

1 **Effects of water extracts of neem (*Azadirachta indica* L.) leaf,**
2 **wood ash and their mixture on soil chemical composition and**
3 **growth and yield of plantain (*Musa sapientum* L)**

4
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12
13 **ABSTRACT**

14 Sustainable plantain production in the tropics is limited by continued decline in
15 soil fertility, hence, an investigation was conducted between 2006 and 2009 to
16 evaluate the efficiency of water extracts of neem (*Azadirachta indica* L.) leaf, wood
17 ash and their mixtures on soil chemical composition, growth and yield parameters of
18 plantain (*Musa sapientum* L) in Akure in the rainforest zone of Nigeria.

19 Treatments with water extracts of the three plant materials: neem leaf, wood
20 ash, mixture of wood ash + neem leaf applied at 833.3L/ha, NPK 15-15-15 fertilizer
21 was applied at 300kg/ha and a control (no fertilizer nor liquid fertilizer extract),
22 replicated three times and arranged in a randomized complete block design.

23 The results showed that there were significant ($P<0.05$) increases in plantain
24 plant height, leaf area, stem girth, leaf population, weight of plantain bunches, fingers
25 weight, fingers diameter and population, total soil N available P, exchangeable K, Ca
26 and Mg under the different treatments compared to the control treatment.

27 For the growth parameters, the mixture of neem leaf and wood ash extracts
28 increased significantly ($P<0.05$), the leaf area and stem girth of plantain by 49.24%
29 and 12% respectively compared to neem leaf extract. For the yield performance of
30 plantain, the mixture of water extracts of neem leaf and wood ash increased the bunch
31 weight, finger weight, diameter, length and finger population by 39%, 41%, 3%, 36%
32 and 41.66% compared to neem leaf extract. Also, when compared with NPK 15-15-15
33 fertilizer, the mixtures of the two extracts increased plantain bunch weight, finger
34 weight, diameter, length and finger population by 29.7%, 31%, 6%, 8% and 25%
35 respectively.

36 In addition, the mixture of water extract of neem leaf and wood ash increased
37 soil pH, organic matter (O.M), K, Ca, and Mg by 14%, 78%, 31%, 95.5% and 94%
38 compared to NPK 15-15-15 fertilizer except N and P. The soil K/Ca, K/Mg and P/Mg
39 ratios were higher under NPK 15-15-15 fertilizer than the liquid extracts signifying
40 nutrient imbalance.

41 Mixture of water extracts of neem leaf and wood ash gave the best growth and
42 yield parameter of plantain and this was due to its nutrients superiority compared to
43 the other treatment.

44 **KEY WORDS:** Water extracts of neem leaf and wood ash, their mixtures, soil
45 chemical composition, growth and yield parameter of plantain.

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48 **INTRODUCTION**

49 Plantain (*Musa sapientum* L) belongs to the family Musaceae and it originated
50 from Malaysia. It is a herbaceous plant with short lived stalks which are corm like
51 rhizomes usually 1.8m tall. Plantain is a food crop eaten by people in the West, East
52 and Central Africa, interesting, it has become exportable crop which is consumed in
53 Europe, America and Asia. Plantain has high iron content, minerals and vitamins
54 which provide dietary needs of people for better health living and it is processed into
55 different food stuff such as plantain flour, snacks and chips which are highly sought
56 for in both local and international markets (1). Therefore, there is an enormous
57 increase in demand for the crop.

58 Total world production of the plantain and banana is estimated to be over 16
59 million metric tones out of which are estimated 12 metric tones are produced in Africa
60 annually. About 70 million people in African sub region are estimated to derive more
61 than one quarter of their food energy requirements from plantain. (2). In Nigeria, there
62 are some yield reduction constraints such as decline in soil fertility, pests and diseases
63 and weeds infestation that limit expansion (3).

64 Apart from medicinal value, neem leaf extract has many uses in plant
65 protection and production. Neem leaf extract can inhibit soil nematodes (4). Products
66 derived from neem leaf can act as powerful Insect Growth Regulation (IGR) and also
67 help in controlling several nematodes and fungi.

