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Influence of Composted Tithonia-biomass and N-Mineral Fertilizer on Soil Physico-Chemical Properties and Performance of Tomato (*Lycopersicon lycopersicum*)

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Abstract: An adoption of a low input technology, which carefully incorporates wild-plant residues such as Mexican sunflower (*Tithonia diversifolia* (Hemsl.) A. Gray), into soils 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, most especially in the aspects of improved soil fertility, productivity, pH, regulated soil temperature, moisture and bulk density. Field studies were conducted to assess the response of tomato to composted tithonia-biomass with or without N-mineral fertilizer and the possible effects on soil physical and chemical properties, in southwestern Nigeria. The treatments introduced were 0, 3.0 and 6.0 tons ha^{-1} of composted tithonia-biomass and 0, 30 and 60 kg N ha^{-1} of urea (46% N). Soil physical and chemical properties were significantly and positively enhanced with increasing rate of compost application. Growth and yield parameters such as plant height, leaf area, number of branches, tap-root length, stem circumference, fruit diameter and fruit yield significantly increased with increasing levels of sole and combined application of compost and N-mineral fertilizer. Combined application of 30 kg N ha^{-1} and 3.0 tons ha^{-1} was found adequate for optimum growth and fruit yield and even for desirable improvement in the soil physical and chemical properties.

Key words: Composted tithonia-biomass, N-mineral fertilizer, soil physico-chemical properties, tomato, nutrient uptake

INTRODUCTION

Tomato (*Lycopersicon lycopersicum*) is an important and highly versatile arable crop. It has become widely distributed all over the world, as an integral part of human diet commonly 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 (Ojeniyi and Adeniyan, 1999; Akanbi *et al*., 2005; Adebooye *et al*., 2006). A very low yield of 9 tons ha^{-1} obtained from tomato production in Nigeria, which is far below the world average of 20.6 tons ha^{-1} (FAO, 1998), could be easily traced down to low soil fertility, physical limitations and poor soil management strategies (Fagbola *et al*., 2001; Akanni and Ojeniyi, 2007). Amongst all inputs required to boost agricultural output, nitrogenous fertilizer ranks the first. Nitrogen constitutes 50% of all the required nutrients inputs for crop production and as such its availability may play an inevitable role in growth and fruit yields of tomato (Akanbi *et al*., 2005). Moreso, nitrogenous fertilizers are mostly unavailable, particularly for the resource-poor farmers located in the developing countries like Nigeria. Although, adequate and timely nitrogen fertilization of crop-plant is crucial, substantial leaching losses/ volatilization and harmful residual effects induced by incessant/high rate of nitrogen application are also the undesirable aspects of N-mineral application (Sobulo, 2000). Therefore, in order to reduce/eliminate the total dependency of farmers on such harmful and highly priced synthetic fertilizers, it is reasonable to develop an organic, environmentally friendly and sustainable technology, which can totally substitute or successfully supplement the widely-used inorganic fertilizers.

Tithonia diversifolia (Hemsl.) A. Gray is one of the numerous indigenous wild plant species, which are commonly found growing on or near small holder farms. Tithonia is a common weed, which is relatively high in nutrient concentrations, but little is known about its potentials as a dependable nutrient source for improved

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soil fertility and crop yields (Sonke, 1997). *Tithonia* is known as wild flower or Mexican Sunflower. It is a shrub belonging to the family Asteraceae. It is an annual and highly aggressive weed, which grows usually to a height of about 2.5 m and adaptable to most soils (Olabode *et al*., 2007). *Tithonia* was probably introduced into Africa as an ornamental plant. It had been observed to be widely spread in Nigeria on abandoned waste-lands, beside highways, waterways and cultivated farmlands. It has been reported in other countries like Kenya (Niang *et al*., 1996), Malawi (Ganunga *et al*.,1998), Nigeria (Ayeni *et al*., 1997), Rwanda (Drechsel and Reck, 1998), Zimbabwe (Jiri and Waddington, 1998) and Cameroon, Uganda and Zambia (Jama *et al*., 2000). The reported uses of tithonia include; fodder (Anette, 1996; Rootheart and Paterson, 1997), poultry feed (Odunsi *et al*., 1996), fuel-wood (Ng'inja *et al*., 1998), building materials and shelter for poultry (Otunma *et al*., 1998).

