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COMPARATIVE EVALUATION OF MODIFIED NEEM LEAF AND WOOD ASH EXTRACTS ON SOIL FERTILITY STATUS GROWTH AND FRUIT YIELDS OF TOMATO (*Lycopersicon esulentum* L)

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ABSTRACT
Two field experiments were carried out at Akure (7^{o}N, 5^{o} 10^{1} E) in the rainforest zone of Nigeria in 2006 and 2007 to determine the effectiveness of neem leaf, wood ash and modified neem leaf extracts as fertilizer sources in improving soil fertility, growth and fruit yields of tomato (*Lycopersicon esculentum* L). There were six treatments namely, poultry manure, neem leaf extract (sole), wood ash extract (sole), NPK 15-15-15 and a control (no fertilizer nor extract), replicated three times and arranged in a randomized complete block design (RCB). The extracts (neem leaf, wood ash and modified neem leaf) were applied at 1200 litres per hectare each, NPK 15-15-15 at 300kg/ha and poultry was applied at 6t/ha. The results showed that there were significant increases ($P<0.05$) in the growth, fruit yield of tomato and soil N, P, K, Ca, Mg, pH and O.M under different treatments compared to the control treatment. For growth parameters, modified neem leaf extract had the highest values of plant height, stem girth, leaf area and number of branches of tomato plants compared to the poultry manure, neem leaf and wood ash extract (sole application). For-example, modified neem leaf extract increased the plant height, stem girth, number of branches and leaf area by 13.2%, 9.5%, 17.3% and 30% respectively compared to neem leaf extract. When compared to NPK 15-15-15 fertilizer, modified neem leaf extract increased plant height, stem girth, number of branches and leaf area of tomato plants by 2%, 5.4%, 3.4% and 31%. For the fruit yields, modified neem leaf extract increased most the tomato fruit weight and diameter compared to poultry manure, neem leaf extract, wood ash extract and NPK 15-15-15 fertilizer. For-instance, modified neem leaf extract increased tomato fruit weight and diameter by 44% and 7% compared to neem leaf extract (sole). Also, when compared to poultry manure, it increased the tomato fruit weight and diameter by 25% and 14% respectively. In-addition, modified neem leaf extract increased the tomato fruit weight and diameter by 16% and 9.2%% respectively compared to NPK 15-15-15 fertilizer. For soil chemical composition, modified neem leaf extract had the highest values of soil O.M, N, P, K, Ca and Mg compared to neem leaf, wood ash extracts and poultry manure respectively. When compared to NPK 15-15-15 treatment, it increased soil pH, O.M, K, Ca and Mg by 14%, 78%, 30%, 95% and 93% respectively. However, NPK increased soil N and P more than modified neem leaf extract.The high soil K/Ca, K/Mg and P/Mg ratios in the NPK 15-15-15 fertilizer treatment led to an imbalance in the supply of P, K, Ca and Mg nutrients to tomato.The least values for growth, yield and soil parameters were recorded under the control treatment. In these experiments, modified neem leaf extract (wood ash + neem leaf extract) applied at 1200 litres/ha was the most effective in improving soil fertility, growth and yield of tomato and could substitute for 6 tonnes/hectare of poultry manure and 300kg/ha of NPK 15-15-15 fertilizer.

KEY WORDS: Modified Neem leaf, neem leaf, wood ash extracts, tomato and poultry manure.

INTRODUCTION

Tomato (*Lycopersicon esculentum* L) belongs to the family Solanacea and it is grown for its edible fruits which are eaten raw as salads or ground into paste for delicious soups or are made into puree ketch up in canning industries (Adekiya, 2009). In Nigeria, despite the economic importance of the crop, its optimum yield has not been attained and this is because tomato is cultivated on the same piece of land continuously due to increasing rate of population yearly which has led to serious fertility decline. Efforts to improve the soil nutrient status for increased production through the use of inorganic fertilizers are limited by high cost of purchase and deterioration of soil properties on continuous use (Moyin-Jesu, 2009).

