Vol.3, No.1, 90-97 (2012)
http://dx.doi.org/10.4236/as.2012.31012

Agricultural Sciences

Comparative evaluation of modified neem leaf, neem leaf and woodash extracts on soil fertility improvement, growth and yields of maize (*Zea mays* L.) and watermelon (*Citrullus lanatus*) (sole and intercrop)

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Received 10 September 2011; revised 18 November 2011; accepted 16 December 2011

ABSTRACT

Two field experiments were carried out at Akure (7°N, 5°10′E) in the rainforest zone of Nigeria in 2006 and 2007 to determine the effectiveness of neem leaf, woodash and modified neem leaf extracts as fertilizer sources in improving soil fertility, growth and yield of maize (*Zea mays* L) and watermelon (*Citrulus lanatus*) sole and intercrop. There were six treatments namely, poultry manure, neem leaf extract (sole), woodash extract, modified neem leaf (neem leaf + woodash), 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 300 kg/ha and poultry was applied at 6t/ha. The results showed that there were significant increases ($P < 0.05$) in the maize growth and yield parameters (leaf area, plant height stem girth) grain yield, cob weight and % shelling percentage) as well as in watermelon (vine length, stem girth, number of branches, fruits weight, population and fruit diameter) under sole and intercrop compared to the control treatment. Generally, the growth and yield parameters values were slightly higher under the sole crop than the intercrop. The modified neem leaf extract increased the plant height and stem girth of maize (sole) by 11.78% and 27.43% respectively compared to that of neem leaf extract and the same trend of increase was experienced in maize (intercrop) where modified neem leaf extract increased plant height and stem girth by 11.5% and 24.48% compared to neem leaf. Poultry manure also increased the maize leaf area (sole and intercrop) compared to the extracts and NPK 15-15-15. For instance, under maize (sole), the poultry manure increased the leaf area by 8.74% compared to NPK 15-15-15. For yield parameters of maize and watermelon (sole and intercrop), modified neem leaf increased most all values of yield parameters compared to neem leaf and woodash extract. For example, modified neem leaf increased the values of sole maize grain yield, cob weight by 65.63% and 57.58% respectively compared to neem leaf extract. The LER value for maize and watermelon (intercrop and sole) was 2.61 while relative yield is 1.575 or 157.5%. For soil fertility improvement after harvesting, modified neem leaf extract and poultry manure had the highest values of soil pH (H_2O), K, Ca, Mg, Na, O.M, P and N compared to NPK 15-15-15 and neem leaf extract. For instance, modified neem leaf extract increased soil pH (H_2O), K, Ca, Mg, Na, O.M, P and N by 12.4%, 32.8%, 25%, 23.7%, 19.32%, 17.24% and 20% respectively compared to neem leaf extract under intercrop plot. 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 maize and watermelon crops. The least values for growth, yield and soil parameters were recorded under the control treatment. In these experiments, modified neem leaf extract (woodash + neem leaf extracts) applied at 1200 litres/ha was the most effective in improving soil fertility, growth and yield of maize and watermelon (sole and intercrop) and could substitute for 6 tons per hectare of poultry manure and 300 kg/ha of NPK 15-15-15 fertilizer.

Keywords: Modified Neem Leaf; Neem Leaf; Wood Ash Extracts; Maize and Watermelon (Intercrop and Sole); Land Equivalent Ratio; Relative Yield; Poultry Manure

1. INTRODUCTION

Maize (*Zea mays* L) is a member of the family Graminae and it is an annual crop serving as a good source of food for human consumption in form of maize powder, maize meal and confectionaries such as bread, biscuits and cakes. It is also used for the production of livestock feeds, corn starch, and alcohol from maize grain [1].

Watermelon (*Citrillus lanatus* L) is an annual creeping crop belonging to the family Cucurbitaceae. Its juice is of high nutritional importance and it is used to prepare fruit salads, jams. It also has 92% water content, Vitamin C and other minerals [2].

