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POTENTIALS OF AQUACULTURE EFFLUENTS ON NEMATODE MANAGEMENT: 1- EFFECT OF TILAPIA EFFLUENTS ON TWO NEMATODE SPECIES AND COWPEA GROWTH

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ABSTRACT

This study was conducted to investigate the effect of tilapia effluents on infectivity, development and reproduction of *M. incognita* and *R. reniformis* on five strains of cowpea and its impact on plant growth under greenhouse conditions. Unfertilized tilapia pond with complete diet (T4) was the best treatment which significantly reduced all *M. incognita* criteria (no. of galls, embedded stages, egg masses, build up and eggs/eggmass) on cowpea strains 1, 2 & 4. Biofloc tanks (T5) was significantly efficient on cowpea strain 3. Low organic fertilized tilapia pond (T2) reduced nematode criteria on strain 5 without significant differences in build up when compared with high inorganic fertilized tilapia pond (T1) & high organic fertilized tilapia pond (T3). On the other hand, T4 significantly reduced build up of *R. reniformis* on cowpea strains 1 & 4. T5 significantly decreased reniform nematode reproduction on strains 2 & 3. However, all treatments failed to reduce nematode criteria on strain 5. In general, all treatments ameliorated cowpea growth parameters and improved plant content of NPK except on strains 1 and 5. Integrating aquaculture-agriculture system (IAA) has an additional benefit which makes the fish waste and algae productions have the potential to decrease the nematode populations and improve plant growth.

Key words: cowpea, irrigation, *M. incognita*, *R. reniformis*, tilapia effluents.

INTRODUCTION

Nematicides have been used to control nematode pests with remarkable results. However, they bring about the problems of high costs and availability, particularly to rural poor farmers and environmental hazards for attendants (Hassan *et al*., 2010). Researchers turned their view to look for alternative measures those are cheaper, readily available and sustainable with minimal negative effects on the environment. The basis of sustainable nematode control is the maintenance of a healthy soil food-web. This begins with routine application of organic matter. Many of the soil amendments used as nutrient sources for crop production have been found to control plant parasitic nematodes with an increase in crop yield and growth (Al-Sayed *et al*., 2007; Mahfoud, 2011).

In many areas, integrating aquaculture with agriculture has become a channel for increasing the use of limited water resources, decreasing dependence on chemical fertilizers, providing a greater economic return per unit of water and/or sustainability (Prein, 2002 and McIntosh and Fitzsimmons, 2003).

Egypt like other tropical and subtropical areas are suffering from availability of water resources necessary for agricultural production. So, reuse of aquaculture effluents in irrigation become of great benefit that is fish waste and algae production have the potential either to decrease the nematode populations and/or improve plant growth. However, no systematic studies have been conducted so far to determine the potential action of aquaculture effluents that may result from practice integrating aquaculture-agriculture system (IAA).

Cowpea is an important food legume and essential component of cropping systems in the drier regions of the tropics and subtropics (Singh *et al*., 2003). Several species of nematodes are known to cause losses to cowpea throughout the world. The root-knot nematodes, *Meloidogyne* spp. and reniform nematode, *Rotylenchulus reniformis* are documented to cause major losses to cowpea (Adegbite *et al*., 2005; Marwoto, 2010 and Farahat *et al*, 2012a).

Aquaculture of Tilapia (*T. nilotica*) are distributed nationwide in Egypt to produce such preferable fish for Egyptian in large scale. The effluents of such aquaculture are considered wastes.

The objective of this study was to determine the effect of different tilapia effluents on the reproduction of *Meloidogyne incognita* and *Rotylenchulus reniformis*, the major nematode parasites in cowpea fields in Egypt, and its impact on cowpea growth.

MATERIALS AND METHODS

Nematodes preparation: Five imported strains of cowpea, *Vigna unguiculata* subsp. *sesquipedalis* seedlings with uniform size (Table 1), were transplanted into 15 cm diameter clay pots filled with sandy soil. Two weeks later, seedlings were inoculated with 1500 infective stages/plant of either *M. incognita* or *R. reniformis* at the same time. Inocula of *M. incognita* or *R. reniformis* were obtained from isolates propagated in pure cultures on sunflower (*Helianthus annus*) and pigeon pea (*Cajanus indicus*), respectively at Nematology Division, Faculty of Agriculture, Cairo University.

