

Effect of *Albizia zygia* and NPK fertilizer on the Improvement of Soil Fertility and Maize yield on a Humid Alfisol in, Southwestern Nigeria

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 organic residues* and *NPK 15-15-15 inorganic fertilizer* 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 2010* at the Teaching and research farm, Joseph Ayo Babalola University, Ikeji-Arakeji, Nigeria *from 2009 to 2011*. *The experiment was laid out as a Randomized Complete Block Design (RCBD) with five treatments and three replicates. A 20m x 60m plot was demarcated at the Teaching and Research Farm of Joseph Ayo Babalola University, Ikeji - Arakeji. This was partitioned into three blocks of 5m x 50m 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: 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 *NPK 0PK* at 250 kg/ha of single superphosphate (SSP) and 90 kg/ha of murjate of potash (KCl). Soil was sampled before planting *for determination of*, soil nitrogen content *was determined at 40, 65 and 90 days after planting (DAP), while all other soil properties such as* 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 was* also evaluated. *Soil properties were significantly improved by treatments over the control. Soil physical properties were significantly improved by applying Albizia levels leaves.* Maize yields were found to have increased significantly in the plot treated with Albizia + NPK 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* to the farmer over other *treatments*.

Keywords: *fertility, soil nutrients, Albizia zygia, NPK 15-15-15, integrated nutrient management*

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 *the* 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].

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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 ~~to-be~~ 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, their use is limited with only 0.38 kg/ha applied to cropland in 2002 compared with average of 9.0 kg/ha for Sub-Saharan Africa, 22.00 kg/ha for Africa and 100.00 kg/ha worldwide [11]. The high cost, and the gap between ~~net benefit revenue collection~~ from harvested products and fertilizer purchase make the use of inorganic fertilizer use unpopular in Nigeria. 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 combination~~ of the two is ~~worth researching proposed~~.

This work is aimed at ~~determining bringing into lime-light~~ the potentials 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. MATERIAL 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 $07^{\circ}16'$ and $07^{\circ}18'$ N and longitude $05^{\circ}09'$ and $05^{\circ}11'$ E. The area is characterized by a ~~tropical~~ climate. 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.

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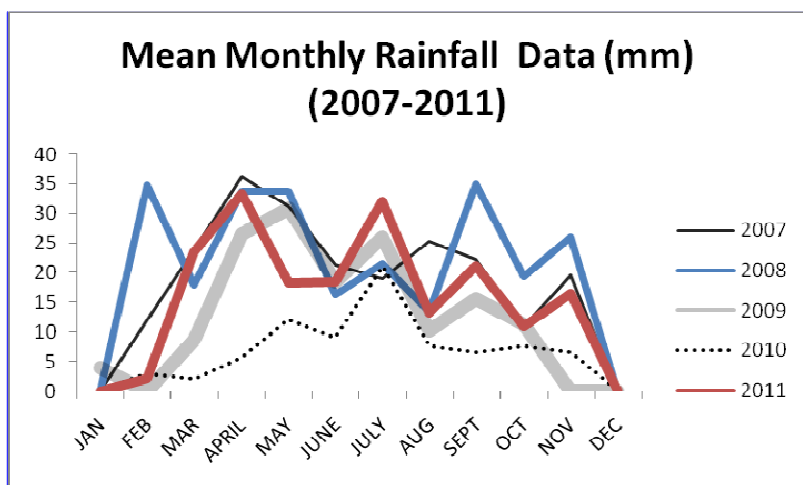


Fig. 1: Mean monthly rainfall in the study area (2007-2011)
Source: Meteorology Department, Federal University Technology, Akure

This was carried out to evaluate the effects of application of leaf biomass of the agroforestry species on the physical and chemical properties of the soil and ascertain the extent to which any changes in the physical and chemical properties of the soil could affect the growth and yield of maize crop

2.1.2: Layout of experiment

The experiment was laid out as a Randomized Complete Block Design (RCBD) with five treatments and three replicates. A 20m x 60m plot was demarcated at the Teaching and Research Farm of Joseph Ayo Babalola University, Ikeji - Arakeji. This was partitioned into three blocks of 5m x 50m 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:

- control (no treatment).
- Abizia zygia* at 5 tons/ha
- N: P: K 15-15-15 at 250 kg/ha
- Abizia zygia* at 2.5 tons/ha +NPK 15-15-15 at 150 kg/ha respectively
- OPK at 250 kg/ha of single superphosphate (SSP) and 90 kg/ha of murate of potash (KCI)

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 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 m 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. OPK plot was included to measure the native or indigenous supply of nitrogen.