Despite the economic importance of these two crops, maize and watermelon, it is observed that their maximum yields have not been attained due to the continuous cultivation of the crops on the same piece of land which has led to decline in yield output and poor soil fertility status.

Efforts aimed at improving the yields and increasing the soil fertility of both maize and water melon using inorganic fertilizers are limited by high cost of purchase and destruction of soil properties on continuous use.

Further attempts to find alternatives to inorganic fertilizers led to the introduction of solid organic fertilizers such as poultry manure, goat, wood ash and others to achieve sustainable production of crops [3-5]. Nevertheless, the bulkiness and difficulty in the transportation are the limiting factors to the adoption of organic wastes as fertilizers by farmers [6].

Further research efforts aimed at reducing the problems of using organic fertilizers led to the development and use of liquid fertilizer extracts from the neem leaves and wood ash. Except for the use of neem leaf and wood ash as insecticides [7,8], there is scarcity of research information on the use of neem leaf, wood ash extracts sole application or in combined form (*i.e.* modified neem leaf + wood ash extracts) as fertilizers to grow maize and water melon (sole and intercrop).

The objectives of this research are as follows:

1) To determine the effect of neem leaf and wood ash extracts on the growth and yield of maize and watermelon (sole and intercrop).

2) To determine the effect of these liquid extract fertilizers on the soil chemical composition of maize and watermelon.

3) To determine the land equivalent ratio (LER) and relative yield of maize and watermelon intercrop.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The experiment was carried out at Akure (7˚N 5˚10′E) in the rainforest zone of Nigeria in 2006 and was repeated in 2007 to validate the results. The rainfall is between 1100 to 1500 mm per annual and the temperature is 24˚C. The soil is sandy clay loam, skeletal, kaolinite, isohyperthermic oxic paleustalf (Alfisol) [9].

2.2. Soil Sampling and Analysis before Planting

Thirty core soil samples were collected randomly from 0 - 15 cm depth on the site using soil auger, mixed thoroughly, bulked, air dried and sieved to pass through a 2 mm sieve for chemical analysis.

The soil pH (1:1 soil/water) and (1:2 soil/0.01M $CaCl_2$) solution was determined using a glass calomel electrode system [10] while organic matter was determined by the wet oxidation chromic acid digestion method [11].

The total nitrogen was determined by the microkjedahl method [12] while available soil phosphorus was extracted by the Bray P1 extractant, measured by the blue colouration on spectronic 20 at 882 Um [13]. The soil K, Ca, Mg and Na were extracted using 1M NH_4OACpH_7. The extract of K, Ca and Na were read on flame photometer while Mg was determined with an atomic absorption spectrophotometer [14].

The exchangeable acidity (H^+ and Al^{3+}) were determined using 0.01M HCl extracts and titrated with 0.1M NaOH [15] while the micronutrients (Mn, Cu, Fe and Zn) were extracted with 0.1M HCl [16] and read on Perkin Elmer atomic absorption spectrophotometer. The mechanical analysis of the soil was done by the hydrometer method [17].

2.3. 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 units and poultry farm at Teaching and Research Farm, Federal College of Agriculture, Akure. NPK 15-15-15 was purchased from Ondo State Agric. Development Project Akure.

Maize (*hybrid oba super* 2) and watermelon seeds were obtained from Oyo State Agricultural Development Programme, Ibadan and Nigeria Institute for Horticultural Research, Ibadan respectively.

2.4. Procedure for Preparation and Application of Extracts Used for the Experiment

The preparation of neem leaf extract was done by

weighing 10 kg 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.

The solution was stirred every 3 days to allow proper leaching of the nutrients in the leaves into the water until the 14th day. Thereafter, the leaves were carefully removed using sieve of 2 mm to obtain clean neem leaf extract. It is diluted at a ratio of 1:1 to reduce the concentration of the extract of the extract to prevent scorching of the plants. The application of the extract to the crop is at 3 litres per plot.