68 Neem products reduce insect growth in crops and plants. Thus, neem products
69 can be used as neem insecticide, neem pesticide, neem fumigant, neem fertilizer, neem
70 manure, neem compost, neem urea coating agent and neem soil conditioner (5), (6).
71 Neem seed extracts can reduce nitrification (7) of applied ammonium sulphate
72 fertilizers and leaching loss of nitrogen. Pot experiments showed that neem extract
73 could increase the use efficiency of chemical nitrogen significantly in soils (8).

74 In Bangladesh, wood ash is regularly used in banana plantations in terrace
75 areas. Farmers say wood ash prevents diseases and improves water use efficiency.
76 Wood ash is a good source of potash and lime; it also improves the pH of acidic soils
77 in a manner similar to agricultural lime (9).

78 Wood ash had long been regarded as a source of potassium for plant growth (1-
79 13% K by weight) but it also contains appreciable quantities of Ca (20-30%), P (0.3 –
80 0.4%), Mg (1 – 3%) and smaller amounts of S, Mn, Fe, B, Cu and Zn (10).

81 Despite the economic importance of plantain to the nation, it is regrettable to
82 note that maximum yields of the crop have not been attained. This is because of the
83 continuous cultivation on the same piece of land without fertilizer application which
84 has led to decline in soil fertility (11). Besides, the present hectareage of plantain is
85 very low because of subsistence farming and poor agronomic knowledge on the part
86 of farmers.

87 Efforts aimed at improving the yield and increasing the soil fertility led to the
88 uses of inorganic fertilizers but their use are limited by high cost of purchase
89 especially by poor resources farmers and the destruction of soil properties on
90 continuous use (12). Further attempts to find substitute for the use of chemical

91 fertilizers led to the use of solid organic fertilizers such as poultry, goat, pig and cattle
92 manures to achieve sustainable production but the problems of bulkiness and
93 difficulty in the transportation of such materials affected their adoption by farmers
94 (13).

95 In order to solve the above problem as well as preserving the environment,
96 there is need to explore the use of water extracts of wood ash, neem leaf and mixed
97 neem leaf and wood ash to grow crops. Except the works of (14), (15) and (16) on the
98 use of neem leaf and wood ash extracts to control pests in maize and cowpeas and as
99 source of fertilizers, there is scarcity of research information on the uses of water
100 extracts of neem leaf and their mixtures on the growth and yield parameters of
101 plantain. Mixed neem leaf + wood ash extract is made up of 50% each of neem leaf
102 and wood ash solution extracts.

103 The objectives of this study are to

- 104 i. Determine the effects of water extracts to wood ash, neem leaf + wood ash on
105 the growth and yield parameter of plantain.
- 106 ii. To determine the effect of the extracts on the soil chemical composition after
107 16 months of planting plantain.

108 **2.0 MATERIALS AND METHODS**

109 **2.1 Site description**

110 A field experiment to evaluate the effects of neem leaf extract , wood
111 ash extract and mixed extracts of neem leaf and wood ash on plantain in the
112 rainforest zone of Akure, Nigeria was conducted during 2006-2009.

113 The soil is sandy clay loam, skeletal, kaolintic, isohyperthermic oxic
114 paleustalf (Alfisol) (17). The annual rainfall is between 1100 and 1500mm
115 while the temperature ranged between 29°C – 32°C per annum.

116 **2.2 Collection and analysis of the extracts**

117 Wood ash and neem leaf were collected from the cassava processing unit and
118 neem leaf plantation in Federal College of Agriculture, Akure while the NPK 15-15-
119 15 fertilizer was purchased from Ondo State Agricultural Input Supply Agency. The
120 plantain suckers were collected from the Nigeria Institute for Agricultural Research,
121 Ibadan.

122 The preparation of neem leaf extract was done by weighing 10kg of fresh
123 leaves, chopped into bits using a knife, immersed in a plastic container containing
124 50litres of water, kept under a shade and properly covered. The solution was stirred
125 every three days to allow proper leaching of the nutrients into the water until the 14th
126 day. Thereafter, the leaf were carefully removed using a sieve of 2mm to obtain clean
127 neem leaf extract and diluted at a ratio of 1:1 to reduce the concentration of extracts as
128 well as preventing scorching of the plants. The application of the extracts is at 3L per
129 plot (833.33 L/ha).