2.1.3: Nutrient Concentration in the *Albizia zygia* leaves

This was carried out to determine the nutrient concentration in of *Albizia zygia* leaves and other chemical parameters influencing their leaf quality and suitability for soil fertility maintenance. Matured but not senescent of *Abizia zygia* leaves were collected from existing

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102 plants along roadsides and on abandoned farmlands very close to the campus of Joseph
103 Ayo Babalola University, Ikeji - Arakeji. The leaves were bulked, air dried for five days and
104 composite samples were taken and analyzed for some nutrients (Nitrogen, Phosphorus,
105 Potassium, Calcium and Magnesium) content, total carbon content, total soluble polyphenol
106 and lignin. Total nutrients and total carbon were determined by the method described by [13]
107 while total soluble polyphenols and lignin contents were determined using the method
108 described by [14].

109 **2.1.43: Plant Samples Collection and Analysis**

110 **2.1.3.1: Maize yield determination**

111 At maturity, four plants were selected from each plot, harvested and weighed and calculated
112 on tone per ha based on this formula: $Pp = (B + b) (L + l) / Lb \times N$
113 [15] and [16], where Pp = Plant population, L = Length of the field farm, B = Breadth of the
114 fieldarm, l = Length of spacing of the field farm, b = Breadth of spacing of the field farm and
115 N = Number of fruits per field farm stand. At maturity (90 DAP), maize cobs were harvested
116 from at a plot size of 3m x 3m from the central rows of each plot centre point of every plot.
117 All the stovers were removed from the plots. The ears were removed and cob length was
118 measured from base to the top. The diameter of each cob was measured at the middle point
119 using a veneer caliper. The cobs were oven dried at 100°C for 48hrs to a constant weight.
120 The cobs were shelled to separate the rachis and grains, the grains were oven dried again at
121 65°C for about 10 minutes to 14% moisture content and weigh to determine the grain weight.
122 The 14% grain moisture content was confirmed with the use of grain moisture tester.

123 **2.1.34: Soil samples collection and analysis**

124 **2.1.4.1: Physical analysis**

125 Soil samples were collected before planting at 40, 60 & 90 days after planting (DAP) using a
126 3.5 cm diameter soil auger. There were four auger points in each plot and samples were
127 collected at 0-20cm depth. Samples from each plot were bulked and composite soil samples
128 were collected and taken to the laboratory for analysis. The soil samples were air dried for
129 few days, sieved to pass through 2mm mesh and chemically analysed. Particle size
130 analysis was done by hydrometer method [17] using sodium hexametaphosphate (Calgon) as
131 dispersing agent, water holding capacity-water holding capacity was determined using a
132 pressure plate apparatus at 0.1kPa (field capacity), bulk density was determined on a core
133 cylinder of dried soil and calculated as: Bulk density = Oven dry weight of soil (g) / Volume of
134 the cylinder (cm³) and total Porosity This was calculated as: $\frac{1}{1 - D_b/D_p}$ Total Porosity = 100 (1-Db/Dp;
135 Where Db = bulk density, Dp = particle density (2.65g/cm³).

136 **2.1.4.2: Chemical analysis**

137 The soil samples were air dried for few days, sieved to pass through 2mm mesh and
138 chemically analysed.

139 The pH (in water) was determined using a pH meter in slurries formed from a ratio of 1g soil
140 to 2.5 cm³ water. The organic carbon content of the soil was determined according to [18]
141 dichromate oxidation method. The percentage organic matter content in the samples was
142 calculated by multiplying the values of organic carbon by the conventional Van Bammeller
143 factor of 1.724 based on the assumption that soil organic matter contains 58% carbon [19].
144 Total soil nitrogen was determined by macro kjeldahl methods [20]. Available phosphorus
145 was extracted using Bray II method [21] and determined by spectrophotometer.

146 Exchangeable Na, K, Ca and Mg were extracted with BaCl₂ 0.1m [22] and analysed by
147 atomic absorption. The exchangeable acidity was determined from 0.1N KCl extracts and
148 titrated with 1.0N HCl.

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cobs

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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 fertilizers application) for maize production. ~~organic and inorganic fertilizers were collected from the experimental plots at Joseph Ayo Babalola University, Ikeji Arakeji, Nigeria during 2009, 2010.~~

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2.1.5.1: 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 between~~ 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 Results

3.1.1 Pre-planting physico-chemical properties ~~or soil of the experimental site~~

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.

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 higer~~ with value of 0.2% in 2010, while the value in 2009 was 0.19%, calcium content was higher ~~in or~~ 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 ligning 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~~.

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Table 1: Nutrient composition of the Albizia [zy](#) 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

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

In 2009 planting season, the value of total porosity ranged from 35.99% in [OPK](#) plot to 43.92% in the plot mulched with Albizia [zy](#) 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/cm³ in NPK plot to 1.49g/cm³ in the plot mulched with Albizia leaves (Table 2). There were no significant differences at P< 0.05 among Albizia ~~and 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 [zy](#) 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/cm³ with the plot mulched with Albizia leaves to 1.67g/cm³ in the ~~OPK~~ plot. There were no significant differences among Albizia and Albizia + NPK plot.

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 [zy](#) 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 / cm³ in the plot mulched with Albizia leaves to 1.77g /cm³ in the plot amended with NPK.