Preparation of tested effluents and greenhouse experiment: One week after inoculation, the seedlings were divided into 6 groups (each group contained 5 strains with 6 replicates for each one) and irrigated daily with 250 ml of tilapia effluents. A static outdoor system consisted of 12 rectangular concrete tanks (2.2×1.2×1.0m) were filled with freshwater obtained from a well and used as rearing units to generate four different effluents (treatments from T1 to T4). T1, effluent water was obtained from inorganic fertilizer tilapia pond containing ammonium nitrate (33%N) and super phosphate (8%P) at dose level of 1.65 g/m^3 of nitrogen and 0.38 g/m^3 of phosphorus. T2 and T3, effluent water were obtained from organic fertilizer tilapia pond (amended with chicken manure at low and high doses of 7 and 28 g dry matter/m^3/week, respectively). All fertilizer treatments received supplementary diet (18% crude protein) at a fixed rate of 10.3 g diet/ tank/ day for six days/week. T4, effluent water was obtained from unfertilized tilapia pond provided commercial diet (30% crude protein) as fish feed administrated to satiation for six day/week. Nile tilapia juveniles were randomly distributed among the experimental tanks and stocked at a rate of 6 juveniles (50.2-54.8 g/fish) per tank.

T5, effluent water was obtained from biofloc tanks (biofloc is a technology system engineered based on an enhancement of heterotrophic bacterial growth to assimilate nitrogen and incorporate it into new cellular proteins (Avnimelech, 1999). Microbial flocs were generated from the tilapia effluent in three 1000L fiber-glass tanks. The tanks were stocked with 300 Nile tilapia fry (2.5 -3 g). All biofloc tanks were maintained without water exchanges throughout 45 days. Three diffusive stone aerators were placed in each tank to maintain the dissolved oxygen at greater than 5 mg/L and well-mixed condition. Biofloc tanks were provided daily with the tilapia feeds and molasses (C-source) at C/N ratio 16:1. Thus, the actual amount of molasses varied according to the quantity of tilapia feed added into the tanks. T6 was provided with well water and served as a check.

Pots were arranged in a randomized design in a greenhouse. 45 days from inoculation, plants were harvested and data on plant growth was recorded. The nematode populations were extracted from soil by means of sieving technique (Hooper *et al*., 2005) and counted with the aid of a stereoscopic microscope and a Hawksley counting slide. The stages on or in the roots (developmental stages, females, egg masses, eggs/egg mass) and the root-knot galls were counted.

Water analysis: Chemical analysis, zooplankton and phytoplankton groups of fish effluents were detected and listed in tables 2 & 3. Water temperature, dissolved oxygen and pH from each tank were measured daily at 6 a.m. and 12 p.m. using thermometer, dissolved oxygen meter and pH meter, respectively. Determinations of the other water quality parameters (alkalinity and ammonia) were carried out biweekly the experimental period according to the methods of Boyd (1979). Phytoplankton and zooplankton communities in pond water were determined every 15 days according to the methods described by Boyd (1990) and A.P.H.A. (1985). Samples were randomly collected from different sites of the experimental tanks to represent water of the whole pond.

Plant analysis: Sub-samples (each 1 g) of the dry whole plant from each treatment were analyzed for N, P and K contents by standard methods of the Association of Official Analytical Chemists (Anon., 1990).

Statistical analysis: Significance of differences between mean values was determined by analysis of variance (ANOVA) at the 5% level of probability using MSTAT version 4 (1987).

RESULTS

Water quality parameters: As shown in table 2 most of water quality parameters were affected by fertilizer type and biofloc system. Water temperature ranged from 26.5 to 29.0 ºC through the experimental period with an average of 27.5 ºC; dissolved oxygen ranged from 5.4 to 7.71 mg/L; Secchi disk visibility from 25 to 40 cm; pH from 7.7 to 8.5, total alkalinity from 295 to 355 mg/L and TAN ($NH_{3/4}$-N) from 0.76 to 1.93 mg/L. All tanks were within acceptable range of water quality parameters under integrated agriculture aquaculture. The biofloc system had the highest total phosphorus concentration (19.5 mg/L) and orthophosphate (9.4 mg/L) compared with those of the fertilized treatments ranging from 0.18 to 0.51 and from 0.08 to 0.26, respectively. The organic fertilizers treatments had the lowest ($p<0.05$) TAN concentration. Total alkalinity concentrations were significantly lower in ponds treated with chemical fertilizer than those treated with organic fertilizers.