In addition, extracts protect crops from termites (Adoyo *et al*., 1997) and contain plant growth inhibitory chemicals (Baruah *et al*., 1994; Tongma *et al*., 1997). Extracts cure hepatitis (Lin *et al*., 1993; Kuo and Chen, 1997) and control amoebic dysentery (Tona *et al*., 1998). Composted crop residues when applied to soil improved soil fertility through slow-but-lasting release of the inherent nutrients, improved microbial activities, improved soil moisture content, as well as improved physical and chemical soil properties (Hartz *et al*., 1996; Joao *et al*., 1997; Abad *et al*., 1997; Akanbi *et al*., 2005). Therefore, considering the agro-economical and the related beneficial effects of organic waste recycling and the increasing awareness in organically produced farm produced all over the world, this experiment was carefully designed to determine the effect of composted tithonia-biomass solely and in combination with nitrogenous mineral fertilizer, on the performance of tomato and soil physico-chemical properties, in southwestern Nigeria.

MATERIALS AND METHODS

Field experiments were conducted in the year 2005, at the Teaching and Research Farms, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Oyo State, Nigeria, to determine the effect of composted-tithonia on the performance of Tomato (*Lycopersicon lycopersicum*) and physico-chemical properties of soil. This experimental site falls under the guinea savanna zone of southwestern Nigeria. After land clearing, soil sample collected for analyses revealed that the soil was a mildly-acidic (pH 6.02) and texturally sandy-loam (sand, 85.4%, silt, 11.4% and clay, 3.2%). Also, the soil was grossly low in essential nutrients (total N, 0.04%, available P, 4.78 mg kg^{-1} and exchangeable bases (Cmol kg^{-1}), K, 0.62, Ca, 1.31 and Mg, 0.38) and organic carbon, 1.78%. The soil was known to be under continuous cropping of yam and guinea-corn for 6 years earlier before setting up this experiment.

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 3 cm 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 10 cm, carefully spread and air-dried for 3 days. The manure was equally air-dried, followed by removal of foreign non-biodegradable materials like stones, iron etc. 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 8 weeks. The materials were properly watered and carefully turned once weekly for the first 2 consecutive weeks, followed by once bi-weekly turnings until proper maturation occurred at the 8th week of composting. After maturation of the compost (at 1 week before transplanting), the required plots were amended with composted tithonia-biomass, using hand-fork for proper mixing, at 3 levels (0, 3.0 and 6.0 tons ha^{-1}) in combinations with 3 levels of urea application (0, 30 and 60 kg N ha^{-1}). Urea (46% N) application was done in 2 splits (i.e., at 3 weeks after transplanting and at the initial stage of flowering). Nine treatment combinations emanated from the factorial combination of different compost and N-mineral application rates. The treatment combinations were replicated 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 4 weeks before transplanting to the experimental plots. Each plot size was 2.1×2.7 m at spacing of 90×30 cm. Weeding was manually done using hoe as at when due. 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 (Akanni and Ojniyi (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 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 (65 by 30 cm), for oven-drying at 80°C for 48 h, to assess N, P and K in plants (Akanbi *et al*., 2005). Nutrient uptake was determined using a formula proposed by Ombo (1994), Nutrient uptake = Dry matter yield multiply by Nutrient content (%). Soil temperature was determined (using soil thermometer placed at 5 cm soil depth at 1500 h). At the end of the trials, 2 core soil samples collected from each plot, at a soil depth range of between 5 and 10 cm were composited for gravimetric determination of the soil moisture content and bulk density. Also, post-cropping pH determination only was done as described by IITA (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 (SAS, 1996).