130 Wood ash extract was prepared by weighing 10kg of sieved wood ash into 50
131 litres of water in a plastic, thoroughly stirred with paddle every three days to enhance
132 proper leaching of nutrients. This continued until the 14th day of setting up the
133 experiment and the suspension was properly sieved to obtain clear wood ash extracts.

134 The wood ash extract was also diluted at a ratio of 1:1 with water to reduce the
135 concentration and applied at 3L per plot. The remnants of wood ash solid components
136 was properly disposed to prevent contamination of the environment.

137 The required quantities of these two extracts were obtained by setting up
138 simultaneously in any of the above mentioned procedure for preparing the neem leaf
139 and wood ash extracts.

140 Mixed water extract of neem leaf and wood ash was prepared by taking 50% of
141 undiluted neem leaf extract and 50% of undiluted wood ash by volume, diluted at a
142 ratio of 1:1 with water and applied at 3L per plot while the NPK 15-15-15 fertilizer
143 was applied at 300kg/ha. 5ml each of the filtered extracts of neem leaf, wood ash and
144 mixed neem leaf + wood ash was analyzed for %N using microkjedahl method (18)
145 while soluble P, K, Ca and Mg contents were determined (19).

146 **TABLE 1: The chemical analysis of the extracts used for the experiment**

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Quantity applied per plot	Quantity applied Per hectare
Neem leaf extract	3.56	0.83	1.67	0.77	0.75	3L/36m ²	833.3L
Wood ash extract	0.15	0.53	2.60	15.00	1.00	3L/36m ²	833.3L
Mixed neem leaf + wood ash extract	3.69	1.10	3.20	15.66	1.53	3L/36m ²	833.3L

Table 1 presents the data on chemical composition of the extracts used for the experiment. Mixed water extract of neem leaf and wood ash 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 extract while the wood ash extract had higher values of % K, Ca and Mg than the neem leaf.

TABLE 2: Total amount of nutrients kg/nutrient supplied by each extract and NPK 15-15-15 fertilizer

Treatments	N	P	K	Ca	Mg
	Total kg/nutrient				
++ Neem leaf extract	148.327	34.58	69.58	32.08	31.25
++ Wood ash extract	6.25	22.88	108.33	624.98	41.67
+++ Mixed neem leaf + wood ash extract	153.74	45.83	133.33	625.47	63.75
+ NPK 15-15-15	45.00	45.00	45.00	0.20	0.10

Note

- + = Application of NPK 15-15-15 fertilizer at 300kg/ha
- ++ = Application of neem leaf (sole) at 833.33L/ha
- +++ = Application of mixed extract of wood ash + neem leaf (416.66L + 416.66L)
= 833.L/ha

The amount of nutrients (total kg/nutrient) supplied by each extract; mixed neem leaf + wood ash, neem leaf, wood ash and NPK 15-15-15 fertilizer is also

presented in Table 2. More nutrients were supplied by the extracts particularly the mixed extract of neem leaf+ wood ash than the NPK 15-15-15 and control treatments.

The quantities of nutrients supplied by the extracts were adequate for sustaining growth and yield of plantain in the field as reflected in the soil chemical composition after harvest of plantain.

2.3 Field experiment

The land was cleared, ploughed and harrowed, divided into plots and each plot size is 6m X 6m (36m²). Hybrid plantain suckers treated with nemagon (a.i 1, 2 Dibromo-3-chloropropane) to control nematode were planted in early July, 2006 at a spacing of 2m X 2m.

There were five treatments namely: neem leaf extract, wood ash extract, mixed extract of neem leaf + wood ash applied at 3litres/36m² plot, NPK 15-15-15 fertilizer applied at 300kg/ha and a control treatment (no fertilizer nor extract), replicated three times and arranged in a randomized complete block design.

Weeding operation was first done after three weeks of planting and continued at three weeks interval until harvest. Five plants of sprouted plantain suckers were sampled in each plot on which parameters for plant height (cm), leaf area (cm²), stem girth (cm) and leaf population or number were taken every week starting from 2 weeks after establishment and this continued till 20 weeks after establishment.