As shown in table 3 the phytoplankton average counted for T1 , T2 , T3, T4 and T5 treatments were

16665769, 15389810, 24475770, 25262419 and 29123077 organisms/l, respectively. Blue green algae were, however, the dominant group in all treatments. Total chlorophyll "a" concentrations were lower in pond treated with organic fertilizer (1213 mg/L) than those of other treatments (from 22 to 1154 mg/L). The average numbers of zooplankton organisms per liter were higher in water samples of T5 than those of other treatments. Rotifers were the most dominating zooplankton group in all treatments. In general, the community composition of phytoplankton and zooplankton in all treatment ponds fluctuated greatly according to temperature, fertilization and feeding habits of fish.

Nematode behavior on cowpea strains under stress of tilapia effluents: In general, the tested five strains of cowpea supported successfully the development and reproduction of *M. incognita* and *R. reniformis* with significant differences in their susceptibility (Tables 4 & 5). Strains 3 & 4 were the most favorable, followed by strains 1 & 2; while strain 5 was the least one to both nematode species as measured by numbers of galls, embedded stages, final population, rates of build up and egg deposition. Also, it's interesting to notice that cowpea strains, to some extent, were in favor to *R. reniformis* reproduction than *M. incognita* All water sources significantly reduced the root-knot nematode criteria (number of galls, the embedded stages, final population and rate of build up) on the infected roots of strains 1 & 2 as compared with the T6 (check) except the numbers of eggs/egg mass. T4 was significantly efficient than the other treatments. Similar results were observed with the reniform nematode criteria (embedded stages, final population and the rate of nematode build up as well as the number of eggs/egg mass) but T5 increased the rate of build up. T4 significantly achieved the best results in suppressing the root-knot and reniform nematodes reproduction and causing nematode reduction by 18 & 32% on strain 1, respectively.

Table-1 Cowpea strains.

Strain	Planted	Inventory	Accession	Country
1	OLLUKARA VIII	PI 352968 01	SD PI 352968	India
2	TSI CHIAN 7513	PI 419164 01	SD PI 419164	China
3	ECO CARPOLE 1	PI 487489 01	SD PI 487489	Philippines
4	GUILIN LONG BEANS	PI 512286 02	SD PI 512286	China
5	LOS BANOS BUSH SITAO	PI 582429 01	SD PI 582429	Trinidad and Tobago

Table-2 Average of water quality parameters of tilapia effluents during the experimental period.

Water quality parameters	Effluent water treatments					
	T1	T2	T3	T4	T5	T6
Water temperature (ºC)	26.8± 2.47	26.6± 2.75	27.4± 2.24	28.7± 0.7	29± 3.1	26.5± 0.2
Dissolved oxygen (mg/l)	6.50± 1.45	7.71± 2.37	6.03± 1.01	5.5± 1.03	5.4± 1.5	2.8± 0.02
Total alkalinity ($mgCaCO_3/l$)	294.2± 36.1	321.5± 40.2	355.5± 91.9	295.23± 27.81±	297± 24.5	110± 3.41
pH	8.22± 0.26	8.55± 0.33	8.53± 0.57	7.91± 0.59	7.7± 0.23	8.8± 0.25
Total ammonia (mg-N/l)	1.95± 0.17	0.76± 0.15	1.43± 0.13	1.55± 0.16	1.93± 0.2	Nd
Total phosphorus (mg p/l)	0.227± 0.09	0.214± 0.05	0.513± 0.02	0.18± 0.01	33.5± 3.3	Nd
Orthophosphate (mg p/l)	0.089± 0.01	0.077± 0.012	0.256± 0.05	0.09± 0.01	16.4± 1.9	Nd
Secchi disc visibility (cm)	26.0± 9.1	39.5± 18.3	28.95± 7.1	25.21± 7.22	40.01± 13.2	100± 0

T1= effluent water from inorganic fertilizer tilapia pond, T2= effluent water from low organic fertilizer tilapia pond, T3= effluent water from high organic fertilizer tilapia pond, T4= effluent water from unfertilized with complete diet tilapia pond, T5= effluent water from biofloc tanks, T6= well water (check). ± standard error.

