Effect of Integrated Nutrient Management Approach on Soil Chemical and Physical Properties and Performance of Tomato (*Lycopersicon Lycopersicum*) Under Mildly-Acidic Alfisol Conditions

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Abstract

Collection and conversion of freely available wild-plant residues into composted materials for vegetable crop production (either as a substitute or supplement to the highly-priced chemical / synthetic fertilizers), may be beneficial to sustainable tropical crop production and improvement of soil conditions. Field studies were conducted in the year 2009, at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso, Nigeria, to assess the response of tomato to Tithonia-compost with or without N-mineral fertilizer, and the effects of such integration on some soil properties. It was a factorial combination of three rates of compost application (0.0, 2.5 & 5.0 tons ha^{-1}) and three rates of inorganic nitrogen application (0.0, 30.0 and 60.0 kg N ha^{-1}). Data collected on growth and yield parameters were analyzed using ANOVA at $p < 0.05$. Compost application significantly improved soil properties, under sole and combined applications. Growth and yield parameters significantly increased with increased levels of sole and combined applications of compost and N-mineral fertilizer. Tomato responded best to integration of 30 kg N ha^{-1} of urea and 2.5 tons ha^{-1} of Tithonia-compost as reflected in best growth rate and fruit yield. The rate was found to be equally adequate for improved soil physical and chemical properties. Integration of organic and inorganic fertilizer is therefore essential for efficient soil management and crop production.

Keywords; Integrated nutrient management approach, Tithonia-compost, N-mineral fertilizer, Soil physico-chemical properties, Tomato.

Introduction

Tomato (*Lycopersicon lycopersicum*) is well known for its dietary importance and versatility all over the world. It is consumed in both fresh / raw (e.g. salad) and processed or cooked forms e.g. paste, soup, stew, ketchup, powdered or juice in canning industries (Adebooye *et al.,* 2006). Low soil fertility and some environmental factors affect its performance in the tropics (Akanni and Ojeniyi, 2007). Adequate fertilizer application, (particularly nitrogen), influences tomato growth and fruit yield more than cultural practices (Akanbi, *et al*., 2005). Unfortunately, nitrogen is mostly applied through synthetic sources, which are known for some notable defects, such as substantial leaching losses / volatilization and harmful residual effects (Tejada *et al*., 2005). It is therefore reasonable to develop an environment friendly and sustainable technology, which can integrate organic and inorganic fertilizer materials, so as to successfully supplement the widely-used inorganic fertilizers.

Tithonia diversifolia (Hemsl.) A. Gray which is also known as wild flower or Mexican sunflower belongs to the family Asteraceae. It is an annual and highly aggressive weed, which is relatively high in nutrient concentrations, but little is known about its potentials as a dependable nutrient source for improved soil fertility and crop yields (Olabode *et al.,* 2007). The reported uses of *Tithonia diversifolia* include fodder; poultry feed, fuel-wood, building materials and shelter for poultry, medicines and insecticides (Kuo and Chen, 1997; Jama *et al.,* 2000).

However, the use of organic manure is limited by the huge quantities needed to meet crop nutritional needs (in view of its relatively low nutrient contents per volume / unit), while the use of chemical fertilizers is limited by cost and scarcity (Ojeniyi and Adeniyan, 1999; Akanbi, *et al.*, 2005). Complementary use of organic and inorganic fertilizers may be beneficial to achieving a sustainable crop production, via improved and long-lasting soil moisture and nutrition (Togun *et al.,* 2004). Therefore, this experiment was aimed at investigating response of tomato to composted Tithonia-biomass solely and in combination with nitrogenous mineral fertilizer, and the possible effects of the applied fertilizer materials on soil properties.

Materials and Methods

Field experiment was conducted in the year 2009, at the Teaching and Research Farms, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Oyo State, Nigeria, to assess the effect of composted- tithonia on the performance of Tomato (*Lycopersicon lycopersicum*) and physico-chemical properties of soil. This experimental location falls under the guinea savanna zone of southwestern Nigeria. Ogbomoso is located at 8^0 10′ N and 4^0 10′ E and the climate is cold and dry from November to March and then warm from and moist from April to October. The experimental site has two rain periods with an average annual rainfall of 1104.0mm collected during the year of the experiment. After land clearing, soil sample collected for analyses revealed that the soil was a mildly-acidic (pH 6.12) and texturally sandy- loam (sand; 83.2%, silt; 12.3% and clay; 4.5%). Also, the soil was grossly low in essential nutrients (total N; 0.06%, available P; 4.25 $mg.kg^{-1}$, and exchangeable bases ($cmol.kg^{-1}$); K; 0.60, Ca; 2.31, and Mg; 0.48), and organic carbon; 1.15%. The soil was previously under continuous cropping of cassava and maize for seven years earlier before this experiment was set up at the location.