The plantain started bearing inflorescence between 10 – 12 months after planting and the first harvest for matured plantain bunches was done at 15th month after establishment (November, 2007) and continued till early 2008. The following yield parameters were taken weight of plantain fingers, length of fingers (cm) plantain

fingers diameter and plantain finger population. After harvesting, the plantain plots were properly weeded and the growth continued till the second harvest in late October, 2008 and April 2009.

Necessary agronomic practices such as propping up the plantain with sticks to prevent being fallen off during storms in early year, also, the plants were sprayed with Avesthrin (Cypermethrin 10EC at 10ml/10L of water) to prevent insect attack on the leaves.

2.4 Soil collection and analysis

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

The soil pH (1:1 soil/water) and (1:2 soil/0.01M CaCl_2) solution was determined by using a glass calomel electrode system. (20) while organic matter was determined by the wet oxidation chromic acid digestion. (21). The total nitrogen was determined by the microkjedahl method (19) while available soil phosphorus (P) was extracted by the Bray P-1 extractant and measured by the Murphy blue colouration and determined on a spectronic 20 spectrophotometer at 882nm (22). Exchangeable soil K, Ca and Mg were extracted with 1M NH_4OAc pH 7 solution. The K, Ca and Na contents were determined with flame photometer while Mg was determined with an atomic absorption spectrophotometer (AAS). (23).

The soil exchangeable acidity (H^+ and Al^{3+}) were determined using 0.01M HCL extractant and titrated with 0.01M NaOH (24) while the micronutrients (Mn, Cu, Fe and Zn) were extracted with 0.1M HCl (25). The mechanical analysis of the soil %

silt, % clay and % sand textural determination was done by the hydrometer method (26). The soil bulk density was determined by core method as described by (27).

After the experiment, soil samples were taken from each plot, air dried, sieved with 2mm sieve, and analysed for soil pH, organic matter (O.M), total N, available P, exchangeable K, Ca and Mg as described earlier.

The soil properties before application of the treatments (initial soil fertility) were presented in Table 3. According to the established critical levels for soil in South West Nigeria ,the soil is acidic pH 5.80 and low in soil organic matter compared to critical levels of 3% (28). The soil nitrogen (%N) is 0.07 which was less than 0.15% total nitrogen considered as optimum for crops (29). The soil available P is 5.10mg/kg p considered as adequate for crop production (28).

Exchangeable K, Ca, Mg and Na values were much lower than the critical level of 0.2mg/kg while the micronutrients were more than the established critical levels of 5mg/kg Fe, 1.0mg/kg Cu, 5.0mg/kg Mn and 3.0mg/kg Zn (30). The soil bulk density was 1.60 mgm^{-3} while the soil textual class is sandy loam.

225 **TABLE 3: Soil properties before planting plantain**

Particulars	Values	Methods
Soil pH (H ₂ O)	5.80	Glass calomel electrode system (1)
Soil pH (0.01M CaCl ₂)	5.32	
Organic matter (%)	0.43	Wet oxidation chromic acid digestion (2)
Nitrogen (%)	0.07	Microkjedahl method (3)
Available P (mg/kg)	5.26	Bray P extractant (4)
Exchangeable Bases		1M NH ₄ OACpH7 (5)
K (mmol/kg)	0.10	0.01M HCL extractant (6) and titrated against 0.1M NaOH
Ca ²⁺ (mmol/kg)	0.11	
Mg ²⁺ (mmol/kg)	0.09	
Exchangeable Acidity		
H ⁺ (mmol/kg)	4.30	0.1M HCL extractant (7)
Al ³⁺ (mmol/kg)	1.45	
Micronutrients		
Fe (mg/kg)	8.50	
Zn (mg/kg)	3.80	Bouycous Hydrometer method (8)
Cu (mg/kg)	2.00	
Mn (mg/kg)	1.80	
Particle Size Analysis (Soil Texture)		
Sand (%)		Core method (9)
Silt (%)	79.50	
Clay (%)	14.70	
Bulk density (Mgm ⁻³)	5.70	
% Porosity	1.60	
	41.81	

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2.5 Statistical analysis

Analysis of variance followed by Duncan Multiple Range Test was done according to (31)

3.0 RESULTS

3.1 Treatment effects on growth and yield parameters of plantain

There were significant increases ($P<0.05$) in the plant height, leaf area, leaf population/number and stem girth (Table 4) as well as plantain bunch weight, diameter of plantain fingers, length and population for two cropping years (Table 5) under different fertilizer extracts compared to the control treatment.

