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ESTIMATION OF FRUIT YIELD AND PARASITIC NEMATODES IN IRRIGATED TOMATO FIELD TREATED WITH ORGANIC AMENDMENTS AND MINERAL FERTILIZER

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ABSTRACT
Field experiments were carried out at the irrigation research station, Kadawain the Sudan Savanna Zone of Nigeria to estimate tomato fruit yield during the 2007/2008, 2008/09 and 2009/2010 dry seasons and population of plant parasitic nematodes during the 2008/09 and 2009/2010 dry seasons in irrigated tomato field treated with organic amendments and mineral fertilizer (NPK). There were thirty six treatments made up of factorial combinations of three sources of organic manure; urban waste, neem based and poultry manure each at three levels (50, 100 and 150 kg N ha^{-1} equivalent) and four levels of inorganic compound fertilizer NPK (0, 150, 300 and 450 kg ha^{-1}). The treatments were laid out in a split plot design replicated three times. The combinations of manure sources and manure rates were assigned to the main plots while inorganic fertilizer rates were assigned to the sub plots. Results revealed that application of poultry manure at the highest rate of 150 kg N ha^{-1}equivalent combined with 450 kg ha^{-1}NPK resulted in the highest total fruit yield. Plant parasitic nematodes population was higher at mid sampling period than at the initial or harvest periods.

Keywords: Organic Amendments, NPK, Parasitic Nematode Population, Tomato

INTRODUCTION

Tomato belongs to the family Solanaceae, and is one of the most widely eaten vegetables in the world due to the fact that it can be eaten fresh or in multiple of processed forms (Anon. 2014). Nigeria is ranked second largest producer of tomato in Africa, and thirteenth largest in the world producing 1.6 million tons of tomato annually (Anon. 2013) over an area of 1 million hectares at an average yield of 25-30 t ha^{-1} (Anon.2012). The consumption of tomatoes has been associated with prevention of several diseases mainly because it contains antioxidants including carotenes (lycopene), ascorbic acid and phenolic compounds (Anon.2014). There is growing interest in the use of organic manures due to soil fertility depletion in most African soils coupled with the scarcity and cost of mineral fertilizer (Oyewole *et al.* 2012). Root knot nematodes cause histopathological changes in root tissues of tomato (Wahundeniya, 1991). This abnormality can upset the normal physiological activities of vascular tissues of the root system and finally causes wilting, stunting, leaf chlorosis and poor growth and yield of plants (Ekanayake *et al.* 1938). Yield loss on tomato due to root knot nematodes (*meloidogyne* species) ranges from 40 – 46 % (Zaki and Kazuyoshi 2009). Studies conducted showed that organic manures were very effective in suppressing parasitic nematodes populations (Summers 2011; Abolusoro *et al.* 2013 and Aisha *et al.* 2015).

Due to the numerous advantages of combining organic and inorganic fertilizers for tomato production, as reported by Ayoola and Adeniyan (2006), it is therefore important to combine these two nutrients sources with a view to determining appropriate combination for use in the cultivation of tomato in the Sudan Savanna ecological zone. This study was conducted to study the effects of organic nutrient sources and NPK on tomato fruit yield and population of plant parasitic nematodes.

METHODOLOGY

The experiment was conducted at the Irrigation Research Station, Kadawa (11°39'N 08° 02'E, 500m above sea level), in the Sudan Savanna agro-ecological zone of Nigeria, to study effect of organic manure and NPK on fruit yield of tomato and population of plant parasitic nematodes at different sampling periods during the2008/2009 and 2009/2010 dry seasons. Soils of the experimental site were analyzed for physical and chemical properties before and after the experiment. Meteorological data were collected from the Irrigation Research Station, Kadawa during the period of the experiment. Composite soil samples of the experimental site were randomly taken at depths of 0-15cm and 15-30cm using soil auger. The

