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Effect of *Albizia zygia* and NPK Fertilizer on the Improvement of Soil Fertility on a Humid Alfisol in Southwestern Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The effect of integrating *Albizia zygia* and NPK 15-15-15 on soil fertility and maize yield were studied to investigate the effect of *Albizia zygia* and NPK 15-15-15 on soil properties, growth and yield of maize. The experiment was laid out as a Randomized Complete Block Design (RCBD) with five treatments and three replicates. The experiment was conducted from 2009 to 2011 at the Teaching and Research Farm, Joseph Ayo Babalola University, Ikeji-Arakeji, Nigeria. The treatments were: control (no treatment), *Abizia zygia* at 5 tons/ha, *Albizia zygia* + NPK 15-15-15 at 2.5 tons/ha and 125kg/ha respectively, NPK 15-15-15 at 250kg/ha and 0PK at 250 kg/ha of single superphosphate (SSP) and 90 kg/ha of muriate of potash (KCl). Soil was sampled before planting for determination of soil nitrogen conten, phosphorous, potassium, organic matter, soil pH, total soil porosity, Water holding capacity and soil bulk density were determined. Maize yield was determined at end of growing seasons as well as profitability of the treatments were also evaluated. Soil physical properties such as total porosity, water holding capacity, soil organic matter, total exchangeable bases, cations exchange capacity and soil pH were significantly improved by applying *Albizia* zygia biomass. Maize yields (1.33, 1.93 and 1.33 ton/ha in 2009, 2010 and 2011 planting seasons) were found to have increased significantly in the plot treated with *Albizia* + NPK

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15-15-15 over other treatments. In the same vein, the same treatment (*Albizia* + NPK 15-15-15) was found to have returned more money (N37, 459 and N76,204 in 2009 and 2010 cropping seasons respectively) to the farmer over other treatments.

Keywords: Fertility; soil nutrients; Albizia zygia; NPK 15-15-15; integrated nutrient management; green manure; mulching.

1. INTRODUCTION

Soil degradation which is defined as the decline in the physical, chemical, biological as well as hydrological properties of soil is widely recognized as a global problem associated with desertification in dry lands [1]. In sub-Saharan Africa, it is influenced with the depletion in soil nutrient potential (mainly nitrogen, phosphorus and carbon content), this has been identified as a major threat to food security [2]. This problem is exacerbated by wind, water and stream bank erosion [3], poor rainfall distribution [4], low and unbalance rates of mineral fertilizers application. The region is also characterized by climatic conditions that influenced the depletion of soil organic matter [5] which affects the water holding capacity of the soils and also lead to deficiency in soil nitrogen and phosphorus.

In Nigeria, like many other Sub-Saharan African countries, soil fertility and hence productivity are declining at an alarming rate because areas of high agricultural potential are densely populated, for example, Nigerian population is increasing at the rate of 0.3% annually. In most cases, farms holdings are less than 1ha. Farmers practice intensive continuous cropping with limited or no replacement of nutrients through fertilizer application due to the high cost and non availability of inorganic fertilizers as well as perceived negative effect of inorganic fertilizer on weakly buffered West African soils which may lead to soil degradation through a rapid decrease in the soil organic matter, exchangeable bases and pH, hence cannot sustain crop productivity in the long term [6].

Organic inputs, including composts, animal manure, crop residues and green manure are good methods of enhancing physical, chemical and biological properties of soils and crop performance [7]. It contributes to improving soil structure and aggregation and decrease soil bulk densities and increased the percentages of pore spaces [8]. Due to this, soil water infiltration and water holding capacity increase [9]. Organic inputs are also source of energy and slowly available carbon to support soil organism's activity which are the primary agent for decomposition in the soil.

The role of agroforestry systems becomes important in the marginalized area in Nigeria with low capital and technological inputs. The conservation benefits, sustainable yield potential, biological and socio-economic characteristics make it more desirable in soil fertility management. One of such trees is *Albizia zygia*, a leguminous plant, deciduous, up to 25m high in forest, usually a shrubby weed in bush re-growth. One of the practices of agroforestry for soil fertility in Nigeria is biomass transfer which is defined as the transfer and application of cut and fallen mulch or tree litter from the source to the field on which crops are grown or to be grown [10]. In Nigeria, inorganic fertilizer addition is the major method of replenishing soil fertility and boosting crop performance. However, inorganic fertilizer use in Nigeria is estimated at 13 kg/ha in 2009 by the Federal Ministry of Agriculture and Rural Development (FMARD), is far lower than 200 kg/ha recommended by the FAO as well as the 104 kg/ha in South Asia and 142 kg/ha in Southeast Asia [11]. The high cost and the gap between net benefit from harvested products and fertilizer purchase make the use of inorganic fertilizer use unpopular. On the other hand, significant investments in labour, land availability, bulkiness and unbalanced nutrient content [12] as well as increase in soil heavy metal as a result of continuous application of compost limit the fullest adoption of organic inputs in Nigeria. In view of the limitation of both organic and inorganic fertilizers, a combined application of the two is worth researching. The abundance of *Albizia zygia* coupe with its nitrogen fixing ability in the study area makes it an excellent agroforestry species of choice.