Wood ash extract was prepared by weighing 10 kg 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 14th day of setting the experiment. The suspension was properly sieved to obtain clear suspension of the wood ash extracts. The remnants of wood ash solid components was properly disposed off to prevent environmental pollution.

The liquid wood ash extract was also diluted at a ratio 1:1 with water to reduce concentration and applied to the crops at 3 litres per plot. The required quantities were obtained by setting up the preparation of the neem leaf and wood ash extracts simultaneously.

Modified neem leaf extract was prepared by taking 50% of concentrated neem leaf extract and 50% of concentrated solution of wood ash extract, mixed together thoroughly, diluted at a ratio of 1:1 with water and applied at 3 litres per plot.

Poultry manure was collected, air dried, stacked properly and applied at 6t/ha while NPK 15-15-15 fertilizer was applied at 300 kg/ha.

2.5. Field Experiment

The land was cleared, ploughed and harrowed, divided into plots and each plot size is 5 m × 5 m (25 m^2).

Maize variety (*hybrid oba super* 2) and water melon (*Citrulus lanatusi*) seeds were planted in early 2006 at a spacing of 80 × 40 cm for sole maize, 90 × 60 cm for sole watermelon and 70 × 45 cm for maize and watermelon intercrop.

There were six treatments namely neem leaf extract (3 litres per plot or 44 ml per stand), wood ash extract, modified neem leaf extract applied (3 litres per plot or 44 ml per stand), poultry manure (6 t/ha^{-1}) or 220 g per stand, NPK 15-15-15 fertilizer applied at 300kg/ha and a control (no fertilizer nor manure), replicated three times and arranged in a randomized complete block design (RCBD).

Weeding operation was first done at 2 weeks after planting and continued at 2 weeks intervals until the peak of flowering. The plant population for the sole maize was 78 stands, watermelon (sole) was 46 stands and for the maize and watermelon (intercrop) was 79 for each (158 stands). Six plants of maize were sampled in each plot on which the following parameters for plant height (cm), leaf area (cm^2) number of tassels and stem girth (cm) were taken.

At 18 weeks after planting, maize cobs were harvested dehusked and dried to 13% moisture content, shelled and the grains were weighed for yield determination.

For watermelon, six plants were sampled also in each plot on which the vine length (cm), stem girth (cm), number of branches, from 2 weeks after planting till 5 weeks after planting. At flowering, data on days to first flowering were taken and at harvest (12 weeks after planting), yield parameters such as fruit population, fruit weight, fruit length (cm) and fruit diameter (cm).

The land equivalent ratio (LER) was calculated using the formula.

$$\text{LER} = \frac{\text{Yield of maize(sole) kg}}{\text{Yield of maize + water melon (kg)}} + \frac{\text{Yield of watermelon (sole) kg}}{\text{Yield of maize + water melon (kg)}}$$

While the relative yield of both water melon and maize is calculated from the formula.

RY = O/M where O is the yield of the intercrop and M = yield of the sole crop and it can also be expressed in percentage by multiplying with 100%; % RY = O/M × 100.

2.6. Soil Analysis after the Experiment

Soil samples were taken from each plot, air dried, sieved with 2 mm sieve, analysed for soil pH, O.M, N, P, K, Ca and Mg as described earlier.

2.7. Statistical Analysis

The data collected from the treatment effects of the extracts on the growth parameters yield, leaf and soil chemical composition of maize (sole) water melon (sole) and maize + water melon (intercrop) 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 of significant [18].

3. RESULTS

3.1. Soil Fertility Status before Planting

Table 1 presents the soil fertility status before planting water melon and maize. The sole is slightly acidic and the soil organic matter (O.M) is 0.69% which is less than 3% recommended for crop production in Nigeria [19].