Table-3 Phytoplankton and zooplankton groups in different tilapia effluents used.

Water microorganisms	Effluent water treatments				
	T1	T2	T3	T4	T5
Phytoplankton					
BLUE GREEN					
Anabana sp.	252115	608462	553846	73846	1620000
Chrooccus sp.	-	-	-	-	180000
Merismo sp.	-	249231	2012308	-	6978462
Nostoc sp.	-	-	-	41538	-
Spirulina sp.	39231	76154	143077	-	-
Microcystis sp.	10798077	8910577	15615385	22586651	13500000
Total Blue Green Algae (org/l)	**11089423**	**9844424**	**18324616**	**22702035**	**22278462**
GREEN					
Ankistradesmus sp.	127500	115385	45000	-	747692
Chllorela sp.	183077	186923	-	-	747692
Coilastrium sp.	152308	-	-	41538	-
Pandorina sp.	3572308	3569231	4984615	1144615	4984615
Volvox sp.	50769	-	-	73846	-
Pediastrum sp.	468462	186923	957693	-	-
Sendesmus sp.	480000	761539	36923	249231	-
Tetrodion sp.	66923	664616	-	996923	240000
Total Green Algae (org/l)	**5101347**	**5484617**	**6024231**	**2506153**	**6719999**
Ditomus					
Novicula sp.	78077	60769	66923	54231	62308
Nitzschia sp.	143077	-	60000	-	-
Synedra sp.	71538	-	-	-	-
Cymbella sp.	50769	-	-	-	-
Total Ditomus (org/l)	**343461**	**60769**	**126923**	**54231**	**62308**
Euglina					
Euglina sp.	71538	-	-	-	-
Phacus sp.	60000	-	-	-	62308
Total Euglina (org/l)	**131538**	**0**	**0**	**0**	**62308**
Total Algae (org/l)	**16665769**	**15389810**	**24475770**	**25262419**	**29123077**
Chlorophyll "a" conc. (µg/l)	**1213.18**	**1154**	**741**	**1417**	**22**
Zooplankton					
Rotifers	10519	18901	5203	14544	189604
Cladocerans	219	234	222	264	-
Copepods	705	356	575	306	577
Ostracods	569	447	524	991	1104
Nauplii	401	317	586	497	-
Others	306	330	205	816	206
Total zooplankton (org/l)	**12719**	**20585**	**7315**	**17418**	**191491**

T1= effluent water from inorganic fertilizer tilapia pond, T2= effluent water from low organic fertilizer tilapia pond, T3= effluent water from high organic fertilizer tilapia pond, T4= effluent water from unfertilized with complete diet tilapia pond, T5= effluent water from biofloc tanks, T6= well water (check).

All water sources had moderate effect on strains 3 & 4 especially T1 & T2 which reduced the root-knot nematode criteria (number of galls, the embedded stages, final population and rate of build up) on the infected roots as compared with those of the check. Similar effects were observed on number of eggs/eggmass. T4 and T5 were significantly efficient on strain 4 and 3, respectively than the other treatments. Opposite results were obtained with the reniform nematode criteria (embedded stages, final population and the rate of nematode build up as well as the number of eggs/egg mass); however, other treatments increased nematode reduction (%). It was clear to notice that T4 & T5 increased *M. incognita* reduction (%) on strains 4 & 3 by 48 & 50%, in the same order. But the same sources reduced *R. reniformis* on these strains by 56 & 20%, respectively.

On strain 5, opposite results were obtained in *M. incognita* reductions whereas the water sources (T1 &

T5) significantly increased root galling, the number of embedded stages and final population. No significant differences were observed among T2, T3 & T4 and T6 (check). The negative effect of treatments appeared in *R. reniformis* criteria especially on nematode reduction (%), and the differences in the number of eggs/egg mass were significant between treatments and check.

Plant growth response: T2 gave the best plant growth on cowpea strain 1, followed by T1 (Table 6). However, varying effects were noticed on other cowpea strains due to tested treatments. In general, cowpea strain 1 gave significantly better plant growth (fresh weight) than other strains. Treatment T2 improved fresh weight of strain 1, but it was the best in improving dry weight of strain 5. Finally, the application of these treatments was much beneficial to plant growth when added to sandy soil.

