau and Minteer, 1962).

It can be concluded that biogas manures improve the nutritional status, which was reflected in vegetative growth and reduced the susceptibility of tomato roots to roo-knot nematode. This may also be due to the improving of chemical and biological properties of the sandy soil (El-Huseiny *et al.*, 1986; Estefanous *et al.*, 1997). Biogas slurry proved to be a better organic manure as compared with air dried biogas manure from the standpoint of reducing root-knot disease and improving the chemical and biological properties of the sandy soil. This may be due to the high content of biogas slurry of both easily decomposable organic matter and available nutrients (Zohdy *et al.*, 1984; El-Shinnawi *et al.*, 1990).

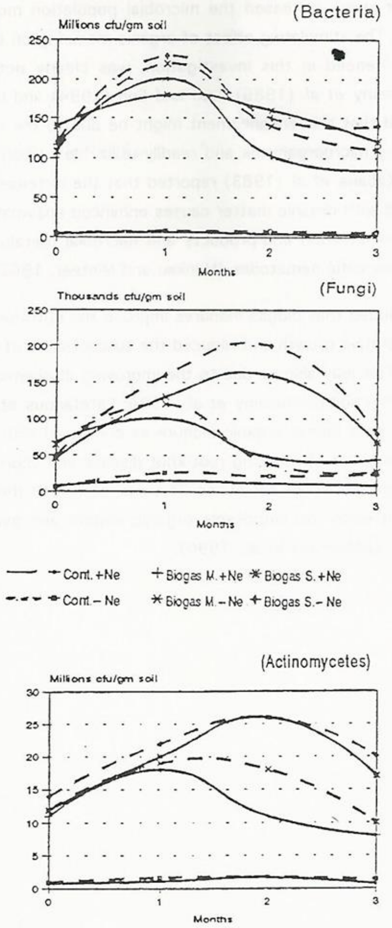

Fig. 1. Viable bacterial counts, Actionmycetes and fungi in the sandy soil amended with dried biogas manure (biogas M.) and biogas slurry (Biogas S.) - Ne non infected with nematodes + Ne Infected.

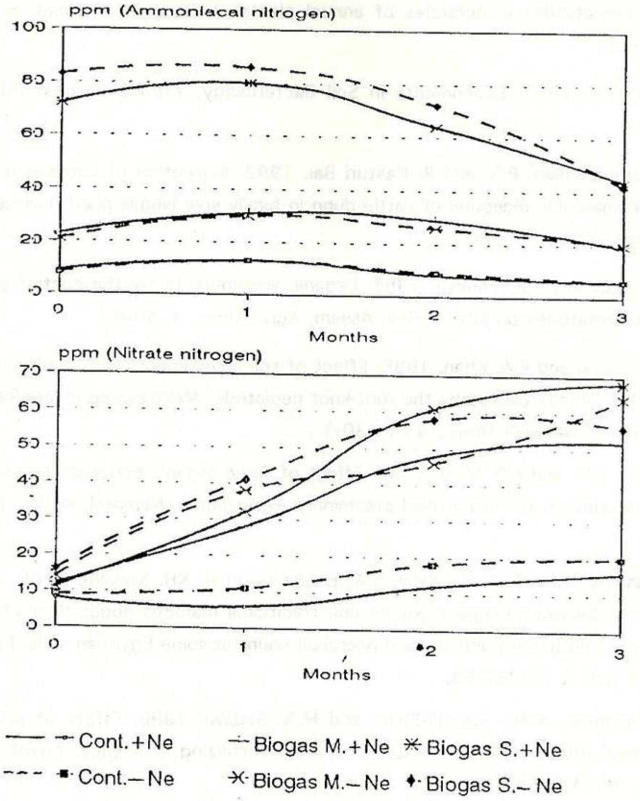

Fig. 2. Ammoniacal and nitrate nitrogen in the sandy soil amended with dried biogas manure (biogas M.) and biogas slurry (Biogas S.) - Ne non infected with nematodes + Ne Infected.

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تأثير سماد البيوجاز على نيماتودا تعقد الجذور ونمو نبات الطماطم

عزمى نصحى اسطفانوس١ ، محمد عبد المنعم خليل٢، فاروق وهبه رياض٢

١ معهد بحوث الأراضى والمياه والبيئه .
٢ معهد بحوث امراض النبات - مركز البحوث الزراعية - مصر.

درس تأثير سماد البيوجاز الناتج من التخمير اللاهوائى لروث الماشية على تقليل حدوث مرض نيماتودا تعقد الجذور على النمو الخضرى لنبات الطماطم. وقد استخدم سماد البيوجاز السائل الناتج من وحدة التخمير مباشرة أو بعد تجفيفه هوائيا. أضيف سماد البيوجاز الجاف قبل الشتل بثلاثة أسابيع بمعدل ١٢٠ مجم ن لكل كجم تربة. أما السماد السائل فأضيف على دفعتين - عند الشتل وبعد الشتل بشهر وبمعدل ٦٠ مجم ن لكل كجم تربة لكل دفعة.

أظهرت النتائج أن هناك زيادة فى النمو الخضرى وفى كل من النيتروجين والفوسفور والبوتاسيوم الممتص فى النباتات المسمدة بسماد البيوجاز السائل أو الجاف عن تلك الغير مسمدة. وكذلك أدى التسميد بأى من نوعى السماد إلى تقليل اعداد العقد المتكونة على جذور نبات الطماطم بفعل نيماتودا *M. javanica* وكذلك اعداد اليرقات المنطلقة فى التربة. وكان سماد البيوجاز السائل اكثر تاثيرا عن سماد البيوجاز الجاف فى تقليل المرض وتحسين الخواص البيولوجية والكيماوية للتربة الرملية المستخدمة حيث تفوق السماد السائل على السماد الجاف فى زيادة اعداد الميكروبات فى التربة وكذلك امداد التربة بالامونيا والنترات وعزى ذلك الى احتواء السماد السائل على مواد عضوية سهلة التحلل وكذلك العناصر الغذائية فى صورة ميسرة اكثر من تلك الموجودة فى السماد الجاف.