experiment consisted of thirty six treatments, made up of factorial combinations of three sources of organic manure (poultry, urban waste and neem-based manure) each at three levels (50, 100 and l50kgN ha^{-1} equivalent) and four levels of inorganic compound fertilizer N.P.K. (0,150, 300 and 450kg ha^{-1}). The treatments were laid out in a split plot design replicated three times. The combination of manure sources and manure rates were assigned to the main plots, while inorganic fertilizer rates were assigned to the sub-plots. Gross plot size was $18m^2$and consisted of six (0.75m wide) ridges each 4m in length 0.75m apart while net plot consisted of two inner ridges (6 m^2). An alley of 0.5m between plots and 1m between replicates was left. The tomato variety used was UC 82B.The nursery beds were mulched and watered regularly till seedlings reached transplanting age of four weeks after sowing (WAS).The experimental site was harrowed twice before ridges were made at 75 cm apart. Main plots and subplots were then marked out. Manures were applied asper treatment after land preparation and thoroughly worked into ridges two weeks prior to transplanting. Seedlings were transplanted from nursery to the field at 4 WAS at 75cm inter-row and 30cm intra-row spacing. Compound fertilizer was applied by side dressing as per treatments in two equal split doses, at 2 and 6 weeks after transplanting (WAT).Plots were hoe-weeded at 3, 6 and 9 WAT. Insect pests and diseases were controlled by spraying Sharper plus EC (cypermethrin and dimethoate) at the rate of 0.15-2.5kg $aiha^{-1}$ at 6, 8 and 10 WAT. Irrigation was carried out at weekly intervals during the first three weeks after transplanting. Thereafter, intervals were adjusted to five days up to 12 WAT. Check basin method was adopted and basins were flooded during each irrigation period. Nematode count on tomato roots was carried out using Cobb sieving and decanting technique (Cobb 1918). This was done at 4 WAS and at 8 and 12 WAT. Total fruit yield was determined by weighing total fruits harvested from each net plot and expressed on a ton per hectare basis. Data collected were subjected to analysis of variance (ANOVA) as outlined by Snedecor and Cochran (1967). Treatment means were compared using Duncan's Multiple Range Test (Duncan 1955).

RESULT AND DISCUSSION

Result

Tables 1 and 2 show the result of the soil analysis during the 2007/08, 2008/09 and 2009/2010 dry seasons before and after the experiment. The textural class of the soil was sandy loam, with a near neutral soil pH, while total nitrogen and organic carbon were low and the CEC was medium, exchangeable bases increased after the experiment during the three seasons.

The effect of source and rate of organic manure and NPK on total fruit yield of irrigated tomato in 2007/08, 2008/09 and 2009/2010 dry seasons and the combined analysis is shown in Table 3. Application of poultry manure to tomato resulted in consistently higher fruit yield than the other manure sources which were statistically similar. Effect of manure rate was significant in the years and when combined except in 2007/2008, application rate of 150kgNha^{-1} equivalent recorded consistently higher yield though at par with 100 kgNha^{-1}equivalent rate in 2008/2009 and 2009/2010 which were statistically similar. Similarly, effect of NPK rate was highly significant in 2008/2009, 2009/2010 and when combined. The result revealed that application of NPK to tomato at the highest rate of 450kg ha^{-1} gave consistently highest total fruit yield in both years and the combined analysis. This was followed by 150 and 300 kg ha^{-1} which were at par.

Table 1: Physical and chemical properties of the soil of the experimental site before the experiment during, the 2007/08, 2008/09 and 2009/2010 dry seasons at Kadawa

Soil properties	**2007/08**		**2008/09**		**2009/10**	
Physical composition(g kg^{-1})	**0 – 15 cm**	**15 – 30 cm**	**0 – 15 cm**	**15 – 30 cm**	**0 – 15 cm**	**15 – 30 cm**
Sandy	620	600	720	700	700	680
Sandy	300	200	180	160	180	160
Clay	80	200	100	140	120	160
Textural class	Sandy-loam	Sand clay loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Chemical Composition						
pH (water)	6.40	7.50	7.10	7.30	7.50	7.70
pH (0.01M $CaCl_2$)	6.10	6.50	6.60	6.50	6.70	6.70
Organic carbon (g kg^{-1})	5.4	2.0	2.9	3.3	5.6	3.6
Total Nitrogen (g kg^{-1})	0.7	0.2	0.2	0.25	0.32	0.31
Exchangeable bases (cmol kg^{-1})						
Calcium (Ca^{2+})	6.20	4.74	3.60	4.40	3.80	4.70
Magnesium (Mg 2+)	1.67	1.55	0.84	1.64	0.72	1.47
Potassium (K^{+})	0.08	0.09	0.34	0.28	0.41	0.29
Sodium (Na^{+})	0.45	0.58	0.17	0.26	0.18	0.32
H+ Al^{3+}	0.20	0.10	0.20	0.20	0.20	0.20
CEC	9.20	7.80	6.20	7.40	5.80	6.90
Available phosphorus (mg kg^{-1})	15.75	5.25	24.5	8.75	28	3.50

Table 2: Physical and chemical properties of the soil of the experimental site after the experiment during, the 2007/08, 2008/09 and 2009/2010 dry seasons at Kadawa