This work is aimed at determining the potential of *Abizia zygia* leaf biomass as source of fertilizer and the combined effect of both *Albizia zygia* and NPK fertilizer for soil fertility improvement in a degraded humid Alfisol in Nigeria.

2. MATERIALS AND METHODS

2.1 Site Description

The experiment was conducted on the teaching and research field plot of the college of agricultural science of Joseph Ayo Babalola University, Ikeji Arakeji, Nigeria which lies between latitude 07º16' and 07º 18' N and longitude 05º 09º and 05º 1' E. The study area is situated in the humid tropical forest zone of Nigeria. It has an annual average rainfall of between 1500-1800mm and relative humidity of between 80-85% annually Fig. 1. It has a gentle undulating elevation of about 1150m-1250m above sea level.

2.1.1 Layout of experiment

The experiment was laid out as a Randomized Complete Block Design (RCBD) with five treatments and three replicates. A 20m x 35m plot was demarcated at the Teaching and Research Farm of Joseph Ayo Babalola University, Ikeji–Arakeji, Nigeria from 2009 to 2011. This was partitioned into three blocks of 5m x 35m each. Each block was partitioned into five 5m x 5m plots. Each 5m x 5m plot was separated by buffer of 2.5m wide. The treatments were:

a. Control (no treatment).
b. *Abizia zygia* at 5 tons/ha
c. N: P: K 15-15-15 at 250 kg/ha
d. *Albizia* zygia at 2.5 tons/ha +NPK 15-15-15 at 150 kg/ha respectively
e. 0PK (N at zero level) at 250 kg/ha of single superphosphate (SSP) and 90 kg/ha of murate of potash (KCl)

All the treatments were allocated to the plots in each block at random. *Albizia* leaves (not senescent) after curing were incorporated with hoe in the top of 15cm-20cm at 12.5 kg/plot or 5 tons/ha [6] for two consecutive cropping seasons (2009 and 2010), while NPK was applied at 18g/plant or at 250 kg/ha at two weeks, 10 cm from the maize plant. This was followed by another growing season (2011) without treatment application to study the residual effect of the different treatments. Maize seeds variety TZPBSR-N (IITA) obtained from International Institute of Tropical Agriculture, Ibadan, Nigeria (IITA), Ibadan were planted at 60 x 30 cm to give a plant population of 55, 000 stands per hectare, and 133 stands per plot. Two seeds were sown per hole and thinned to one after germination. Weeding was done as appropriate.

2.1.2 Nutrient concentration in the *Albizia zygia* leaves

This was carried out to determine the nutrient concentration in *Albizia zygia* leaves and other chemical parameters influencing their leaf quality and suitability for soil fertility maintenance.

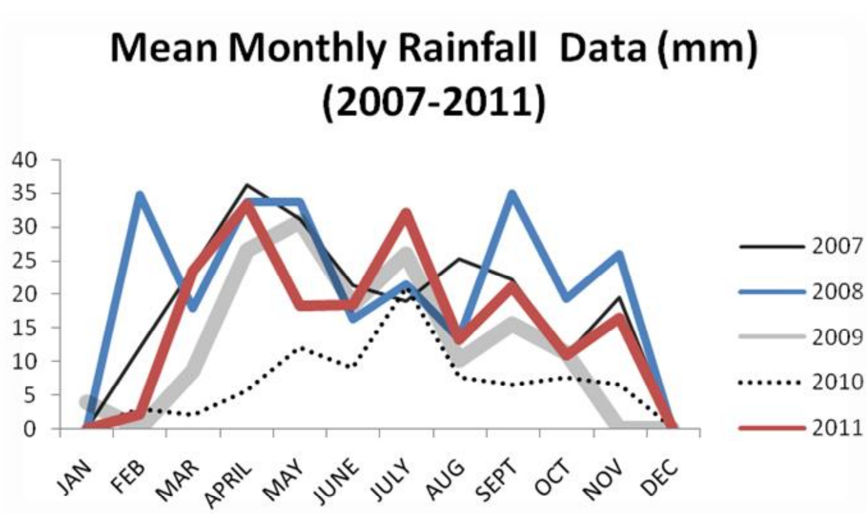

Fig. 1. Mean monthly rainfall in the study area (2007-2011)
Source: Meteorology department, federal university technology, akure

Matured but not senescent *Abizia zygia* leaves were collected from existing plants along roadsides and on abandoned farmlands very close to the campus of Joseph Ayo Babalola University, Ikeji-Arakeji. The leaves were bulked, air dried for five days and composite samples were taken and analyzed for some nutrients (Nitrogen, Phosphorus, Potassium, Calcium and Magnesium) content, total carbon content, total soluble polyphenol and lignin. Total nutrients and total carbon were determined by the method described by [13] while total soluble polyphenols and lignin contents were determined using the method described by [14].