Further attempt to solve these problems led to the use of organic fertilizers to grow crops but the problem of transporting these materials because of their bulkiness discouraged its use by farmers. This scenario has led to the research to exploit extracts from neem leaf, wood ash and their mixture named as modified neem leaf to grow tomato. Apart from the research works of Ayoade (1977), Ivbijaro (1983) and Moyin-Jesu (2010) on the use of neem leaf, wood ash extracts and modified neem leaf extract to control pests in maize and cowpea, there are scarcity of research on the use of modified neem leaf, wood ash and neem leaf extracts as source of fertilizers for growing tomato. Therefore, the objectives of the research study are to (i) determine the effect of neem leaf, wood ash and modified neem leaf extracts on the growth and yield of tomato (ii) determine the effect of these extracts on the soil properties after harvesting of tomato.

MATERIALS AND METHODS

Description of the Study Area

The experiment was carried out at Akure (7^oN 5^o10^1 E) in the rainforest zone of Nigeria in 2006 and was repeated in 2007 to validate the results. The rainfall is between 1100 to 1500mm per annum and the temperature is 24^oC. The soil is sandy, clay, loam, skeletal, kaolinitic, isohyperthermic oxic paleustalf (Alfisol). Soil survey staff (1999). The site had been continuously cropped for five years.

Soil sampling and analysis before planting

Thirty core soil samples were collected randomly from 0-15cm depth on the site using soil auger, mixed thoroughly, bulked, air-dried and sieved to pass through a 2mm sieve for chemical analysis. The soil pH (1:1 soil/water) and (1:2 soil/0.01N $CaCl_2$) solution was read on pH meter while organic matter was determined using wet oxidation method through chromic acid digestion (Walkley and Black, 1934). The percent nitrogen was determined by the micro-kjedahl method (AOAC, 1970) while available soil phosphorus was extracted using Bray P1 extractant, measured by the blue colouration on spectronic 20 at 882 um (Murphy and Riley, 1962). The soil K, Ca, Mg and Na were extracted using I.M NH_4OAC pH_7. The extracts of K, Ca and Na were read on flame photometer while Mg was determined by an atomic absorption spectrophotometer (Jackson, 1958). Exchangeable acidity (H^+ and Al^{3+}) were determined using 0.01M HCl extracts and titrated with 0.01M NaOH (McLean, 1965) while the micronutrients (Mn, Fe, Cu and Zn) were extracted with 0.1M HCl (Ogunwale and Udo, 1978) and read on Perkin Elmer atomic absorption spectrophotometer. The % sand, silt and clay were determined by hydrometer method (Bouycours, 1951).

Source and analysis of the experimental materials used for the experiment

Neem leaves, wood ash and poultry manure were obtained from the paddock unit, cassava processing and poultry farm units at Teaching and Research farm, Federal College of Agriculture, Akure. NPK 15-15-15 fertilizer was obtained from Ondo State, Agricultural Development Project Akure. Tomato seeds were obtained from Nigeria Institute for Horticultural Research, Ibadan.

Procedure for Preparation and Application of Extracts used for the Experiment

The preparation of neem leaf extract was done by weighing 10kg of fresh neem leaves, chopped into bits using a knife, immersed in a plastic container containing 50 litres of water, kept under a shade tree and properly covered to prevent evaporation of the liquid. The solution was stirred every three (3) days to allow proper leaching of the nutrients in the leaves into the water until the 14^{th} day. Thereafter, the leaves were carefully removed using 2mm sieve to obtain clean neem leaf extract. The extract is diluted at a ratio of 1:1 to reduce the concentration of the extract and thereby prevent scorching of the plants. The extract was applied to the crop at 3 litres per plot (1200L/ha). Wood ash extract was prepared by weighing 10kg of sieved wood ash into 50 litres of water in a plastic, thoroughly stirred with paddle every 3 days to enhance proper leaching of nutrients. This continued until the 14^{th} day of setting up the experiment. The suspension was properly sieved to obtain clear suspension of the wood ash extracts. The solid component of the wood ash was properly disposed off to prevent environment pollution. The liquid wood ash extract was also diluted at a ratio of 1:1 with water to reduce concentration and applied to the crop at 3 litres per plot (1200L/ha). The required quantities of neem leaf and wood ash extracts were obtained by setting up their preparation simultaneously. Modified neem leaf extract was prepared by taking 50% of the concentrated neem leaf extract and 50% concentrated wood ash extract, mixed together thoroughly, diluted at a ratio of 1:1 with water and applied at 3 litres per plot (1200L/ha). The poultry manure was collected, air-dried, stacked properly and applied at 6t/ha while NPK 15-15-15 fertilizer was applied at 300kg/ha.