Soil properties	**2007/08**		**2008/09**		**2009/10**	
Physical composition(g kg^{-1})	**0 – 15 cm**	**15 – 30 cm**	**0 – 15 cm**	**15 – 30 cm**	**0 – 15 cm**	**15 – 30 cm**
Sandy	600	600	720	680	700	660
Sandy	300	220	160	180	140	180
Clay	100	180	120	140	160	160
Textural class	Sandy-loam	Sand clay loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Chemical Composition						
pH (water)	5.80	7.20	6.80	7.10	7.30	7.40
pH (0.01M $CaCl_2$)	5.60	6.80	6.30	6.90	7.00	6.80
Organic carbon (g kg^{-1})	7.2	3.4	4.1	3.6	8.0	4.0
Total Nitrogen (g kg^{-1})	0.84	0.4	0.35	0.42	0.70	0.53
Exchangeable bases (cmol kg^{-1})						
Calcium (Ca^{2+})	6.54	5.82	4.60	5.42	4.60	6.10
Magnesium (Mg 2+)	2.40	1.74	1.08	1.74	1.26	1.57
Potassium (K^+)	0.09	0.10	0.38	0.31	0.48	0.35
Sodium (Na^+)	0.47	0.64	0.23	0.32	0.26	0.42
H+ Al^{3+}	0.40	0.20	0.40	0.20	0.40	0.30
CEC	11.40	9.70	8.60	11.40	6.50	8.40
Available phosphorus (mg kg^{-1})	17.30	7.30	26.70	9.40	30	7.60

Table 3: Effect of source and rate of organic manure and NPK on total fruit yield (t ha^{-1}) of irrigated tomato in 2007/08, 2008/09, 2009/2010 dry seasons and the combined

Treatment	Total fruit yield (t ha^{-1})			
	2007/08	2008/09	2009/2010	Combined
Manure source				
Urban waste	16.7^{b}	21.4^{b}	22.9^{b}	20.3^{b}
Neem based	19.5^{b}	19.6^{b}	21.6^{b}	20.3^{b}
Poultry	28.2^{a}	25.4^{a}	27.2^{a}	26.9^{a}
SE±	1.69	0.81	0.79	0.74
Sig.	**	**	**	**
Manure rate				
(kg N ha^{-1} equivalent)				
50	20.2	20.5^{b}	22.2^{b}	20.9^{b}
100	21.1	22.1^{ab}	23.8^{ab}	22.3^{ab}
150	23.2	23.8^{a}	25.6^{a}	24.2^{a}
SE±	1.69	0.81	0.79	0.74
Sig.	NS	*	*	**
NPK rate (kgha^{-1})				
0	21.2	15.9^{c}	17.6^{c}	18.2^{c}
150	22.0	21.8^{b}	23.5^{b}	22.4^{b}
300	21.2	22.1^{b}	24.1^{b}	22.5^{b}
450	21.5	28.6^{a}	30.4^{a}	26.9^{a}
SE±	1.52	0.73	0.71	0.61
Sig.	NS	**	**	**
Interactions				
T * S	NS	NS	NS	NS
S * F	NS	NS	NS	NS
T * F	NS	NS	NS	NS
T * S * F	NS	NS	NS	NS

Means followed by same letter within a treatment group are not statistically different at 5% level of probability using DMRT.NS = Not Significant * = Significant at 5% probability level ** =Significant at 1% probability level

Nematode count

Table 4 shows nematode count by sampling periods in 2008/09 and 2009/2010 dry seasons. In both seasons of study nematode population including *Meloidogyne* species which is prevalent on tomato crop was higher at the mid sampling period than at the initial or harvest periods except for *pratylenchus* species in both years which were at par.

Table 4: Nematode type and population in response to sources and rates of organic manure and NPK on tomato field during the 2008/2009 and 2009/2010 dry season at kadawa, Nigeria.

Species (spp.) **Period**	**C**	**H**	**HP**	**M**	**P**	**R**	**T**
				2008/2009			
Initial (4WAS)	0.28	0.13^{c}	0.03^{b}	3.76^{b}	0.04^{c}	0.11^{c}	0.09b
Mid (8WAT)	0.34	1.95^{a}	0.18^{a}	7.10^{a}	0.97^{b}	0.62^{b}	0.24a
Harvest (12WAT)	0.20	1.58^{b}	0.02^{b}	3.11^{c}	1.34^{a}	1.31^{a}	0.03b
Sig.	NS	**	**	**	**	**	**
SE±	0.054	0.034	0.014	0.153	0.026	0.054	0.041
				2009/2010			
Initial (4WAS)	0.32^{a}	0.07^{b}	0.06	2.29^{b}	0.07^{c}	0.00^{c}	0.18b
Mid (8WAT)	0.38^{a}	1.78^{a}	0.0	5.18^{a}	0.29^{b}	0.65^{a}	0.43a
Harvest (12WAT)	0.04^{b}	0.22^{b}	0.04	0.65^{c}	0.47^{a}	0.35^{b}	0.06b
Sig.	*	**	NS	**	**	**	**
SE±	0.103	0.062	0.043	0.014	0.042	0.049	0.075

Means followed by the same letter within a treatment group are not statistically different at 5% level of probability using DMRT. NS = Not Significant **=Significant at 1% probability level **KEY** C = *Criconemoides* Spp. H = *Helicotylenchuss*Spp.HP = *Haplolaimus*Spp.M = *Meloidogyne*Spp.P = *Pratylenchus* Spp. R = *Rotylenchus*Spp.T = *Tylenchus* Spp.