2.1.3 Plant samples collection and analysis

Maize yield determination

At maturity, four plants were selected from each plot, harvested and weighed and calculated on tone per ha based on this formula: Pp= (B + b) (L + I) **/** Lb **×** N [15] and [16], where Pp = Plant population, L = Length of the field, B = Breadth of the field, I = Length of spacing of the field, b= Breadth of spacing of the field and N = Number of cobs per field stand. At maturity (90 DAP), maize cobs were harvested from a plot size of 3m x 3m from the central rows of each plot. The ears were removed and cob length was measured from base to the top. The diameter of each cob was measured at the middle point using a veneer caliper. Maize cob were dried at 100ºC to reduce the spoilage and to get a constant weight, they were shelled to separate the rachis and grains, the grains were oven dried again at 65ºC for about 10 minutes to 14% moisture content and weigh to determine the grain weight. The 14% grain moisture content was confirmed with the use of grain moisture tester.

2.1.4 Soil samples collection and analysis

2.1.4.1 Physical analysis

Soil samples were collected before planting at40, 60 & 90 days after planting (DAP) using a 3.5 cm diameter soil auger. There were four auger points in each plot and samples were collected at 0-20cm depth. Samples from each plot were bulked and composite soil samples were collected and taken to the laboratory for analysis. The soil samples were air dried for few days, sieved to pass through 2mm mesh and chemically analyzed. Particle size analysis was done by hydrometer method [17] using sodium hexametaphoshate (Calgon) as dispersing agent**,** water holding capacity was determined using a pressure plate apparatus at 0.1kPa (field capacity), bulk density was determined on a core cylinder of dried soil and calculated as: Bulk density = Oven dry weight of soil (g)/Volume of the cylinder (cm3) and total Porosity was calculated as: Total Porosity = 100 (1-Db/Dp; Where Db = bulk density, Dp = particle density (2.65g/cm^3)

2.1.4.2 Chemical analysis

The pH was determined using a pH meter in slurries from a ratio of 1g soil to 2.5 cm^3 water. The organic carbon content of the soil was determined according to [18] dichromate oxidation method. The percentage organic matter content in the samples was calculated by multiplying the values of organic carbon by the conventional Van Bam meller factor of 1.724 based on the assumption that soil organic matter contains 58% carbon [19]. Total soil nitrogen was determined by macro kjeldahl methods [20]. Available phosphorus was extracted using Bray II method [21] and determined by spectrophotometer.

Exchangeable Na, K, Ca and Mg were extracted with $BaCl_2$ 0.1m [22] and analysed by atomic absorption. The exchangeable acidity was determined from 0.1N KCI extracts and titrated with 1.0N HCl.

Cation Exchangeable Capacity (CEC**)** was determined by summing up total exchangeable bases (TEBS) and total exchangeable acidity (TEA).

2.1.5 Basic economic data collection

Production cost (maize seeds, fertilizers, organic matter, weeding and fertilizer application) for maize production.

Economic analysis

a) Economic analysis was done using the prevailing market prices for inputs at planting and for outputs at the time the crop was harvested. All costs and benefits were calculated on hectare basis in Naira (N). The following concepts used in the partial budget analysis are defined as Mean grain yield is the average yield (t/ha) of each treatment.

b) The total production cost (TPC) is the sum of field cost of fertilizer plus the cost of organic manure and the costs of their applications.
c) The value of yield is the product of mean grain yield and the price of ton of maize grain.
d) The net benefit (NB)/ha for each treatment is different from the yield value and the total production cost.

2.1.6 Statistical analysis

Data were subjected to analysis of variance using the general linear model procedure (GLM) for randomized complete Block design (RCBD) in SAS [23]. Analysis of variance was computed to determine the significance of treatments. Mean separation was done using Duncan New Multiple Range Test.

3. RESULTS AND DISCUSSION

3.1 Result

3.1.1 Pre-planting physico-chemical properties

The pre-planting physico-chemical properties of soil of the experimental site showed the soil is slightly acidic with a value of 5.9. The organic matter has the value of 0.6%. The values of total soil nitrogen, phosphorous, potassium, calcium, magnesium, sodium, exchangeable acidity and cations exchange capacity were 0.067%, 3.44mg /kg, 0.15 cmol/kg of soil, 0.80cmol/kg of soil, 0.35cmol/kg of soil, 0.17 cmol/kg of soil, 1.36 cmol/kg of soil and 2.83 cmol/kg of soil respectively. The texture of the area is sandy clay loam.

3.1.2 Nutrient composition of *Albizia* leaves used for the experiment

Table 1 shows the nutrient composition of *Albizia* leaves used for the experiment.

The result show that nitrogen content in 2010 with the values of 4.71% was higher than of 2009 with the value of 4.11%, phosphorus content was also higher with value of 0.2% in 2010, while the value in 2009 was 0.19%, calcium content was higher in 2009 than that of 2010 with values of 0.27% and 0.25% respectively. Magnesium content was higher in 2010 than 2009 with value of 0.25% and 0.28% respectively. Carbon content was higher in 2009 with a value of 65.6% while in 2010, it was the value of 57.21%. The lignin content was higher in 2010 with a value of 34.24% while in 2009, the value was 33.4%. The polyphenols content value was higher in 2010 with a value of 7.2% and 6.5% in 2009 planting season.