Field Experiment

The land was cleared, ploughed, harrowed and divided into plots of 5x5m ($25m^2$) each. There were six treatments namely neem leaf extract wood ash extract and modified neem leaf extract applied at 3 litres per $25m^2$ plot (1200L/ha), poultry manure was applied at 6t/ha, NPK 15-15-15 fertilizer applied at 300kg/ha as a reference treatment and a control (no fertilizer nor manure). They were replicated three times and arranged in a randomized complete block design (RCB).

Seedlings of tomato seeds (Roma variety) from the nursery after 2 weeks of planting were transplanted into the laid out plots at one stand per hole at a spacing of 90cmx60cm. Weeding was carried out promptly at 3, 6 and 9 weeks after transplanting. The plants were also sprayed against insect attack using karate (i.e. 25g lambda-cyhalotron per litre) at 10ml per 10L of water every three weeks interval to control leaf defoliating insects. Six plants each were sampled in each plot on which the measurement for plant height, stem girth, leaf area and number of branches were determined starting from two weeks after transplanting and continued 10 weeks after transplanting. At 15 weeks after transplanting, harvesting of tomato fruits started and continued every 3 days interval until senescence. The fruits weight (kg/ha) and diameter (cm) were determined.

Soil analysis after the experiment

Soil samples were taken from each treatment plot at the end of the experiment, air-dried and sieved for routine analysis of soil N, P, K, Ca, Mg, pH and organic matter (O.M.) as described in the earlier section.

Statistical Analysis

The data collected from the treatment effects of the organic extracts on the growth and yield parameters of tomato crop were analysed using the ANOVA F-test technique and their means were separated and compared using the Duncan Multiple Range Test (DMRT) at 5% level (Gomez and Gomez, 1984).

RESULT

Soil Fertility Status before Planting

Table 1 presents the soil fertility status before planting tomato. The soil is slightly acidic and the soil organic matter (O.M) is 0.68% which is below 3% recommended for crop production in Nigeria (Agboola and Corey, 1973). The available soil P(mg/kg) is 5.05 which is far below the 10mg/kg P recommended as critical level for crops in

South West Nigeria while the soil N content is also very low 0.06% compared to the critical level of 0.15% N recommended by Sobulo and Osiname (1981). The exchangeable bases (K^+, Ca, Mg and Na) are very low below the 0.2 mmol/kg soil while the soil texture is sandy loam.

TABLE 1: Soil fertility evaluation before planting tomato

Soil properties	Values
Soil pH (H_2O)	5.45
Soil pH 0.01M $CaCl_2$	5.30
Organic matter (%)	0.68
Nitrogen (%)	0.06
Available P (mg/kg)	5.05
Exchangeable bases	
K^+ (mmol/kg)	0.10
Ca^{2+} (mmol/kg)	0.11
Mg^{2+} (mmol/kg)	0.09
Al^{3+} (mmol/kg)	1.40
Fe (mg/kg)	8.50
Zn (mg/kg)	3.70
Mn (mg/kg)	1.80
Cu (mg/kg)	2.00
Sand (%)	79.10
Silt (%)	15.20
Clay (%)	5.70

Chemical composition of the extracts used for the experiment

Table 2 presents the data on the chemical composition of the treatments used for the experiment. Among the extracts, modified neem leaf extract had the highest values of % N, P, K, Ca and Mg compared to wood ash and neem leaf extracts (sole forms). Neem leaf extract (sole) had higher values of % N and P than wood ash while wood ash extract also had higher values of % K, Ca and Mg than the neem leaf extract. Poultry manure had the highest values of % N and P than modified neem leaf, neem leaf and wood ash extracts respectively.

TABLE 2: Chemical composition of the treatments used

Treatment	N	P	K	Ca	Mg	Quantity Applied	
	→		% ←			Plot	hectare
Neem leaf extract	1.56	0.83	1.67	0.77	0.75	3L/25m^2	1200L
Wood ash extract	0.15	0.53	2.60	15.00	1.00	3L/25m^2	1200L
Modified neem leaf extract	3.69	1.10	3.2	15.66	1.53	3L/25m^2	1200L
Poultry manure	4.53	3.2	0.97	0.32	0.41	-	6t/ha

Growth parameters of tomato plants under different fertilizer treatments

There were significant increase ($P<0.05$) in the growth parameters of tomato plants such as plant height, stem girth, leaf area and number of branches under different fertilizer treatments compared to the control treatment (Table 3).