All treatments improved plant content of NPK except those of strains 1 and 5. Strain 2 treated with T1 had higher percentages of N and K than those of other strains and treatments. Almost none of the treatments reduced plant content of P or K, but increases were observed in P content in the majority of treatments.

Table-4 Influence of different aquaculture effluent on the reproduction of *Meloidogyne incognita* on five strains of cowpea.

Cowpea strain	Treatment	Galls	Embedded stages	Egg mass	Final Population	Pf/Pi	%N.R.	Eggs
1	T1	136 ^{q}	204 ^{jkl}	167 ^{no}	2514	1.68 ^{mn}	7	210 ^{fgh}
	T2	264 ^{k}	528 ^{f}	433 ^{hi}	2528	1.69 ^{lmn}	7	180 ^{klmn}
	T3	264 ^{k}	403 ^{g}	330 ^{jk}	2403	1.60 ^{no}	13	198 ^{hij}
	T4	113 ^{r}	218 ^{jkl}	179 ^{mno}	2218	1.48 ^{pq}	18	173 ^{mn}
	T5	73 ^{s}	110 ^{l}	90 ^{o}	2420	1.61 ^{no}	11	210 ^{fgh}
	T6 (check)	374 ^{f}	717 ^{de}	588 ^{def}	2717	1.81 ^{jk}	-	182 ^{klmn}
2	T1	298 ^{i}	574 ^{f}	478 ^{gh}	3264	2.18 ^{e}	7	245 ^{d}
	T2	318 ^{h}	640 ^{ef}	533 ^{efg}	3040	2.03 ^{fg}	13	218 ^{ef}
	T3	211 ^{m}	403 ^{g}	336 ^{j}	2753	1.84 ^{ij}	21	214 ^{fg}
	T4	83 ^{s}	161 ^{kl}	134 ^{no}	2161	1.44 ^{q}	38	182 ^{klmn}
	T5	294 ^{i}	529 ^{f}	441 ^{ghi}	3469	2.31 ^{cd}	1	267 ^{c}
	T6 (check)	337 ^{g}	606 ^{ef}	505 ^{fgh}	3506	2.34 ^{c}	-	264 ^{c}
3	T1	988 ^{a}	1412 ^{a}	1196 ^{a}	3412	2.27 ^{cde}	27	185 ^{jklm}
	T2	638 ^{c}	866 ^{c}	734 ^{c}	2866	1.91 ^{hi}	38	175 ^{mn}
	T3	775 ^{b}	1468 ^{a}	1244 ^{a}	3468	2.31 ^{cd}	26	177 ^{lmn}
	T4	275 ^{j}	413 ^{g}	350 ^{ij}	3113	2.08 ^{f}	33	245 ^{d}
	T5	202 ^{m}	318 ^{ghij}	270 ^{jklm}	2318	1.55 ^{op}	50	199 ^{hi}
	T6 (check)	624 ^{d}	1183 ^{b}	1002 ^{b}	4663	3.11 ^{a}	-	316 ^{b}
4	T1	379 ^{f}	705 ^{de}	608 ^{de}	3365	2.24 ^{de}	25	242 ^{d}
	T2	386 ^{e}	622 ^{ef}	536 ^{efg}	3062	2.04 ^{fg}	32	222 ^{ef}
	T3	254 ^{k}	694 ^{de}	598 ^{def}	2924	1.95 ^{gh}	35	203 ^{ghi}
	T4	156 ^{op}	352 ^{ghi}	303 ^{jkl}	2352	1.57 ^{op}	48	196 ^{ij}
	T5	177 ^{n}	311 ^{ghij}	268 ^{jklm}	2671	1.78 ^{jkl}	40	215 ^{fg}
	T6 (check)	370 ^{f}	774 ^{cd}	667 ^{cd}	4484	2.99 ^{b}	-	337 ^{a}
5	T1	240 ^{l}	365 ^{gh}	320 ^{jk}	2365	1.58 ^{o}	-1	190 ^{ijkl}
	T2	150 ^{p}	263 ^{hijk}	231 ^{klmn}	2263	1.51 ^{opq}	3	192 ^{ijk}
	T3	178 ^{n}	339 ^{ghi}	297 ^{jkl}	2339	1.56 ^{op}	0	170 ^{n}
	T4	161 ^{o}	242 ^{ijk}	212 ^{lmn}	2602	1.73 ^{klm}	-11	215 ^{fg}
	T5	373 ^{f}	541 ^{f}	475 ^{gh}	2541	1.69 ^{lmn}	-8	210 ^{fgh}
	T6 (check)	185 ^{n}	338 ^{ghi}	297 ^{jkl}	2338	1.56 ^{op}	-	230 ^{e}

Means followed by the same letter (s) within a column in each block are not significantly different ($P \leq 0.05$) according to Duncans' multiple range test.