3.1.3 Effect of organic and Inorganic fertilization on soil porosity, water holding capacity and soil bulk density

In 2009 planting season, the value of total porosity ranged from 35.99% in 0PK (plot without N and with the application of full doses of P and K) plot to 43.92% in the plot mulched with *Albizia zygia* leaves. The values of water holding capacity (WHC) ranged from 29.29% in the control plot to 35.67% in the plot mulched with *Albizia* leaves. The values of bulk density ranged from 1.67g/cm^3 in NPK plot to 1.49g/cm^3 in the plot mulched with *Albizia* leaves Table 2. There were no significant differences at $P<0.05$ among *Albizia* as well as in NPK and control plots.

In 2010, the values of soil total porosity ranged from 33.93% in the control plot to 44.15% in the plot mulched with *Albizia zygia* leaves. The values of soil water holding capacity ranged from 29.12% in the plot amended with NPK to 35.55% in the plot mulched with *Albizia* leaves. While the values of soil bulk density ranged from 1.47g/cm^3 with the plot mulched with *Albizia* leaves to 1.67g/cm3 in the 0PK plot. There were no significant differences among *Albizia* and *Albizia* + NPK plot.

Table 1. Nutrient composition of the *Albizia zygia* leaves used for the experiment

	2009	2010
Nitrogen (%)	4.11	4.71
Phosphorus (%)	0.19	0.2
Calcium (%)	0.27	0.25
Magnesium (%)	0.25	0.28
Potassium (%)	1.93	1.91
Carbon (%)	65.6	57.21
Lignin (%)	33.4	34.24
Polyphenols (%)	6.5	7.2

In 2011 planting season, the values of soil porosity ranged from 33.11% in NPK plot to 42.26% in the plot mulched with *Albizia zygia* leaves. The values of soil water holding capacity ranged from 26.18% in the plot amended with NPK to 32.64% in the plot mulched with *Albizia* leaves. The values of bulk density ranged from 1.52g/cm^3 in the plot mulched with *Albizia* leaves to 1.77g/cm3 in the plot amended with NPK.

3.1.4 Effect of organic and inorganic fertilization on soil pH, organic matter and soil phosphorous

In 2009 planting season, the values of soil pH ranged from 5.35 in the plots amended with *Albizia* + NPK to 5.93 in the plot applied with *Albizia*. The values of organic matter ranged from 1.05% to 1.74% in the control and *Albizia* respectively. The values of soil phosphorus ranged from 3.20mg/kg to 15.02mg/kg in the control and *Albizia* + NPK respectively. In 2010, the plot values ranged from 5.31 in OPK and *Albizia* + NPK plots to 5.92 in the plot mulched with *Albizia* leaves. While the values of Organic matter ranged from 1.07% to 1.79% in the control and *Albizia* plot respectively. The soil phosphorus values ranged from 3.29 mg/kg in the control plot to 12.7mg/kg in the plot mulched with *Albizia* leaves. In 2011, pH values ranged from 5.23 to 5.04 in NPK and *Albizia* plots respectively.

The organic matter values ranged from 0.69% in the control plot to 1.67% in the *Albizia* plot. The values of phosphorus ranged from 3.14mg/kg in the control plot to 12.16mg/kg in the plot amended with *Albizia* + NPK Table 3. Soil pH, organic matter and available phosphorous were all significant in all the years at $p \geq 0.05$

3.1.5 Effect organic and Inorganic fertilization total exchangeable bases and cation exchangeable capacity

Table 4 shows the effect of organic and Inorganic fertilizer on total exchangeable bases and cation exchangeable capacity. In 2009, total exchangeable bases (TEBs) values ranged from 1.34cmol/kg of soil in the control plot to 2.23 cmol/kg of soil in the plot mulched with *Albizia* leaves. The values of cation exchangeable capacity (CEC) ranged from 2.70 cmol/kg of soil to 3.75cmol/kg of soil in the control and *Albizia* mulched plots respectively.

In 2010 planting season, the values of total exchangeable bases ranged from 1.32 cmol/kg of soil to 2.25cmol/kg of soil in the control and *Albizia* plots respectively. The values of cation exchangeable capacity (CEC) ranged from 2.68 cmol/kg of soil to 3.77 cmol/kg of soil in the control and *Albizia* plots respectively.

In 2011, planting season the values of total exchangeable bases ranged from 0.81 cmol/kg of soil in the control plot to 1.48 cmol/kg of soil in the plot mulched with *Albizia* leaves. Also, the values of cation exchangeable capacity were low and ranged from 2.20 cmol/kg of soil to 3.04cmol/kg of soil in the control and *Albizia* mulched plots respectively.

3.1.6 Effect of organic and Inorganic fertilization on the total soil nitrogen at different sampling time

In 2009 planting season, 40 days after planting (DAP), the values of total nitrogen ranged from 0.067% to 0.074% in the control and *Albizia* + NPK plots respectively and showed significant difference at $p \leq 0.05$ among all the treatments.