DISCUSSION

Poultry manure enhanced total fruit yield measured during the three seasons of experimentation over other sources evaluated, this might be due to its positive role on physical, chemical, and microbial properties of the soil. The advantages conferred on the soil of the experimental site, which was sandy loam were the improvement of water holding capacity, chemical and microbial properties, thus ensuring better conditions for improvement in crop growth and yield. This supported the findings of Adekiya and Agbede, (2009) who reported that poultry manure improved soil nutrient status, as well as growth and yield of tomato and therefore is a suitable source of nutrients for improving soil fertility, and growth and yield of tomato. Application of organic amendments to the soil of the experimental site during the two years increased cation exchange capacity and nutrients such as P, Ca, Mg, K and Na (see Tables 1 and 2) The findings that poultry manure performed better than the other manure sources could be adduced to the fact that poultry manure supplied more nutrients coupled with its physical and microbial biomass carbon enhancement characteristics. Oladotun (2002) reported that poultry manure contains macro and micro nutrients such as N, P, K, S, Ca, Mg, Cu, Mn, Zn, B and Fe. This also corroborates the findings of Adekiya and Agbede (2009).

Furthermore, microbial biomass in poultry manure was higher than in other manure sources, which probably explained its soil fertility improvement advantages which resulted in better growth and yield. Furthermore, urban waste contains lower amount of essential macro and micro nutrients necessary for the growth, development and fruit yield of tomato. Application of manure at higher rates of 100 and 150kg N ha^{-1} equivalent significantly increased total fruit yield during the three seasons. This may be due to the increase in micro and macro nutrients (Ca, Mg, K, Fe etc.) contained in the manure for crop uptake and utilization which resulted in better crop growth and yield. Furthermore, the manure may have improved the physical properties and microbial activities of the soil thereby enhancing better soil and nutrient status which improved crop growth and yield, confirming an earlier report by Akanni, (2005). Application of the highest NPK rate of 450 kg ha^{-1} resulted in increased growth and total fruit yield. Addition of NPK fertilizer to organic amendments including poultry manure probably aided mineralization of nutrients due to enhanced supply of nutrients leading to better growth and development as postulated by Makinde *et al.,* (2001). Similarly, Qian and Schoenau (2002) and Okwugwu and Alleh (2003) reported that high and sustained crop growth and yield could be achieved with judicious and balanced NPK fertilizer treatment combined with organic matter amendments. Ayoola and Adeniyan (2006) reported that nutrients from mineral fertilizers enhanced the establishment of crops, while those from mineralization enhanced yield when both fertilizers are combined.

In conclusion, application of poultry manure at the rate of 150 kg N ha^{-1} equivalent combined with 450 kg ha^{-1} NPK to tomato gave the highest fruit yield. In both seasons of study, plant parasitic nematodes population was higher at the mid sampling period than at the initial or harvest periods.

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Appendix 1: Meteorological data (means) of the trial location at Kadawa in the Sudan Savanna during 2007/2008, 2008/2009 and 2009/2010 seasons

	Temperature (0 ^{0}C)		Rel. humidity (%)		
Season	Wind direction				
2007/08	**max**	**min**	**10 :00am**	**4 :00pm**	
Nov.	32	15	23	18	SE
Dec.	30	13	18	16	NE
Jan.	32	12	37	13	SE
Feb.	35	19	50	37	SE
March	37	22	51	16	NE
Mean	**33.2**	**16.2**	**35.8**	**20.0**	
2008/09					
Nov	30	14	22	22	SE
Dec.	32	12	18	14	NE
Jan.	33	13	36	13	SE
Feb.	34	20	48	37	SE
March	36	21	53	19	NE
Mean	**33.0**	**16.0**	**35.4**	**21.0**	
2009/10					
Nov.	30	15	23	17	SE
Dec.	31	12	20	18	NE
Jan.	30	12	37	13	SE
Feb.	33	19	50	37	SE
March	32	19	51	16	NE
Mean	**31.2**	**15.4**	**36.2**	**20.2**	

Source: Department of Soil Science IAR/ABU, Zaria