Among the extracts, modified neem leaf (neem leaf + wood ash extracts) treatment had the highest values of plant height, stem girth, leaf area and number of branches of tomato plants compared to neem leaf and wood ash sole application. For-example, the modified neem leaf extract increased the plant height, stem girth, number of branches and leaf area of tomato plants by 13.2%, 9.5%, 17.3% and 30% respectively compared to neem leaf extract. When compared to poultry manure, modified neem leaf extract increased the plant height, stem girth, number of branches and leaf area of tomato plant by 4.5%, 8.3%, 16.4% and 8.1% respectively. In-addition, the modified neem leaf extract also increased the plant height, stem girth, number of branches and leaf area of tomato plants by 2%, 5.4%, 3.4% and 31% compared to NPK 15-15-15 fertilizer respectively. With the exception of leaf area and number of tomato, poultry manure had higher value of plant height and stem girth than neem leaf extract. Generally, the least values of all the growth parameters of the crop were recorded under the control treatment where neither fertilizer nor extract was applied.

Yield parameters of tomato plants under different fertilizer treatments

There were significant increases ($P<0.05$) in the tomato fruit weight and diameter under different fertilizer extracts compared to the control treatment. Modified neem leaf extract had the highest values of tomato fruit weight and diameter compared to poultry manure, neem leaf extract, wood ash extract and NPK fertilizer. For-instance, modified neem leaf extract increased the tomato fruit weight and diameter by 44% and 7% compared to neem leaf extract respectively. In-addition, when compared to poultry manure, modified neem leaf extract increased

tomato fruit weight and diameter by 25% and 14% respectively. When compared to NPK 15-15-15 fertilizer, modified neem leaf extract increased the tomato fruit weight and diameter by 16% and 9.2% respectively. Generally, the control treatment (no fertilizer) had the least values of tomato fruit weight and diameter compared to other treatments.

TABLE 3: Growth parameters of tomato plants under different fertilizer treatments

Treatments	Plant height (cm)	Stem girth (cm)	Leaf area (cm^2)	Number of branches
Control	19.40[a]	1.16[a]	62.10[a]	2.70[a]
Poultry manure	44.25[c]	2.57[bc]	206.25[b]	4.85[c]
Neem leaf extract	40.25[b]	2.48[b]	233.30[e]	4.80[c]
Wood ash extract	40.25[b]	2.57[bc]	224.50[c]	3.40[b]
Modified neem leaf extract	46.35[de]	2.74[e]	333.50[f]	5.80[de]
NPK 15-15-15	45.50[d]	2.59[cd]	231.75[d]	5.60[d]

Treatment means within each group followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

TABLE 4: Yield parameters of tomato under different fertilizer treatments

Treatments	Fruit diameter (cm)	Fruit weight (kg/ha)
Control	16.00[a]	884.00[a]
Poultry manure	25.20[c]	1720.00[d]
Neem leaf extract	27.30[d]	1280.00[c]
Wood ash extract	22.20[b]	1200.00[b]
Modified neem leaf extract	29.30[e]	2280.00[f]
NPK 15-15-15	26.60[d]	1920.00[e]

Treatment means within each group followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

TABLE 5: Soil chemical composition after harvesting tomato under different fertilizer treatments

Treatments	Soil pH	%O.M	%N	P	K mg/kg	Ca	Mg mmol/kg
Control (no fertilizer)	5.20[a]	0.28[a]	0.03[a]	3.60[a]	0.03[a]	0.03[a]	0.06[a]
Poultry manure	6.00[b]	1.56[d]	0.07[c]	7.78[c]	0.39[e]	0.83[b]	0.68[b]
Neem leaf extract	6.20[c]	1.48[c]	0.06[b]	6.83[b]	0.34[c]	0.85[bc]	0.69[b]
Wood ash extract	6.60[e]	1.45[c]	0.06[b]	7.00[b]	0.36[cd]	1.15[d]	0.75[c]
Modified neem leaf extract	6.24[cd]	1.74[e]	0.08[cd]	8.10[cd]	0.42[f]	1.29[c]	0.83[d]
NPK 15-15-15	5.36[a]	0.37[ab]	0.20[e]	17.30[e]	0.29[b]	0.06[a]	0.05[a]

Treatment means within each group followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

Soil chemical composition after harvesting tomato under different fertilizer treatments