RESULTS AND DISCUSSION

The results from the pre-cropping physical and chemical soil analyses revealed that the soil used for this experiment was mildly-acidic (pH 6.02) and texturally sandy-loam (sand, 85.4%, silt, 11.4% and clay, 3.2%). Also, the soil was grossly low in essential nutrients (total N, 0.04%, available P, 4.78 mg kg^{-1} and exchangeable bases (Cmol kg^{-1}), K, 0.62, Ca, 1.31 and Mg, 0.38) and organic carbon, 1.78%. Moreso, considering the pre-cropping and post-cropping pH values obtained (Table 1), increasing dosage of composted tithonia-biomass significantly improved the pH values. Poorly fertilized soil or the control had the least soil pH value (i.e. found to be mostly acidic). Increasing urea levels were observed to significantly increase soil acidity level, particularly in the absence of compost application. Tithonia biomass effectively improved soil physical properties (Table 1). Values of soil temperature and bulk density reduced significantly, while that of soil moisture increased, as resulted from increased tithonia-biomass application up to 6.0 tons ha^{-1} but, these values were not significantly different from those obtained from 3.0 tons ha^{-1} with or without urea application. These results 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 2 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 3 tons ha^{-1} of composted tithonia and 30 kg N ha^{-1} produced the best number of fruitsper plant (39.5), fruit diameter (4.6 cm) and cumulative fruit yield (32.2 tons ha^{-1}), which were not significantly different from 39.2, 4.0 cm and 30.7 tons ha^{-1}, respectively as obtained from those plants that received a combined application of 6.0 $ha^{-1}$and 60 kg N ha^{-1} of tithonia and urea, respectively (Table 3). These results are in order with the reports of Togun *et al*. (2004) and Akanni and Ojeniyi (2007), who reported increased fruit yield of

Table 1: Soil physical and chemical properties as influenced by composted Tithonia-biomass and N-mineral fertilizers

Treatment combinations	Temperature (°C)	Bulk density (cm^{-3})	Moisture (%)	pH (pre-cropping)	pH (post-cropping)
C0N0	28.1a	1.42a	21.12c	6.02NS	5.80c
C0N1	28.2a	1.36a	23.53bc	6.02NS	5.77c
C0N2	27.6a	1.39a	23.50bc	6.02NS	5.74c
C1N0	26.8a	1.24b	24.43b	6.02NS	6.04b
C1N1	24.2b	0.92b	28.52ab	6.02NS	6.08b
C1N2	24.0b	1.22b	27.60b	6.02NS	6.08b
C2N0	23.8b	0.94b	28.49ab	6.02NS	6.19a
C2N1	24.1b	0.92b	29.95a	6.02NS	6.17a
C2N2	24.0b	0.91b	30.10a	6.02NS	6.21a

Table 2: Effect of composted Tithonia-biomass and N-mineral fertilizer on different growth parameters

Treatment combinations	Plant height (cm)	Stem circumference (cm)	Leaf area (cm^2)	No. of branches	Taproot length (cm)
C0N0	43.8d	0.9c	16.1c	05.2c	22.1c
C0N1	50.6d	1.2c	17.5c	07.8bc	25.6c
C0N2	61.1c	1.9c	20.6bc	10.4b	29.2bc
C1N0	84.4ab	2.4ab	26.3ab	08.4bc	31.7b
C1N1	89.8a	2.8a	32.8a	18.6a	41.2a
C1N2	67.7c	2.3ab	28.1ab	09.8b	30.4b
C2N0	87.6a	2.0b	25.8b	12.4b	33.6b
C2N1	81.4b	2.2b	31.7a	17.6a	36.8a
C2N2	80.7b	2.6a	33.4a	19.1a	38.2a

Means followed by same letters are not significantly different at p = 0.05, using DMRT. C0 = no or zero application of composted tithonia-biomass, C1 = application of 3.0 tons ha^{-1} of composted tithonia-biomass, C2 = application of 6.0 tons ha^{-1}, N0 = no application of urea, N1 = application of 30 kg N ha^{-1} of urea and N2 = 60 kg N ha^{-1} of urea