The available soil P (mg/kg) is 5.06 mg/kg which is for below the 10 mg/kg P recommended as critical level

Table 1. Soil fertility status before planting maize/water melon intercrop.

Soil parameters	Values
Soil pH (H_2O)	5.45
Soil pH 0.01 M $CaCl_2$	5.32
Organic matter (%)	0.69
Nitrogen (%)	0.07
Available P (mg/kg)	5.06
Exchangeable bases	
K^+ (mmol/kg)	0.10
Ca^{2+} (mmol/kg)	0.11
Mg^{2+} (mmol/kg)	0.09
Al^{3+} (mmol/kg)	1.45
Fe (mg/kg)	8.50
Zn (mg/kg)	3.75
Mn (mg/kg)	1.80
Cu (mg/kg)	2.0
Sand (%)	79.10
Silt (%)	15.20
Clay (%)	5.70

in South West Nigeria while the soil N content is also very low 0.07% compared to the critical level of 0.15% N recommended by [20]. 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.

3.2. 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). The sole form of neem leaf had better values of % N and P than wood ash. Wood ash extract had higher values of % K, Ca and Mg than neem leaf. Poultry manure had highest values of N and P (376 mg/kg) when compared to modified neem leaf, neem leaf and wood ash extracts.

3.3. Growth Parameters of Maize and Water Melon (Sole and Intercrop under Different Treatments

There were significant increases ($P < 0.05$) in the growth parameters such as plant height, stem girth, vine length and number of branches in maize and water melon (sole and intercrop) under different fertilizer treatments compared to the control treatment (**Tables 3** and **4**).

Generally, the values of plant height and vine length and number of branches of maize and water melon were slightly higher under sole crop than the intercrop. Except, the leaf area of maize plant and stem girth of water melon plant which were better under intercrop than the sole crops.

The modified neem leaf extract increased the plant height and stem girth of maize (sole) by 11.78% and 27.43% respectively compared to that of neem leaf extract and the same trend of increase was experienced in the maize (intercrop) where modified neem leaf extract also increased the plant height and stem girth by 11.51% and 24.48% compared to neem leaf extract. However, poultry manure slightly increased the leaf area values for maize (sole and intercrop).

In-addition, modified neem leaf extract under water melon (sole and intercrop) had the highest values of vine length, stem girth and number of branches compared to neem leaf extract, woodash extract, poultry manure and NPK 15-15-15 fertilizers respectively.

For instance, the modified neem leaf extract increased the vine length, stem girth and number of branches of water melon (sole) by 27.9%, 15.5% and 9.2% compared to NPK 15-15-15 fertilizer respectively.

Finally, the least values of all growth parameters in both maize and water melon (sole and intercrop) were obtained under the control treatment which did not receive any fertilizer treatment.

Table 2. Chemical composition of the treatment solutions.

Treatments	N	P	K	Ca	Mg	Quantity Applied	
			%			plot	hectare
Neem leaf extract	3.56	0.83	1.67	0.77	0.75	3 L/25 m^2	1200 L
Wood ash extract	0.15	0.53	2.60	15.00	1.00	3 L/25 m^2	1200 L
Modified neem leaf	3.69	1.10	3.2	15.66	1.53	3 L/25 m^2	600 L + 600 L
Poultry manure	4.53	3.2	0.97	0.32	0.41		6 t/hectare

Table 3. Growth parameters of maize (sole and intercrop) under different fertilizer treatments.

Treatments	Sole Plant height (cm)	Stem girth (cm)	Leaf area (cm^2)	Intercrop Plant height	Stem girth	Leaf area (cm^2)
NPK 15-15-15	69.66b	4.82bc	378.41d	68.33b	4.89b	382.23c
Neem leaf extract	69.73b	4.71b	312.29b	69.68b	4.75b	330.78b
Poultry manure	72.13c	5.24d	411.25e	72.37c	5.13c	407.32e
Woodash extract	74.29d	5.66d	375.30c	72.94c	5.92d	397.35d
Modified neem leaf extract	79.04e	6.49e	387.80d	78.75d	6.21e	381.16c
Control	54.69a	3.86a	254.07a	55.00a	3.73a	255.1a

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

Table 4. Growth parameters of watermelon (sole and intercrop) under different fertilizer treatments.