Among the leaf extracts, the mixed of neem leaf + wood ash had the highest values of plantain leaf area and stem girth while the neem leaf and wood ash extracts (sole forms) had the highest values of plant height and leaf population/number respectively. For example, mixed extract of neem leaf + wood ash treatment increased the leaf area and stem girth by 49.24% and 12% respectively compared to neem leaf extract. When compared with NPK 15-15-15 Fertilizer, the mixed extracts of neem leaf + wood ash treatment increased slightly plantain plant height and stem girth by 1.0%, 32.60%, 13.8% and 13.8% respectively.

In 2007/2008 cropping season, the mixed extract of neem leaf + wood ash treatment increased the plantain bunch weight, finger weight, diameter length and finger population significantly ($P<0.05$) compared to other extracts. For example, mixed extract of neem leaf + wood ash increased plantain bunch weight, finger weight, diameter, length of fruit and population by 29.7%, 31%, 6%, 8% and 25% respectively.

Generally, the plantain bunch weight, diameter and length of fingers increased significantly in 2008/2009 cropping season under the mixed extract of neem leaf + wood ash more than 2007/2008 except plantain finger population and weight of fingers.

TABLE 4: Effect of the treatments on the growth parameters of plantain

Treatments	plant height(cm)	Leaf area(cm²)	leaf population/ number	Stem girth(cm)
Control	45.60a	1454.60a	4.60a	17.68a
Wood ash extract	81.30b	4790.59d	8.20cd	29.39bc
NPK 15-15-15	85.90bc	3601.51c	6.30b	28.41b
Neem leaf extract	91.20d	2712.81b	6.83b	28.08bc
Mixed neem leaf + wood ash extract	86.50c	5344.17e	7.31c	32.96d

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.

261 **Table 5: Effect of the treatments on the yield parameters of plantain**

Treatments	Cropping year	Weight of plantain bunch (kg/ha)	Weight of plantain fingers (kg/ha)	Diameter of plantain fruit finger (cm)	Length of fruit finger (cm)	Plantain finger population
Control	Nov 2007	2772.70a	2221.60a	2.2a	10.90a	9.0a
Wood ash	/Mar 2008	11529.45c	10555.25d	6.5b	20.30dc	28.00cd
NPK15-15-15		12496.5d	11215.65d	6.4b	17.80b	27.00c
Neem leaf		10833.30b	9580.65b	6.6bc	18.60bc	21.00b
Mixed neem leaf + wood ash extract		17777.5d	16495.45e	6.8d	19.3d	36.00c
Control	Nov 2008	2752.70a	2220.60a	2.8a	13.60a	10.00a
Wood ash	/Mar 2009	11941.10c	10833.33c	6.9bc	29.8c	27.00d
NPK15-15-15		12079.95d	10833.33c	5.8b	26.3b	26.00c
Neem leaf		9580.65b	8611.00b	6.3d	27.8c	23.00b
Mixed neem leaf + wood ash extract		24165.95e	11944.10d	7.7d	28.3cd	29.00c

262 Treatment means within each column followed the same letters are not

263 significantly different from each other using Duncan Multiple Range Test at 5%

264 **3.2 Treatment effects on soil properties after harvest of plantain**

265 There were significant increases ($P < 0.05$) in the total N, available P,
 266 exchangeable K, Ca, Mg and Organic matter (O.M) under different fertilizer extract
 267 compared to the control treatment after harvest of plantain (16 months after
 268 establishment) Table 6.

269 Mixed extract of neem leaf + wood ash treatment increased the soil organic
 270 matter (O.M), N, P, K, Ca and Mg by 16.00%, 15.7%, 19% and 16.9% compared to
 271 the neem leaf extract. When compared with NPK 15-15-15 fertilizer, the mixed
 272 extract of neem leaf + wood ash increased soil pH, O.M, K, Ca and Mg by 14%,
 273 2.78%, 31%, 95.3% and 94% except N and P.