The compost used was prepared from *Tithonia diversifolia (Hemsl.) A. Gray* plant materials and well-cured poultry manure. The tithonia-biomass was harvested (by cutting each plant from 3cm above the soil level), at exactly 8 weeks after emergence (i.e. before flowering), from a nearby experimental plot, specially reserved for this research. The plant materials were cut into pieces below 10cm, carefully spread and air-dried for three (3) days. The manure was equally air-dried, followed by removal of foreign non-biodegradable materials like stones, iron e.

t.c. These two organic materials (tithonia-biomass and poultry manure) were then carefully mixed together at the weight ratio of 4:1 tithonia-biomass to poultry manure and was composted in a concreted pit for eight (8) weeks. The materials were properly watered and carefully turned once weekly for the first two (2) consecutive weeks, followed by once bi-weekly turnings until proper maturation occurred at the 8th week of composting. Matured compost was carefully evacuated from the pit for air-drying for seven days followed by sieving. At one week before transplanting, the required plots were amended with composted tithonia-biomass, using hand- fork for proper mixing, at three (3) levels (0.0, 2.5 and 5.0 tons ha^{-1}) in combinations with three (3) levels of urea application (0, 30 and 60 kg N ha^{-1}). Urea (46%N) application was done in two splits (i.e. at three weeks after transplanting and at the initial stage of flowering). Nine (9) treatment combinations emanated from the factorial combination of different compost and N-mineral application rates. The treatment combinations were replicated four (4) times and the trial was laid out in a Randomized Complete Block Design (RCBD). Tomato seeds (variety Roma VF), were first sown and raised in the nursery for four (4) weeks before transplanting to the experimental plots. Each plot size was 2.1m × 2.7m at spacing of 90cm × 30cm. Weeding was manually done using hoe as at 2, 4 and 6 weeks after sowing. The growth parameters determined at the early boom of flowering were; plant height (by using measuring tape), stem circumference (by using calipers which first gave the value of the diameter, which was later converted to circumference using a fomular of πD (i.e. 3.142 multiplied by the obtained diameter (D) value), number of branches (determined by direct counting of all well-developed branches per plant) and leaf area [by graph method as described by Akanni and Ojeniyi, (2007)]. Laboratory determination of length of tap root (using a measuring tape) was done. At every harvest, number of ripe fruits per plant was determined (by direct counting) and weighed. Fruit diameter was also determined (using calipers). The cumulative fruit weight values per plant, obtained from multiple harvestings spanning eight (8) weeks, were later converted to fruit yield (tons ha^{-1}). However, the entire soil-less tomato plants were carefully packed into giant-brown envelopes (65cm by 30cm), for oven-drying at 80^{0}C for 48 hours, to assess N, P and K in plants (as described by Akanbi *et al.*, 2005). Nutrient uptake was determined using a formular proposed by Ombo, (1994); Nutrient uptake = Dry matter yield multiply by Nutrient content (%). Soil temperature was determined (using soil thermometer placed at 5cm soil depth at 1500 Hour). At the end of the trials, two core soil samples collected from each plot, at a soil depth range of between 5 & 10cm were composited for gravimetric determination of the soil moisture content and bulk density. Also, post-cropping pH determination only was done as described by I.I.T.A., (1982).

All data collected were analyzed following the procedures of analysis of variance (ANOVA). Where differences were observed, Duncan's Multiple Range Test (DMRT), at 95% level of probability, was used to compare differences between the treatment means using Statistical Analysis System (SAS, 2009).