Table 2. Effects of organic and inorganic fertilization on soil total porosity, water holding capacity (%) and bulk density (g/cm^3) for 2009, 2010 and 2011 planting seasons

Treatments	2009			2010			2011		
	TP	WHC	BD	TP	WHC	BD	TP	WHC	BD
ALBI ZIA	43.92^a	35.67^a	1.49^d	44.15^a	35.55^a	1.47^b	42.26^a	30.64^a	1.52^c
ALB +NPK	43.35^a	34.09^b	1.49^d	43.77^a	33.87^b	1.46^b	40.11^b	31.83^a	1.60^b
NPK	36.25^b	30.12^c	1.67^a	36.47^b	29.12^c	1.66^a	33.11^c	26.18^b	1.77^a
OPK	35.99^c	34.21^b	1.55^c	36.98^b	30.48^c	1.67^a	33.35^c	27.37^b	1.76^a
CONTROL	36.90^b	29.29^c	1.66^b	33.93^c	29.89^c	1.66^a	33.97^c	27.59^b	1.74^a

Means on the same column followed by the same letter are not significantly different at $P \leq 0.05$
TP = soil total porosity, WHC = water holding capacity, BD = soil bulk density
ALB = Albizia. statistical analysis: analysis of variance was computed to determine the significance of treatments. mean separation was done using Duncan new multiple range test

Table 3. Effect of organic and inorganic fertilization on soil pH, organic matter (%) and soil phosphorous

Treatments	2009			2010			2011		
	pH (H_2O)	OM (%)	P (mg/kg)	pH (H_2O)	OM (%)	P (mg/kg)	pH (H_2O)	OM (%)	P (mg/kg)
ALBIZIA	5.93[a]	1.74[a]	11.99[c]	5.92[a]	1.79[a]	12.07[e]	5.64[a]	1.67[a]	10.25[b]
ALB +NPK	5.35[d]	1.57[b]	15.02[a]	5.37[d]	1.65[ab]	16.02[b]	5.37[c]	1.67[a]	12.16[a]
NPK	5.64[c]	1.27[c]	14.54[b]	5.65[c]	1.28[cd]	15.33[c]	5.23[d]	1.00[b]	12.06[a]
OPK	5.36[d]	1.22[d]	9.50[d]	5.37[d]	1.24	9.90[c]	5.41[b]	1.17[b]	9.41[c]
Control	5.85[b]	1.05[e]	3.20[e]	5.84[b]	1.07[de]	3.29[e]	5.24[d]	0.69[c]	3.14[d]

Means in the same column followed by the same letter are not significantly different at P≤0.05. statistical analysis: analysis of variance was computed to determine the significance of treatments. mean separation was done using Duncan new multiple range test. OM = soil organic matter, N = soil total nitrogen, P = available phosphorus

Table 4. Effect of organic and inorganic fertilization on soil total exchange bases & cation exchange capacity

Treatments	2009		2010		2011	
	TEB	CEC	TEB	ECEC	TEB	ECEC
	(cmol/kg of soil)					
ALBIZIA	2.23[a]	3.75[a]	2.25[a]	3.77[a]	1.48[b]	3.04[a]
ALB +NPK	1.93[a]	3.21[a]	1.98[b]	3.27[b]	1.89[a]	3.21[a]
NPK	1.82[b]	2.87[b]	1.82[c]	3.01[c]	1.11[c]	2.27[b]
OPK`	1.64[b]	2.76[b]	1.63[d]	2.90[d]	0.95[c]	2.32[b]
Control	1.34[c]	2.70[b]	1.32[e]	2.68[e]	0.81[d]	2.20[c]

Means on the same column followed by the same letter are not significantly different at P≤0.05. ALB = Albizia. statistical analysis: analysis of variance was computed to determine the significance of treatments. mean separation was done using Duncan new multiple range test

At 60 days after planting the values of total nitrogen ranged from 0.066% in both control and OPK plots to 0.073% in the *Albizia* + NPK plot and there were significant differences among the treatments at p≤0.05. At 90 days after planting the values ranged from 0.064% in the control to 0.071% in both *Albizia* and *Albizia* + NPK plots (Table 5).

In 2010 planting season, at 40 days after planting, the values of total soil nitrogen ranged from 0.064% in both control and OPK plot to 0.075% in the *Albizia* + NPK plot. At 60 days after planting (DAP). It ranged from 0.063% in control and OPK plot to 0.075% in *Albizia* + NPK plots. At 90 days after planting the values ranged from 0.062% and *Albizia* + NPK plots. However, there were no significant differences between the control and OPK at 60 & 90 days after planting as well as between *Albizia* and *Albizia* + NPK at 90 days after planting at p≤0.05 (Table 5).

In 2011 planting season, at 40 days after planting (DAP), the values ranged between 0.059% to 0.073% in the control and *Albizia* + NPK respectively and significantly different at p≤0.05. At 60 days after planting the values ranged from 0.058% in the control plot to 0.070% in the *Albizia* plot. At 90 days after planting, the values ranged from 0.055% in the control plot to 0.072% in the plot mulched with *Albizia* and statistically different among the treatments at p≤0.05 (Table 5).