Treatments	Sole Vine length (cm)	Stem girth (cm)	Number of branches	Intercrop Vine length (cm)	Stem girth (cm)	Number of branches
NPK 15-15-15	79.79c	2.39b	11.32b	12.46e	2.23b	10.123c
Neem leaf extract	73.26b	2.55c	11.02bc	75.52b	2.59c	10.123c
Poultry manure	99.21d	2.69d	11.93cd	99.75d	2.59c	10.123c
Woodash extract	102.81e	2.69d	10.55b	99.07d	2.72d	9.93b
Modified neem leaf extract	110.64f	2.83e	12.46e	106.76e	2.93e	11.94de
Control	61.97a	2.83e	12.46e	57.25a	1.63a	8.14a

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

3.4. Yield Parameters of Maize and Water Melon (Sole and Intercrop under Different Fertilizer Treatments

There were significant increases ($P < 0.05$) in the grains weight, cob weight and shelling percentages, (**Table 5**) fruits population, fruit weight and fruit diameter of watermelon (**Table 6**) for sole and intercrop under different fertilizer treatments compared to the control treatment.

Generally the grain yield of maize, fruit weight population, weight and diameter of water melon were higher in values under sole crop than their intercrop.

The modified neem leaf increased the values of grain yield, cob weight and shelling percentage both in maize (sole and intercrop) compared to neem leaf extract, wood ash extract, poultry manure and NPK 15-15-15 fertilizer respectively. For example, modified neem leaf extract increased the grain weight, cob weight and shelling percentage by 65.63%, 57.5% and 46.42% compared to the neem leaf extract under maize sole crop.

In-addition, modified neem leaf extract under watermelon (sole crop) increased the fruit weight, length and diameter by 25.39%, 23.73% and 14.58% respectively compared to neem leaf extract. The same trend was noticed in the watermelon (intercrop) for modified neem leaf extract compared to the neem leaf extract and woodash extract, poultry manure and NPK fertilizers respectively.

However, poultry manure and NPK 15-15-15 fertilizers treatment increased the fruit weight, length and diameter of watermelon (sole and intercrop) compared to neem leaf extract (sole). For instance, poultry manure increased the fruit weight, fruit length and fruit diameter of water melon (sole crop) by 16.18%, 15.89% and 6.51% respectively compared to neem leaf extracts.

The land equivalent ratio (LER) value for maize and watermelon (sole and intercrop) was 2.61 while the relative yield percentage was 1.575 (157.5%). The fact that LER value was greater than 1 and the higher relative yield parameter signified that the maize and watermelon (intercrop) was compatible.

The implication is that maize contributed 64% (0.64) and melon 92.9% (0.929) to the intercrop in term of relative yield which signified the compatibility of the intercrop.

3.5. Soil Chemical Composition after Harvesting under Different Fertilizer Treatments

There were significant increases ($P < 0.05$) in the soil nutrient status both in plots sole and intercrop of maize

Table 5. Yield parameters of maize (sole and intercrop) under different fertilizer treatments.

Treatments	Sole			Intercrop		
	Grain Weight (kg)	Cob Weight (kg)	Shelling percentage (%)	Grain Weight (kg)	Cob Weight (kg)	Shelling percentage (%)
NPK 15-15-15	2.52b	6.80c		2.15c	4.35d	
Neem leaf extract	2.20b	5.60b		1.65b	3.20b	
Poultry manure	3.25c	7.90d		1.70b	3.85bc	
Woodash extract	4.50d	10.25e		3.00d	6.20e	
Modified neem leaf extract	6.40e	13.20f		3.85e	7.80f	
Control	1.10a	3.50a		1.20a	2.50a	

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

Table 6. Yield parameters of watermelon (sole and intercrop) under different fertilizer treatments.