T1= effluent water from inorganic fertilizer tilapia pond, T2= effluent water from low organic fertilizer tilapia pond, T3= effluent water from high organic fertilizer tilapia pond, T4= effluent water from unfertilized with complete diet tilapia pond, T5= effluent water from biofloc tanks, T6= well water (check).

Table-5 Influence of different aquaculture effluent on the reproduction of *Rotylenchulus reniformis* on five strains of cowpea.

Cowpea strain	Treatment	Embedded stages	Final Population	Pf/Pi	%N.R.	Eggs
1	T1	157 ^{u}	2497	1.66 ^{klmno}	25	140 ^{fghij}
	T2	1044 ^{b}	3044	2.03 ^{fghij}	8	120 ^{klmn}
	T3	336 ^{o}	2336	1.56 ^{mno}	30	132 ^{ghijklm}
	T4	257 ^{rst}	2257	1.50 ^{o}	32	115 ^{mn}
	T5	409 ^{m}	3649	2.43 ^{cde}	-10	140 ^{fghij}
	T6 (check)	701 ^{g}	3321	2.21 ^{efg}	-	121 ^{klmn}
2	T1	169 ^{u}	2859	1.91 ^{ghijkl}	0	163 ^{bcd}
	T2	360 ^{n}	2960	1.97 ^{ghijk}	-4	145 ^{efgh}
	T3	789 ^{e}	3839	2.56 ^{cd}	-34	143 ^{fghi}
	T4	507 ^{k}	3227	2.15 ^{efgh}	-13	121 ^{klmn}
	T5	240 ^{t}	2710	1.81 ^{jklmno}	5	178 ^{b}
	T6 (check)	275 ^{pqr}	2855	1.90 ^{ghijkl}	-	176 ^{bc}
3	T1	504 ^{k}	3164	2.11 ^{fghi}	8	123 ^{jklmn}
	T2	638 ^{h}	2878	1.92 ^{ghijk}	16	117 ^{lmn}
	T3	624 ^{h}	2924	1.95 ^{ghijk}	15	118 ^{klmn}
	T4	930 ^{d}	2930	1.95 ^{ghijk}	15	163 ^{bcd}
	T5	753 ^{f}	2753	1.84 ^{hijklmn}	20	133 ^{ghijkl}
	T6 (check)	704 ^{g}	3444	2.30 ^{def}	-	211 ^{a}
4	T1	263 ^{qrs}	2593	1.73 ^{jklmno}	49	161 ^{cde}
	T2	436 ^{l}	2656	1.77 ^{jklmno}	48	148 ^{defg}
	T3	286 ^{p}	3436	2.29 ^{def}	33	135 ^{ghijk}
	T4	280 ^{pq}	2280	1.52 ^{o}	56	131 ^{ghijklm}
	T5	599 ^{i}	2599	1.73 ^{jklmno}	49	143 ^{fghi}
	T6 (check)	2367 ^{a}	5127	3.42 ^{a}	-	225 ^{a}
5	T1	545 ^{j}	4285	2.86 ^{b}	-84	127 ^{ijklmn}
	T2	252 st	3932	2.62 ^{bc}	-69	128 ^{hijklmn}
	T3	397 ^{m}	2397	1.60 ^{lmno}	-3	113 ^{n}
	T4	91 ^{v}	2811	1.87 ^{hijklm}	-21	143 ^{fghi}
	T5	1010 ^{c}	3490	2.33 ^{cdef}	-50	140 ^{fghij}
	T6 (check)	331 ^{o}	2331	1.55 ^{no}	-	153 ^{def}

Means followed by the same letter (s) within a column in each block are not significantly different ($P \leq 0.05$) according to Duncans' multiple range test. T1= effluent water from inorganic fertilizer tilapia pond, T2= effluent water from low organic fertilizer tilapia pond, T3= effluent water from high organic fertilizer tilapia pond, T4= effluent water from unfertilized with complete diet tilapia pond, T5= effluent water from biofloc tanks, T6= well water (check).

$$\% \text{ N.R. (nematode reduction)} = \frac{\text{Final pop. of check} - \text{Final pop. of treatment}}{\text{Final pop of check}} \times 100$$

Table-6 Influence of different aquaculture effluent on plant growth and NPK content of five strains of cowpea infected with two nematode species.