3.1.7 Effect of organic and Inorganic fertilization on maize cob length (cm) cob diameter (cm) and grain weight (t/ha)

In 2009 planting season, the values of cob length ranged from 18.35 cm in the control plot to 22.58cm in the plot treated with *Albizia* + NPK. However, there was no statistical difference between cob length in NPK and *Albizia* + NPK plots at P≤0.05 Table 6. The values of cob diameter ranged from 3.14cm to 5.60cm in the control and *Albizia* + NPK plots respectively. In the same vein, there was no statistical difference between the plots amended with NPK and *Albizia* + NPK at P≤0.05 Table 6. Grain weight values ranged from 0.74 t/ha in the plot without amendment to 1.33 t/ha in the plot amendment with *Albizia* + NPK.

Table 5. Effects of organic and inorganic fertilization on total soil nitrogen (%) at different sampling time

Treatments	2009			2010			2011		
	40*	60*	90*	40*	60*	90*	40*	60*	90*
ALBIZIA	0.073[b]	0.072[b]	0.071[a]	0.074[a]	0.072[a]	0.072[a]	0.072[a]	0.070[a]	0.0720[a]
ALB +NPK	0.074[a]	0.073[a]	0.071[a]	0.075[a]	0.073[a]	0.072[a]	0.073[a]	0.069[a]	0.0710[a]
NPK	0.070[c]	0.069[c]	0.067[b]	0.068[b]	0.066[b]	0.067[b]	0.065[b]	0.060[b]	0.0590[b]
OPK	0.068[d]	0.066[d]	0.065[c]	0.064[c]	0.063[c]	0.062[c]	0.060[c]	0.060[b]	0.0570[c]
Control	0.067[d]	0.063[d]	0.064[c]	0.064[c]	0.063[c]	0.062[c]	0.059[c]	0.058[c]	0.0550[d]

*Means on the same column followed by the same letter are not significantly different at P<0.05. ALB = Albizia, *=days after planting. statistical analysis: analysis of variance was computed to determine the significance of treatments. mean separation was done using Duncan new multiple range test*

Table 6. Effect of organic and inorganic fertilization on maize cob length (cm), cob diameter (cm) and grain weight (t/ha)

Treatments	Cob length			Cob diameter			Grain weight		
	2009	2010	2011	2009	2010	2011	2009	2010	2011
ALBIZIA	20.24[b]	19.83[b]	17.98[c]	4.14[b]	5.14[b]	3.11[c]	1.17[c]	1.44[b]	1.13[c]
ALB +NPK	22.58[a]	22.65[a]	20.90[a]	5.60[a]	5.24[a]	5.13[a]	1.33[a]	1.93[a]	1.33[a]
OPK	19.90[b]	18.98[b]	16.67[d]	4.05[b]	4.57[d]	3.04[d]	1.05[c]	1.15[d]	1.01[d]
NPK	22.40[a]	22.45[a]	19.35[b]	5.46[a]	5.04[c]	4.51[b]	1.26[b]	1.18[c]	1.15[b]
Control	18.35[c]	16.70[c]	15.27[e]	3.14[c]	4.05[e]	2.05[d]	0.74[d]	0.67[e]	0.33[e]

Means on the same column followed by the same letter are not significantly different at P<0.05. ALB = Albizia, statistical analysis: analysis of variance was computed to determine the significance of treatments. mean separation was done using Duncan new multiple range test

In 2010 planting season, the values of maize cob length ranged from 16.70 cm in the control plot to 22.65 cm in the plot amended with *Albizia* + NPK and showed no significant difference in the plots amended with NPK and *Albizia* + NPK at $P \leq 0.05$. The cob diameter values ranged from 4.05cm to 5.24cm in the control and *Albizia* + NPK plots respectively. On the other hand, the grain weight ranged from 0.67 t/ha in the control plots to 1.93 t/ha in the plot amended with *Albizia* + NPK.

In 2011 planting season, the cob length values ranged from 15.27cm in the control plot to 20.90 cm in the plot amended with *Albizia* + NPK. The cob diameter ranged from 2.05 cm to 5.13 in the control and *Albizia* + NPK plots respectively. The grain weight values ranged from 0.33 t/ha in the control plot to 1.33 t/ha in the plot amended with *Albizia* + NPK.

3.1.8 Profitability analysis of maize yield, organic and inorganic fertilizers for 2009 and 2010 planting seasons

In 2009 planting season, the total yield (discounted at 10%) ranged from 0.67 t/ha in the control plot to 1.2 t/ha in the plot amended with Alibizia + NPK, and there were significant among the treatments at $P \leq 0.05$. The yield value in (Nigerian Naira) ranged from N46, 900 (USD 296.84) in the control plot to N84, 000 (USD 531, 65) in the plot amended with *Albizia* and NPK. The cost of production ranged from N39, 690 (USD 251.20) in the control plot to N50, 055 (USD 316.99) in the plot mulched with *Albizia* leaves. The net profit, values ranged from N7, 210 (USD 45.63) in the control plot to N37, 459 (USD 237.08) in the plot amended with *Albizia* + NPK (Table 7).