Results and Discussion

The pre-cropping physical and chemical soil analyses showed that, the soil used for this experiment was mildly-acidic (pH 6.12) and texturally sandy-loam (sand; 83.2%, silt; 12.3% and clay; 4.5%). Also, the soil was grossly low in essential nutrients (total N; 0.06%, available P; 4.25 $mg.kg^{-1}$, and exchangeable bases ($cmol.kg^{-1}$); K; 0.60, Ca; 2.31, and Mg; 0.48), and organic carbon; 1.15%. The soil pH values significantly increased with increased dosage of composted tithonia-biomass. The inadequately fertilized soil and or the control had the least soil pH values (i.e. found to be mostly acidic). Increased concentration of urea application levels significantly increased soil acidity level, particularly when manure application was inadequate or missing. Application of composted tithonia-biomass significantly enhanced soil physical properties (Table 3). Soil temperature and bulk density significantly reduced. Soil moisture increased significantly with increased tithonia-biomass application. These results are in line with earlier scientific report that, nutrients contained in compost made from organic wastes, are slowly supplied to crop-plant over a long period of time (Hartz *et al*; 1996). Also, these results also agree with Akanni and Ojeniyi (2007), who reported the relevance of increased rate of organic matter application to improved physical and chemical properties of soils. Table 1 shows the significant effect of improved soil nutrition by organic and inorganic sources (i.e. tithonia and urea), as reflected on the fertilized tomato plant which were significantly better in growth parameters (i.e. plant height, stem circumference, leaf area, number of leaf, number of branches and tap root length), than their unfertilized/control counterparts. A combined application of 2.5 tons ha^{-1} of composted tithonia and 30kg N ha^{-1} produced the best number of fruits per plant, fruit diameter and cumulative fruit yield, which were statistically similar to those obtained from a combined application of 5.0 ha^{-1} and 60kg N ha^{-1} of tithonia and urea respectively (Table 2). These results are in order with the reports of Togun *et al.*, (2004) and Akanni and Ojeniyi, (2007), who reported increased fruit yield of tomato in relation to improved/increased availability of nutrients supplied through improved levels of plant residue compost and poultry manure respectively. Significant effects of composted-tithonia and N-mineral fertilizer on the N, P and K uptakes are shown on Table 4. Generally, N, P and K uptakes were observed to be significantly higher in both organically and inorganically fertilized plants than their unfertilized counterparts. These reflect a direct relationship between improved soil nutrition and nutrient uptake by crop-plants (Akanbi *et al.*, 2005; Adeniyan and Ojeniyi, 2003). Therefore, adequate and regular maintenance of soil organic matter is one of the most important conditions to be met, in order to stabilize agricultural systems in the humid and sub-humid tropics. This could be achieved by ensuring regular supply of organic materials to the soils (Akanbi *et al.*, 2005; Chukwuka and Omotayo, 2008).

Conclusion

Tithonia diversifolia which is a wild plant is relatively high in nutrient concentrations and could be a dependable nutrients' source for improved soil fertility and crop yields. Combined application of 2.5 tons N ha^{-1} of composted Tithonia-biomass and 30 kg N ha^{-1} urea is therefore recommended for tomato production in the study area. Also, for organic tomato production, sole application of 5.0 tons ha^{-1} of composted Tithonia-biomass is therefore recommended, for optimum growth and yield of tomato, and for improved soil properties in the study area.

Table 1: Effect of composted Tithonia-biomass and N-mineral fertilizer on different growth attributes of tomato at four weeks after transplanting (4WAT).

Treatment combinations	Plant height (cm)	Stem circumference (cm)	Leaf area (cm^2)	Number of branches	Tap root length (cm)
C_0F_0	34.80d	0.60d	13.20c	4.10d	18.40d
C_0F_1	60.10c	1.00d	16.30c	5.20d	27.20c
C_0F_2	58.70c	1.80c	20.60b	8.40c	38.80b
C_1F_0	76.50b	2.00c	25.20b	6.20c	40.40ab
C_1F_I	92.60a	3.10a	35.60a	18.08a	51.20a
C_1F_2	90.10a	2.50ab	31.20a	10.00c	37.50b
C_2F_0	91.20a	2.60ab	29.60ab	12.05ab	40.20ab
C_2F_1	89.80a	2.60ab	29.80ab	16.06ab	46.40a
C_2F_2	86.40a	2.60ab	33.20a	19.00a	47.20a

Means followed by same letters are not significantly different at P=0.05, using DMRT. C_0= no or zero application of composted tithonia-biomass, C_1=application of 2.5 tons ha^{-1} of composted tithonia-biomass, C_2=application of 5.0 tons ha^{-1}, F_0= no application of urea, F_1=application of 30kg N ha^{-1} of urea and F_2=60 kg N ha^{-1} of urea.