274 The NPK 15-15-15 fertilizer decreased significantly the soil Ca and Mg while
 275 the control treatment had the least values of the soil parameters (soil pH, O.M, N, P,
 276 K, Ca and Mg). The soil K/Ca, K/Mg and P/Mg ratios were 5:1, 6:1 and 346:1
 277 respectively under NPK 15-15-15 Fertilizer compared to soil K/Ca 1:3, 1:2, 10:1
 278 under mixed extract of neem leaf + wood ash respectively.

279 **Table 6: Effect of the treatments on soil properties after harvest of plantain**

Treatments	Soil pH	O.M %	N %	P mg/kg	K mmol/kg	Ca mmol/kg	Mg mmol/kg
Control	5.20a	0.28a	0.03a	1.60a	0.03a	0.03a	0.06a
Wood ash extract	6.60e	1.45c	0.06b	7.00cd	0.36cd	1.15d	0.75c
NPK15-15-15	5.36ab	0.37d	0.23d	11.73ab	0.29b	0.06ab	0.05a
Neem leaf extract	6.20c	1.4c	0.06b	6.83c	0.34c	0.85c	0.69b
Mixed neem leaf + wood ash extract	6.24d	1.68d	0.08c	8.10e	0.42e	1.29e	0.83de

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281 Treatments within each column followed by the same letters are not significantly
 282 different from each other using Duncan Multiple Range Test at 5%

283 **4.0 DISCUSSION**

284 The fact that NPK 15-15-15 fertilizer improved the vegetative growth
285 parameters such as plant height, leaf area, leaf population of plantain is consistent
286 with its better soil N and P nutrients which are made much more readily available in
287 mineralised forms than the organic forms in the neem leaf, wood ash extracts and
288 mixed extract of neem leaf + wood ash.

289 The decrease in soil Ca and Mg nutrients in plots treated with NPK 15-15-15
290 Fertilizer could be due to nutrient imbalances reflected in high K/Ca, K/Mg and P/mg
291 ratio which consequently affected up take of Ca and Mg by plantain. In addition, the
292 low values of soil organic matter (O.M), Ca and Mg under the NPK 15-15-15 Fertilizer
293 plot signified low base saturation, and the sandy loam texture also encouraged soil
294 leaching activities and poor nutrients retention.

295 These observations could explain the reduction in values of plantain growth
296 and yield parameters i.e. plant height, leaf area, stem girth, leaf population, weight of
297 plantain bunches, weight of plantain fingers and fingers population under the NPK 15-
298 15-15 fertilizer compared to the mixed extract of neem leaf + wood ash treatment
299 which contained Ca, Mg and organic matter (O.M) and subsequently increased soil
300 fertility status for higher values of growth and yield parameters of plantain. (32)
301 reported that continuous use of ammonium sulphate and NPK 15-15-15 Fertilizer
302 decreased soil pH , K and macronutrients in Okra, also (33) reported that arbitrary use
303 of inorganic fertilizers resulted into signs of toxicities, poor yield responses and
304 deterioration of soil properties in okra.

The performance of neem leaf extract in improving the growth and yield parameters of plantain could be traced to its high N, P, K, Ca and Mg nutrients supplied to the soil which subsequently increased the soil O.M, total N, available P, exchangeable K, Ca and Mg.

This also reflected in the increased values of the plant height, leaf area, stem girth, leaf population, plantain bunch weight, fingers weight, length, diameter and population. The finding was also supported by (8) who reported that neem seed extract enhanced the nitrogen use efficiency in soils as well as increasing the yield of crops. Also, (34) also reported the use of neem leaf extract increased soil nutrients, growth and yield parameters of tomato.

In addition, the moderate potassium content of neem leaf extract also contributed to better performance of plantain yield parameters and this was supported by (35) who reported the vital role of potassium in crop production.