In 2010 planting season, the yield value ranged from 0.60 t/ha to 1.3 t/ha in the control and *Albizia* + NPK plot respectively, however, there was no significant different at $P \leq 0.05$ between OPK and NPK plots. The yield values ranged between N42, 000 (USD 265.82) to N121, 800 (USD 770.89) in the control and *Albizia* + NPK plots respectively. The cost of production values ranged from N39, 218 (USD 248.22) to N48, 667 (USD 188.63) in the control plot and *Albizia* mulched plots. There was significant differences among the treatment at P<0.05. The net profit, values ranged from N2782 (USD 17.61) to N76204 (USD 482.30) in the control and *Albizia* + NPK plots respectively. There were significant differences among the treatments at $P \leq 0.05$. The net profit were higher in all the plots except in the control and NPK plots (Table 7).

Table 7. Profitability analysis of maize production, organic and Inorganic fertilizers for 2009 and 2010 planting seasons

Treatments	2009				2010			
	Yield	Value of yield	Cost of production	Net profit	Yield	Value of yield	Cost of production	Net profit
ALBIZIA	1.06[c]	73,500[c]	50,085[a]	23,415[b]	1.3[d]	91,000[b]	48,667[a]	42,333[b]
ALB + NPK	1.2[a]	84,000[a]	46,541[b]	37,459[a]	1.74[a]	121,800[a]	45,596[b]	76,204[a]
OPK	0.95[d]	66,500[d]	43,942[c]	22,557[b]	1.04[c]	72,800[d]	44,415[c]	28,385[d]
NPK	1.13[b]	79,100[b]	42,998[d]	36,102[a]	1.06[c]	74,200[c]	42,525[d]	31,675[c]
CONTROL	0.67[e]	46,900[e]	39,690[e]	7,210[c]	0.60[d]	42,000[e]	39,218[e]	2782[e]

Means on the same column followed by the same letter are not significantly different at P<0.05. statistical analysis: analysis of variance was computed to determine the significance of treatments. mean separation was done using Duncan new multiple range test

3.2 Discussion

3.2.1 Pre-planting physico-chemical properties of soil of the experimental site

The texture of the area was sandy clay loam. This may be attributed to the lithology of the parent material [24]. Nitrogen, phosphorous, potassium, calcium, magnesium and sodium contents were low in the study area. This may be due to the over cropping, leaching of soluble cations, soil erosion and lack of proper land management practices in the area. The acidic nature of the soil may be due to the leaching of soluble cations observed in the area as well as the distribution of exchangeable acidity [25]. Olojugba, 2002, [26] Reported that sufficient exchangeable acidity is responsible for soil acidity. Also [25] observed that leaching of Na, K, Ca and Mg were largely responsible for the development of acidity in the soil. The low value of organic matter in the area may be due to continuous cropping without the addition of organic manure.

3.2.2 Nutrient concentration in *Albizia* leaves used for the experiment

In 2009 and 2010 cropping seasons, the concentration of nitrogen in the leaves showed that *Albizia* leaves are good source of nitrogen; this reason might be due to the nitrogen fixing ability [27]. The lignin, polyphenols and carbon were higher which makes *Albizia* resistant to decomposition thereby enabling it to stay more on soil as organic humus [27]. The low values of calcium, magnesium, potassium and phosphorus suggested that inorganic source of these nutrients or plant biomass richer in these nutrients is needed to be integrated when using *Abizia* leaves as organic materials.

3.2.3 Effect of organic and inorganic fertilization on soil total porosity, water holding capacity and soil bulk density

The moderate to higher values of soil total porosity and water holding capacity in most of the *Albizia* amended plots over the low values in the control and NPK plots may be due to moderate organic matter content as this encouraged better and higher activities of soil micro-organisms which in turn enhanced better soil structure and porosity [28]. They were of the opinion that organic inputs such as compost, animal manure, crop residues and green manures are a good way of enhancing both physical, chemical and biological soil properties which includes soil porosity and available water capacity. Anikwe 2000, [15] Submitted that moderate to higher total porosity in the soil was beneficial because as it improves gaseous exchange and creates healthier environment for root elongation, expansion and nutrient uptake. The low to moderate soil bulk density in the *Albizia* amended plot over its higher values in un-amended and NPK plots may be due to the distribution of soil organic matter. Soil organic matter contributes to improving soil structure, aggregate stability, decrease soil bulk density and increase the percentage of pore spaces [8].