Table 2: Effect of composted Tithonia-biomass and N-mineral fertilizer on some yield parameters of Tomato.

Treatment combinations	Days to 50% flowering	Number of fruits per plant	Fruit diameter (cm)	Fruit yield (tons ha-1)
C_0F_0	51.10c	12.20c	1.80c	4.80f
C_0F_1	50.00c	18.40c	1.90c	8.40ef
C_0F_2	51.40c	19.80c	2.20c	12.06d
C_1F_0	50.20c	31.20b	3.10b	18.04c
C_1F_I	71.20a	51.40a	4.90a	30.02a
C_1F_2	60.50ab	47.20a	4.60a	21.08b
C_2F_0	70.10a	48.10a	4.60a	22.05b
C_2F_1	65.80ab	49.30a	4.50a	24.02ab
C_2F_2	66.10ab	49.00a	4.40a	24.04ab

Means followed by same letters are not significantly different at P=0.05, using DMRT. C_0= no or zero application of composted tithonia-biomass, C_1=application of 2.5 tons ha^{-1} of composted tithonia-biomass, C_2=application of 5.0 tons ha^{-1}, F_0= no application of urea, F_1=application of 30kg N ha^{-1} of urea and F_2=60 kg N ha^{-1} of urea.

Table 3: Soil physical and chemical properties as influenced by composted Tithonia-biomass and N-mineral fertilizer.

Treatment combinations	Temperature (^{0}C)	Bulk density (cm-3)	Moisture (%)	pH (pre-cropping)	pH (post-cropping)
C_0F_0	29.40a	1.44a	16.12c	6.12 NS	5.92c
C_0F_1	29.20a	1.40a	19.50c	6.12NS	5.65d
C_0F_2	27.80a	1.40a	21.4b	6.12NS	5.16e
C_1F_0	26.90a	1.29a	25.12b	6.12NS	6.15b
C_1F_I	24.00b	1.00b	33.92a	6.12NS	6.17b
C_1F_2	23.90b	1.25ab	30.15a	6.12NS	6.18b
C_2F_0	23.60b	0.94b	30.10a	6.12NS	6.29a
C_2F_1	23.6.01b	0.93b	30.15a	6.12NS	6.29a
C_2F_2	23.20b	0.93b	34.10a	6.12NS	6.34a

Means followed by same letters are not significantly different at P=0.05, using DMRT. C_0= no or zero application of composted tithonia-biomass, C_1=application of 2.5 tons ha^{-1} of composted tithonia-biomass, C_2=application of 5.0 tons ha^{-1}, F_0= no application of urea, F_1=application of 30kg N ha^{-1} of urea and F_2=60 kg N ha^{-1} of urea.

Table 4: Effect of Tithonia-biomass and N-mineral fertilizer application on Nitrogen, Phosphorus and Potassium uptake of Tomato.

Treatment combinations	Nitrogen uptake (g plant^{-1})	Phosphorus uptake (g plant^{-1})	Potassium uptake (g plant^{-1})
C_0F_0	1.02c	0.11f	0.42d
C_0F_1	3.01c	0.39ef	2.10c
C_0F_2	4.08cd	0.60d	2.45c
C_1F_0	4.40cd	0.60d	0.75d
C_1F_I	13.08a	1.82a	5.11b
C_1F_2	11.11a	1.72a	7.10a
C_2F_0	11.40a	1.68b	5.12b
C_2F_1	10.80ab	1.45bc	5.90ab
C_2F_2	8.94bc	1.26c	5.00b

Means followed by same letters are not significantly different at P=0.05, using DMRT. C_0= no or zero application of composted tithonia-biomass, C_1=application of 2.5 tons ha^{-1} of composted tithonia-biomass, C_2=application of 5.0 tons ha^{-1}, F_0= no application of urea, F_1=application of 30kg N ha^{-1} of urea and F_2=60 kg N ha^{-1} of urea.

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