The wood ash extract increased the values of plantain bunch weight, weight of fingers, diameter, length and finger population more than neem leaf and this could be traced to its very high K, Ca and Mg nutrients which subsequently increased the soil O.M, K, Ca and Mg for uptake by plantain. This finding was supported by (36) who reported that wood ash is a good source of potash and lime which encouraged the growth and yield of plantain.

The increase in soil pH under wood ash extract compared to others was traced to its high K, Ca and Mg and could be effective as a liming material (37) unlike the NPK 15-15-15 fertilizer which with the continuous use could decrease soil pH. The soil pH been reported to influence nutrient uptake and availability. (38) reported that

oil palm bunch ash, wood ash and cocoa pod husk improved soil K, Ca and Mg nutrients and connected soil acidity in an Alfisol grown to coffee and maize.

In addition, (9) reported that wood ash improved the pH of acidic soils in a manner similar to agricultural lime which in turn translated significantly into increases in crop yields resulting from this pH adjustment (39) also reported that industrial wood ash was a good soil amendment for crop production.

The highest values of plantain bunch weight, weight of fingers, diameter of finger, length of fingers and finger population under the mixed extract of neem leaf + wood ash treatment could be due to the fact that it had the combined nutrient superiority of P, K, Ca Mg and N compared to neem leaf and wood ash extracts applied in sole forms. Therefore, the positive impact of extract of neem leaf + wood ash also reflected in the increase in soil pH, O.M, N, P, K, Ca and Mg and the subsequent uptake by the plantain.

Hence, the impact of the mixed extract on the soil properties has been responsible for high yield parameters, plantain bunch weight, finger weight, diameter and length of fingers and finger population which further signified higher economic returns, food security and profitability for plantain farmers as well as providing raw materials to establish plantain flour, chips and biscuit industries. It is believed that this would promote plantain values chain development for export trade.

The observation was supported by (34) who reported superior performance of mixed extract of neem leaf + wood ash treatment in maize and water melon intercrop. Beside, the uptake of nutrients (N, P, K, Ca and Mg) in a liquid form from the mixed extract of neem leaf + wood ash could also be responsible for better plantain yield

performance over the solid organic fertilizers which must be mineralised with adequate moisture before uptake by plant roots. Also, it has residual values which would have contributed to plantain bunch weight in the 2nd cropping year which NPK 15-15-15 fertilizer did not possess for subsequent cropping.

The poor growth and yield performance of plantain in the control treatment was consistent with the fact that the soil was very low in nutrient contents and this observation was supported by (13) who reported poor growth and yield responses of crops in soils that are not fertilized. The lowest values of soil N, P, K, Ca and Mg in the control treatment were a reflection of poor soil fertility status, hence, there is need to ensure fertilization of soils for bumper crop productivities in the tropical region where soils are low in organic matter, K, Ca, Mg and low soil pH. (12).

In term of nutritional status, plantain has high iron, minerals and vitamins contents which helped to build up both physiological and metabolic activities in the body when consumed by people. This will reduce money spent on purchase and consumption of iron and vitamins based drugs and this observation was in line with meeting millennium development goals (MDGs) in food security and sound health for people in the world.

5.0 CONCLUSION

It could be concluded from the research work that mixed extract of neem leaf + wood ash treatment gave the highest values of plantain growth and yield parameters and also improved the soil nutrients (soil N, P, K, Ca, Mg and O.M) compared to NPK 15-15-15 fertilizer, neem leaf and wood ash extracts (sole forms) respectively. It is

recommended that for better performance of plantain bunch weight, finger weight, finger diameter and length, growth parameters and improvement of soil fertility status, application of mixed extract of neem leaf + wood ash at 833.3L/ha is appropriate.

Hence, the use of mixed extract of neem leaf + wood ash could substitute for 300kg/ha of NPK 15-15-15 Fertilizer and it also reduced the problems of high cost of purchasing the inorganic fertilizer as well as solving problems of bulkiness and difficulty in the transportation of solid organic waste. Finally, it will help to prevent environmental pollution and deterioration of soil properties associated with continuous use of inorganic fertilizers such as NPK 15-15-15 fertilizers.

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COMPETING INTERESTS

504 There is no competing interests exist

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AUTHORS' CONTRIBUTION

509 100 percent

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ETHICAL APPROVAL

514 The study is not against the public interest