Treatments	Sole				Intercrop			
	Number of fruit	Fruit Weight (cm)	Fruit length (cm)	Fruit diameter (cm)	Number of fruit	Fruit Weight (cm)	Fruit length (cm)	Fruit diameter (cm)
NPK 15-15-15	12c	3.60cd	10.30cd	67.83d	07d	3.40d	10.10c	64.80d
Neem leaf extract	10b	2.85b	9.00b	61.33b	07d	2.90b	9.50b	60.40b
Poultry manure	12c	3.40c	10.70d	65.60c	05c	3.35d	10.80e	63.30c
Woodash extract	12c	2.90b	10.10c	62.10b	04b	2.60a	10.80e	64.80d
Modified neem leaf extract	14d	3.82e	11.80e	71.80e	09e	3.20c	10.90f	70.13e
Control	06a	2.65a	8.20a	60.53a	03a	2.60a	8.10a	57.17a

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

and watermelon after harvesting compared to the control treatment (**Table 7**). Generally, the values for soil O.M, N, P, K, Ca and Mg in the intercrop plots were slightly higher than the nutrients in the sole plots.

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 (sole application) in the intercrop.

For instance, modified neem leaf extract increased the soil O.M, N, P, K, Ca, Mg and pH by 5%, 10%, 6.2%, 6.8%, 18.5% and 45% respectively compared to poultry manure treatment under plots of maize/water melon intercrop plots. The same trend of performance was also observed under the sole crop plots.

Modified neem leaf, extract increased the soil pH, O.M, K, Ca and Mg by 6.4%, 78%, 38%, 95.4%, and 93% compared to NPK 15-15-15 fertilizer treatment in maize/watermelon intercrop plots increased soil N and P more than the modified neem leaf extract.

NPK 15-15-15 fertilizer decreased the soil pH O.M, K, Ca and Mg compared to neem leaf and wood ash extracts. The same trend was observed in the sole crop plots.

4. DISCUSSION

The poor growth and yield performances of maize and watermelon (sole and intercrop) in the control treatment was consistent with the fact that the soil was very low in nutrient contents. This observation was supported by [21] who had reported poor growth and yield responses of crop in soil that is not fertilized. In-addition, the lowest soil N, P, K, Ca and Mg values were also recorded in the crops sole and intercrops under the control treatment.

Therefore, there is need to ensure better fertilization of soils in the tropics to enhance productivity of crops because the soils are usually low in organic matter (O.M), exchangeable bases K, Ca, Mg and Na and high acidity.

The fact that NPK fertilizer improved the shoot and vegetative growth of maize and watermelon is consistent with its better soil N and P status which were made more readily available to crops than their organic forms in the modified neem leaf, neem leaf extract, wood ash extract and poultry manure respectively. NPK 15-15-15 fertilizer

Table 7. Soil chemical composition after harvesting for maize/watermelon (sole and intercrop) plots under different fertilizer treatments.

Treatments	Intercrop (plots)							Sole plots						
	Soil	O.M	N	P	K	Ca	Mg	Soil	O.M	N	P	K	Ca	Mg
	pH	%	%	mg/kg		mmol/kg		pH	%	%	mg/kg		mmol/kg	
Neem leaf extract	6.25d	1.44b	0.08b	6.96b	0.36bc	1.00b	1.00b	6.20d	1.40c	0.06b	6.83b	0.34c	0.85b	0.69b
Poultry manure	6.10c	1.66e	0.09bc	7.89d	0.41d	1.25c	0.84d	6.00c	1.56e	0.07c	7.78d	0.39d	1.10c	0.81cd
Woodash extract	6.80f	1.51bd	0.09bc	7.09c	0.39c	1.29d	0.78c	6.60f	1.45d	0.06b	7.00bc	0.36cd	1.15cd	0.75c
Modified neem leaf extract	6.34d	1.74f	0.10c	7.09c	0.48e	1.31e	0.88e	6.24de	1.68f	0.08d	8.10e	0.42f	1.29e	0.83e
NPK 15-15-15	5.38ab	0.38b	0.24d	17.5f	0.30b	0.06a	0.06a	5.36ab	0.37b	0.23b	17.3f	0.29b	0.06a	0.05a
Control	5.2a	0.28a	0.03a	3.6a	0.04a	0.03a	0.07a	5.20a	0.28a	0.03a	3.6a	0.03a	0.03a	0.06a