3.2.4 Effect of organic and inorganic fertilization on soil pH, organic matter and soil phosphorous

There were significant differences in soil pH in 2009 and 2010 planting season and only the plot mulched with *Albizia* at 5 ton/ha had increased pH while other treatments had decreased soil pH. This is consistent with the findings of Opala 2011, [28] who attributed a similar situation to the proton exchange between the soil and added *Albizia* which contains more phenolic, humic–like material. Another mechanism that has been proposed to explain the increase in soil pH by such materials as *Albizia* is the specific adsorption of humic material and/or organic acids (the products of decomposition of organic materials) onto hydrous surfaces of aluminum and iron oxides by ligand exchange with corresponding release of OH^- [29]. The moderate values of organic matter recorded in 2009 and 2010 planting season in the plots treated with *Albizia* and *Albizia* + NPK over the control and OPK plots might be due to the decomposition of the mulch materials used which gave rise to the build-up of soil organic matter in this study. Moderate organic matter was found in the plots mulched with more resistant mulch materials which could be attributed to their ability to decompose more slowly over time leading to the build-up of organic matter as it was observed in the plot mulched with *Albizia* and NPK + *Albizia*. Schmel 2007, [30] reported that litter which decomposes slowly favours the build-up of soil organic matter. They further observed that the decomposition rate of this resistant litter was enhanced by mixing it with nutrient–rich litter [30]. This type of increase is attributed to N-transfer from nutrient–rich to nutrient poor litter [31]. In 2011 planting season, the soil organic matter was low except for the plots mulched with *Albizia* and NPK + *Albizia* which are attributable to build–up of soil organic matter.

3.2.5 Effect of organic and inorganic fertilization on total nitrogen

The moderate value of total nitrogen in *Albizia* and *Albizia* + NPK plots and in all the sampling days (40, 60 and 90 DAP) and across the years may be due partly to the nitrogen fixing ability of *Albizia* Table 1, in addition to NPK treatments and in part to the soil organic matter distribution. [32] Stated that organic matter of plant origin serves as a reservoir of nutrient such as nitrogen, sulphur, phosphorous and many minor elements. In 2011, plots treated with *Albizia* had the highest nitrogen content at 90 DAP due to build-up of organic matter by *Albizia* because of its slow decomposition which might lead to build–up of nutrient [30]. Salamanca, Kaneko & Katagiri 1998, [31] submitted that the build-up of soil nutrients may be attributed to N-transfer from nutrient-rich litter to nutrient-poor litter.

3.2.6 Effect of organic and inorganic fertilization on maize cob length, cob diameter and grain weight

The maize cob length, cob diameter and grain yield were higher in the plot mulched with *Albizia* + NPK with the highest in 2009, 2010 and 2011 planting seasons. This may be due to the supplying of large quantities of needed nutrients as well as improving the soil physico-chemical properties [27]. The improvement in soil fertility exceeded expectation in an integrated system probably because of combined effect of soil conservation, nutrient enrichment, enhancement of biological activities and improvement in moisture retention capacity [33]. Adekayode and Olojugba, 2010 [34] and Awodun, Ojeniyi, Adeboye and Odedina, 2007 [35] showed that highest yield of maize grain were obtained in the plot amended with NPK and wood ash due to the improvement in the soil fertility.

3.2.7 Profitability analysis of maize production, organic and inorganic fertilization

The profitability analysis of maize production was discounted at 10% for all treatments in 2009 and 2010 cropping seasons. Generally, all the treatments had higher net benefit over the control in the two seasons. In 2009 planting season, the low net benefit recorded in the control plot may be due to low yield as a result of non amendments while the low net benefit recorded in plots amended with *Albizia* could be attributed to high labour cost associated with this practice. On the other hands, higher net benefit recorded in the plot amended with NPK + *Albizia* might be due to moderate labour cost as a result of application of the component treatments at their half dose each which invariably reduced their total variable cost.

4. CONCLUSION AND RECOMMENDATIONS

Improving soil quality and crop production on farms is a major issue for agricultural research. This study has contributed to knowledge on some of the processes governing integrated nutrient management using low income technology such as agro forestry systems in the form of biomass transfer. This work has shown that there is a potential to improve yield of maize by integrating NPK fertilizer with agroforestry species (*Albizia zygia*). It was also shown that integrating *Albizia zygia* with NPK fertilizer increased the release of soil nutrients as manifested by maize yield increase. Thus, the slowly-decomposing litter of *Albizia zygia* is useful contribution to improve soil fertility, rather than being burnt as currently practiced by the farmers. It was also established in this study that combined used of *Albizia* + NPK fertilizer resulted in yields of maize grain, nitrogen, phosphorus, pH compared to those achieved with the application of either inorganic fertilizer or *Albizia* alone. Organic matter was found to be necessary for soil health; hence, its application is advised. Application of *Albizia* had much protective function on both physical and chemical properties of the soil because of its slow decomposing pattern. *Albizia* alone has more residual effects on soil physical and chemical properties, while *Albizia* + NPK have residual effects on maize yield. Labour requirement is very high for *Albizia* which could have affected negatively its full adoption. The financial benefits to farmer were more when using NPK + *Albizia* over all other treatments which made it more viable option among the treatments.

The following recommendations are offered;

(a) Further investigations into effects (i.e. crop yield and nutrient up take) of *Albizia zygia* biomass (litter) either applied directly or used to produce compost is required before recommendations can be made about its use as a source of organic fertilizer.
(b) Labour requirement studies should be further investigated by comparing biomass transfer and green manuring methods.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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