Table 3: Effect of composted Tithonia-biomass and N-mineral fertilizer on some yield parameters

Treatment combinations	Days to 50% flowering	Number of fruits per plant	Fruit diameter (cm)	Fruit yield (tons ha^{-1})
C0N0	52.6c	17.6c	2.1d	06.2d
C0N1	54.1bc	20.7c	2.2d	08.1d
C0N2	55.2bc	20.4c	2.4d	10.1d
C1N0	55.4bc	31.4b	3.3c	16.3c
C1N1	73.6a	39.5a	4.6a	32.2a
C1N2	61.6b	35.1a	3.9b	28.6ab
C2N0	69.1ab	32.8b	3.8bc	27.8ab
C2N1	68.4ab	33.5b	3.6bc	26.8b
C2N2	76.2a	39.2a	4.2a	30.7a

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

Treatment combinations	Nitrogen uptake (g plant^{-1})	Phosphorus uptake (g plant^{-1})	Potassium uptake (g plant^{-1})
C0N0	00.47f	0.10e	0.38e
C0N1	02.85e	0.49d	2.17d
C0N2	03.72d	0.51d	2.62c
C1N0	04.89d	0.55d	0.82e
C1N1	12.12a	1.64a	4.81bc
C1N2	12.09a	1.46b	8.11a
C2N0	10.10b	1.49b	5.16b
C2N1	11.46a	1.45b	6.08a
C2N2	07.91c	1.28c	5.02b

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 as earlier reported by Smith and Hadley (1992), Akanbi and Ojeniyi (2003), Akanbi *et al.* (2005) and Adeniyan *et al.* (2003), for onion, grain amaranth, tomato and maize, respectively. The highest N and P contents determined in the plant tissues were 12.12 and 1.64 g plant^{-1} being recorded for plants, which received a combined application of 3.0 tons ha^{-1} compost and 30 kg N ha^{-1} urea. After this level, the nutrient uptake values declined to the extent that plant, which received the highest dosage of both the organic (6.0 tons ha^{-1} tithonia compost) and inorganic (60 kg N ha^{-1} urea) materials, had as low as 7.91 and 1.28 values for N and P uptake, respectively (Table 4). K uptake is contrary to that of N and P. The value of the highest P uptake was 8.11 g plant^{-1} obtained from plant, which received a combined application of composted tithonia (3.0 tons ha^{-1}) and urea (60 kg N ha^{-1}). Further more, a significant delay in flowering was observed in those maximally fed plants, which received highest dosage of both fertilizer materials. Such, undesirable delayed flowering/fruiting may be connected to possible aggressive consumption of the excessively available nitrogen by the crop-plant, which may favour a luxuriant vegetative growth, at the expense of reproductive growth and development (Akanbi *et al.*, 2005).

CONCLUSION

Mineral fertilizers are generally highly-priced and therefore, mostly unaffordable, particularly for the resource-poor local farmers. Moreso, Nitrate pollution of the underground water, is currently a serious problem associated with usage of synthetic or inorganic fertilizers, especially, in the tropics. Tithonia is a very common 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. Therefore, since this wild plant is freely and readily available on most farmlands, beside highways, waterways and wasteland, an adoption of a low input technology, which incorporates tithonia as either a substitute or supplement to inorganic fertilizer, may be beneficial to sustainable crop production in the tropics. Composted tithonia-biomass alone can successfully supply an appreciable level of nutrients to plant to attain a yield, which is comparable to others derived from combined application of inorganic fertilizers and some other plant residues. Therefore, combined application of 3.0 tons ha^{-1} of composted tithonia-biomass and 30 kg N ha^{-1} urea or sole application of 6.0 tons ha^{-1} of composted tithonia-biomass is recommended, for optimum growth, development and yield of tomato in south-western Nigeria.

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