Cowpea strain	Treatment	Plant fresh weight (g)	% change over check	Plant dry weight (g)	% change over check	N	% change over check	P	% change over check	K	% change over check
1	T1	10.8 ^{b}	+36.7	3.2 ^{cde}	0.0	3.1	0.0	1.8	+20.0	1.7	+30.8
	T2	13.3 ^{a}	+68.4	3.8 ^{ab}	+18.8	1.9	-38.7	1.7	+13.3	1.6	+23.1
	T3	9.5 ^{d}	+20.3	2.8 ^{efgh}	-12.5	2.8	-9.7	1.6	+6.7	1.6	+23.1
	T4	7.7 ^{ef}	-2.5	2.7 ^{fghi}	-15.6	2.7	-12.9	1.6	+6.7	1.5	+15.4
	T5	7.8 ^{e}	-1.3	2.4 ^{hijkl}	-25.0	2.4	-22.6	1.8	+20.0	1.4	+7.7
	T6 (check)	7.9 ^{e}	-	3.2 ^{cde}	-	3.1	-	1.5	-	1.3	-
2	T1	6.3 ^{ijk}	+96.9	3.2 ^{cde}	+60.0	3.8	+111.1	1.8	+20.0	1.7	+183.3

	T2	5.4 ^{lm}	+68.8	3.4 ^{bcd}	+70.0	2.1	+16.7	1.8	+20.0	1.6	+166.7
	T3	4.0 ^{n}	+25.0	2.7 ^{fghi}	+35.0	3.1	+72.2	1.3	-13.3	1.2	+100.0
	T4	4.8 ^{m}	+50.0	3.0 ^{cdefg}	+50.0	2.5	+38.9	1.6	+6.7	1.4	+133.3
	T5	6.2 ^{jk}	+93.8	3.4 ^{bcd}	+70.0	2.4	+33.3	1.6	+6.7	1.5	+150.0
	T6 (check)	3.2 ^{o}	-	2.0 ^{lm}	-	1.8	-	1.5	-	0.6	-
	T1	9.8 ^{cd}	+145.0	3.5 ^{bc}	+66.7	3.4	+70.0	1.9	+26.7	1.2	0.0
	T2	10.7 ^{b}	+167.5	4.0 ^{a}	+90.5	2.8	+40.0	1.5	0.0	1.4	+16.7
3	**T3**	5.9 ^{kl}	+47.5	2.4 ^{hijkl}	+14.3	2.9	+45.0	1.6	+6.7	0.7	-41.7
	T4	6.9 ^{ghi}	+72.5	2.7 ^{fghi}	+28.6	2.2	+10.0	1.2	-20.0	1.4	+16.7
	T5	5.8 ^{kl}	+45.0	2.5 ^{ghijk}	+19.0	2.8	+40.0	1.8	+20.0	1.3	+8.3
	T6 (check)	4.0 ^{n}	-	2.1 ^{klm}	-	2.0	-	1.5	-	1.2	-
	T1	8.0 ^{e}	+105.1	3.1 ^{cdef}	+55.0	3.4	+88.9	1.8	+20.0	1.2	0.0
	T2	5.9 ^{kl}	+51.3	2.3 ^{ijklm}	+15.0	2.0	+11.1	1.6	+6.7	1.4	+16.7
	T3	6.8 ^{hij}	+74.4	2.6 ^{fghij}	+30.0	2.0	+11.1	1.8	+20.0	0.8	-33.3
4	**T4**	3.1 ^{o}	-20.5	1.7 ^{m}	-15.0	2.5	+38.9	1.8	+20.0	1.1	-8.3
	T5	5.1 ^{m}	+30.8	2.2 ^{jklm}	+10.0	2.7	+50.0	1.2	-20.0	1.1	-8.3
	T6 (check)	3.9 ^{n}	-	2.0 ^{lm}	-	1.8	-	1.5	-	1.2	-
	T1	10.5 ^{bc}	+47.9	3.9 ^{ab}	+34.5	2.4	+9.1	1.7	+6.2	1.5	+66.7
	T2	6.3 ^{ijk}	-11.3	4.0 ^{a}	+37.9	2.2	0.0	1.6	0.0	1.1	+22.2
	T3	7.6 ^{efg}	+7.0	3.0 ^{cdefg}	+3.4	2.1	-4.5	1.6	0.0	0.6	-33.3
5	**T4**	6.7 ^{hij}	-5.6	2.1 ^{klm}	-27.6	2.2	0.0	1.8	+12.5	1.1	+22.2
	T5	3.9 ^{n}	-45.1	2.1 ^{klm}	-27.6	2.1	-4.5	1.8	+12.5	0.7	-22.2
	T6 (check)	7.1 ^{fgh}	-	2.9 ^{defg}	-	2.2	0.0	1.6	-	0.9	-