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

also decreased soil Ca and Mg nutrients both in sole and intercrop plots and this could be due nutrient imbalance in the soil as shown by high P/Mg and K/Ca ratio which affected Ca and Mg uptake [22]. Furthermore, the low soil O.M, Ca and Mg nutrients in the NPK fertilizer plot coupled with sandy loam texture, would not allow much retention of the nutrients as a result of erosion. This could be responsible for the slight reduction yields of maize and water melon crop (sole and intercrop) compared to the organic leaf extracts of neem and wood ash and poultry manure which improved soil pH, O.M, K, Ca and Mg, thereby supporting growth and yield performances.

The higher soil K, Ca and Mg nutrients under the modified neem leaf extracts constituted better soil base saturation and thereby increasing the soil cation exchange capacity, organic matter and pH, hence, the soils are capable of retaining nutrients and resist erosion better than the NPK fertilizer plots.

The growth of the associated melon crop with maize (intercrop) because of its creeping characteristics also protected the soil against erosion and thereby improved soil properties. This could be responsible for the better values of soil pH, O.M, N, P, K, Ca and Mg in the intercrop plots than the sole crop plots.

This observation was supported by [23] who reported that the soil covering provided by melon, curcibita pepo and other creeping crops guided against soil erosion, prevention of weeds growth and stabilizing soil buffering capacity for sustainable growth.

The best yield performance of maize and watermelon (sole and intercrop) using modified neem leaf extract could be attributed to the fact that it had the combined nutrient superiority of P, K, Ca, Mg, N compared to neem leaf and wood ash extracts (sole) application.

The positive effect of the balanced nutrient composition of modified neem leaf extract has translated to high yields of maize and water melon which signified higher economic returns and profitability for farmers. This observation was supported by [7] who reported superior performance of modified neem leaf extract. The performance of poultry manure in improving the growth and yield of maize and watermelon could be due to the fact that it had high amount of N and P which encouraged growth [24].

The relative yield of both maize and water melon was higher than 100% while the LER was 2.6. The implication was that maize and watermelon intercrop is compatible and efficient as crop combination in term of high yield advantages and efficient land use. This fact was corroborated by [25] and [26] who reported that LER > 1 in cassava groundnut and cassava/maize indicated high yield advantages and efficient land use.

5. CONCLUSION AND RECOMMENDATION

It could be concluded from the experiment that modified neem leaf extract gave the best yield performance in maize and watermelon (sole and intercrop). Watermelon grown with maize in the intercrop improved the soil nutrients (N, P, K, Ca and Mg) and increased the farmers harvest of the two crops leading to better economic returns. It is recommended that for better yield, land utilization and improvement of soil nutrient status, maize could be intercropped with water melon using 1200 L/ha of modified neem leaf extract as liquid fertilizer to the field for optimum yield.

Therefore, the use of modified neem leaf extract could substitute for 300 kg/ha of NPK 15-15-15 fertilizer and 6t/ha poultry. It also reduced the problems of high cost of

purchasing NPK 15-15-15 fertilizers as well as solving problems of bulkness and difficulty in the transportation of organic wastes such as poultry manure. Above all, it will help to prevent environmental pollution and deterioration of soil properties associated with continuous use of NPK 15-15-15 fertilizer.

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