There were significant increases ($P<0.05$) in the soil chemical composition after harvesting under different treatment compared to the control treatment. The modified neem leaf extract had the highest values of soil O.M, N, P, K, Ca and Mg compared to poultry manure, neem leaf extract and wood ash extract. For-instance, modified neem leaf extract increased the soil O.M, N, P, K, Ca, Mg and pH by 10%, 12%, 3%, 7%, 55%, 18% and 3% respectively compared to poultry manure treatment. Modified neem leaf extract increased the soil pH, O.M, K, Ca and Mg by 14.0%, 78%, 30%, 95% and 93% compared to NPK 15-15-15 fertilizer treatment except soil N and P where NPK 15-15-15 increased the soil N and P by 65% and 53% more than the modified neem leaf extract. NPK fertilizer decreased the soil pH, O.M, K, Ca and Mg compared to neem leaf and wood ash extracts. The K/Ca, K/Mg and P/Mg ratios were very high 79:1, 82:1 and 99:1 compared

to that of 1:3, 1:2 and 1:9 in modified neem leaf extract treatment respectively.

DISCUSSION

The poor growth and yield performance of tomato in the control treatment was consistent with the fact that the soil was very low in nutrient contents. This observation was supported by Moyin-Jesu and Atoyosoye (2002) who had reported poor growth and yield responses of crop in soils that are not fertilized. Also, the lowest value of soil N, P, K, Ca and Mg in the control treatment was a reflection of poor soil fertility status. Therefore, there is need to ensure better soil fertilization for higher crop productivities in the tropics where soils are low in organic matter (O.M), exchangeable bases (K, Ca, Mg and Na) and high in soil acidity. The fact that NPK 15-15-15 fertilizer improved the vegetative growth (plant height, stem girth, leaf area and number of branches) of tomato is consistent with its better soil N and P nutrients status which are made more readily available in mineralized forms to tomato than their organic forms in the modified neem leaf, neem leaf extract, wood ash extract and poultry manure respectively. NPK 15-15-15 fertilizer also decreased soil Ca and Mg nutrients in plots grown to tomato which could be due to nutrient imbalance as reflected in high K/Ca, K/Mg and P/Mg ratios and this phenomenon affected uptake of Ca and Mg (Folorunso *et al*, 2000).

Furthermore, the low soil O.M, Ca and Mg in the NPK fertilized plot indicating low base saturation coupled with sandy loam texture might not allow much retention of nutrients because of soil erosion menace in the tropics. This observation could be responsible for the slight reduction in tomato fruits yield compared to the modified neem leaf extract which contained high Ca, Mg and O.M contents and subsequently increased soil fertility status for higher yield value of tomato and fruit diameter. The highest tomato fruits weight and diameter under modified neem leaf treatment could be due to the fact that it had the combined nutrient superiority of P, K, Ca, Mg and N compared to sole application of neem leaf and wood ash extracts. The positive impact of the balanced nutrient composition of modified neem leaf extract has translated to high yield of tomato fruits which signified higher economic returns and profitability for farmers. This observation was supported by Moyin-Jesu (2012) who reported superior performance of modified neem leaf extract in maize and watermelon intercrop. The performance of poultry manure in increasing the growth and fruits yield of tomato could be due to the fact that it has high contents of N and P which encouraged performance. In-addition, the uptake of nutrients (N, P, K, Ca and Mg) in liquid form from the modified neem leaf extract might be responsible for the better fruit yield performance compared to poultry manure which is in solid form and must be mineralized with adequate moisture in soils before the nutrients can be taken up by plant roots.

CONCLUSION & RECOMMENDATION

It could be concluded from the experiment that modified neem leaf (wood ash + neem leaf) extract gave the best fruit yield, diameter, growth parameters of tomato and improved the soil nutrients (N, P, K, Ca, Mg and O.M) compared to the poultry manure, wood ash and neem leaf extract (sole forms). It is recommended that for better fruit yield, diameter growth of tomato and improvement of soil nutrient status, application of modified neem leaf extract at 1200L/ha is appropriate. Therefore, the use of modified neem leaf extract could substitute for 300kg/ha of NPK 15-15-15 fertilizer and 6t/ha of poultry manure. It also reduced the problems of high cost of purchasing NPK 15-15-15 fertilizers as well as solving problems of bulkiness and difficulty in the transportation of organic wastes such as poultry manure. Above all, it will help to prevent environmental pollution and deterioration associated with continuous use of NPK 15-15-15 fertilizer.

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