Means followed by the same letter (s) within a column in each block are not significantly different ($P \leq 0.05$) according to Duncans' multiple range test.

T1= effluent water from inorganic fertilizer tilapia pond, T2= effluent water from low organic fertilizer tilapia pond, T3= effluent water from high organic fertilizer tilapia pond, T4= effluent water from unfertilized with complete diet tilapia pond, T5= effluent water from biofloc tanks, T6= well water (check).

DISCUSSION

The present results indicated that all tilapia effluents reduced the root-knot nematode criteria on the infected roots. Application of organic and inorganic materials to the soil is known to have beneficial effects on soil nutrients (as substrate for microorganisms), soil physical conditions (water retention, cation exchange capacity and soil aggregation), soil biological activity and crop performance (Abubakar and Majeed, 2000; Abubakar *et al.*, 2004; Al-Sayed *et al*., 2007 and Mahfoud, 2011). In addition, the increasing evidences that organic materials regarded as safe and low cost products are an alternative method for nematode management. The tested organic materials were pestilential and possessed significant reduction in *M. incognita* development, total numbers of galls, egg masses, egg production, size of nematode population and subsequent nematode build up. Potency of these water sources on nematode population was more or less up to the comparable well water (check) and seemed to be dependent on their nature and concentration. Irrigation water overmatched well water (T6) in reducing nematode population. Our results are in coincidence with those of (Maareg *et al*., 2000; Al-Rehiayani, 2001 and Farahat *et al*., 2010 & 2012b).

The mechanism involved in nematode control by using organic and inorganic materials are variable and complimentary. The nematode control achieved by NPK is documented by Rodriguez-Kabana (1986) and Akhter and Mahmood (1997). Accumulated toxins of the decomposing products (Johnson, 1974 and Alam *et al*., 1973), tannins in nematotoxic polyphenols (Tayler and Murant, 1966), marked increase in numbers of natural enemies that are parasitic or predacious on nematodes (Mankau, 1962 & 1963), changed physical and chemical properties of soil which inimical to phytonematodes (Alam *et al*., 1973), or increased host resistance to nematode infection (Alam *et al*., 1977 and Alam *et al*., 1994) are attributable postulations to explain the effects of such materials. Also, the organic acids produced by the decomposed organic material (chicken manure) have contact nematicidal action on free stages of parasitic nematodes (Kesba, 2003 and Browning *et al*., 2004). Our results proved that these acids may have a direct role in biological defense mechanism or indirect one since they increased proteins and fatty acids in the root tissues.

Furthermore, the microbial breakdown of nitrogen containing substances in soil via processes of mineralization might have acted as operative tools against nematodes by increasing predacious nematodes, nematode-trapping fungi and their toxins (Walker, 1992). NH_3 or possibly nitrite produced is among principle compounds responsible for the decreased nematode populations. Also, the direct or indirect influence of pH,

Ca^{+} ions, and moisture could adversely affect nematode activity (Dubey, 1968).

Therefore, integrating aquaculture-agriculture system (IAA) has an additional benefit is that the fish waste and algae production have the potential to decrease the nematode populations and improve plant growth. Further investigations are needed to confirm these results with other crops.

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