Table 2: Effects of organic and inorganic fertilization on Soil Total Porosity, Water Holding Capacity (%) and Bulk Density (g/cm³) for 2009, 2010 and 2011 Planting Seasons.

Treatments	2009	2010	2011
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	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

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221 Means on the same column followed by the same letter are not significantly different at $P \leq$

222 0.05

223 TP = Soil Total porosity, WHC = Water Holding Capacity, BD = Soil Bulk Density

224 ALB = Albizia.

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226 **3.1.4: Effect of organic and inorganic fertilization on soil pH, organic matter and soil**

227 **phosphorous**

228 In 2009 planting season, the values of soil pH ranged from 5.35 in the plots amended with
 229 Albizia + NPK to 5.93 in the plot applied mulched with Albizia. The values of organic matter
 230 ranged from 1.05% to 1.74% in the control and Albizia respectively. The values of soil
 231 phosphorus ranged from 3.20mg/kg to 15.02mg/kg in the control and Albizia + NPK
 232 respectively. In 2010, the plot values ranged from 5.31 in OPK and Albizia + NPK plots to
 233 5.92 in the plot mulched with Albizia leaves. While the values of Organic matter ranged from
 234 1.07% to 1.79% in the control and Albizia plot respectively. The soil phosphorus values
 235 ranged from 3.29 mg/kg in the control plot to 12.7mg/kg in the plot mulched with Albizia
 236 leaves. In 2011, pH values ranged from 5.23 to 5.04 in NPK and Albizia plots respectively.

237 The organic matter values ranged from 0.69% in the control plot to 1.67% in the Albizia plot.

238 The values of phosphorus ranged from 3.14mg/kg in the control plot to 12.16mg/kg in the

239 plot amended with Albizia + NPK (Table 3)

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Table 3: Effect of Organic and Inorganic Fertilization on Soil pH, Organic Matter (%) and Soil Phosphorous

	2009			2010			2011			
	OM									
Treatments	pH(H ₂ O)	(%)	P(mg/kg)	pH(H ₂ O)	OM (%)	P(mg/kg)	pH(H ₂ O)	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	Common

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240 Means in the same column followed by the same letter are not significantly different at $P \leq$

241 0.05.

242 OM = soil organic matter, N = Soil total nitrogen, P = available phosphorus.

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 cm/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 3.04

cm/kg of soil in the control and Albizia mulched plots respectively.

Table 4: Effect of Organic and Inorganic Fertilization on Soil Total Exchange Bases & Cation Exchange Capacity

	2009		2010		2011	
	TEB	CEC	TEB	ECEC	TEB	ECEC
Treatments	(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 $P \leq 0.05$. ALB = Albizia.

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. 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 $p \leq$

274 0.05. At 90 days after planting the values ranged from 0.064% in the control to 0.071% in
 275 both Albizia and albizia + NPK plots
 276 In 2010 planting season, at 40 days after planting, the values of total soil nitrogen ranged
 277 from 0.064% in both control and OPK plot to 0.075% in the Albizia + NPK plot. At 60 days
 278 after planting (DAP). It ranged from 0.063% in control and OPK plot to 0.075% in albizia +
 279 NPK plots. At 90 days after planting the values ranged from 0.062% and Albizia + NPK plots.
 280 However, there were no significant differences between the control and OPK at 60 & 90
 281 days after planting as well as between Albizia and Albizia + NPK at 90 days after planting at
 282 $p \leq 0.05$.
 283 In 2011 planting season, at 40 days after planting (DAP), the values ranged between
 284 0.059% to 0.073% in the control and Albizia + NPK respectively and significantly different at
 285 $p \leq 0.05$. At 60 days after planting the values ranged from 0.058% in the control plot to
 286 0.070% in the Albizia plot. At 90 days after planting, the values ranged from 0.055% in the
 287 control plot to 0.072% in the plot mulched with Albizia and statistically different among the
 288 treatments at $p \leq 0.05$.

Table 5: Effects of Organic and Inorganic Fertilization on Total Soil Nitrogen (%) at Different Sampling Time Comment [S25]: Format table

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

289 Means on the same column followed by the same letter are not significantly different at $P <$
 290 0.05.

291 ALB = Albizia, *=Days After Planting.

292 **3.1.7: Effect of organic and Inorganic fertilization on maize cob length (cm) cob** 293 **diameter (cm) and Grain weight (t/ha)**

294 In 2009 planting season, the values of cob length ranged from 18.35 cm in the
 295 control plot to 22.58cm in the plot treated with Albizia + NPK. However, there was no
 296 statistical difference between NPK and Albizia + NPK plot at $P \leq 0.05$ (Table 6). The values
 297 of cob diameter ranged from 3.14cm to 5.60cm in the control and Albizia + NPK plots
 298 respectively. In the same vein, there was no statistical difference between the plots
 299 amended with NPK and Albizia + NPK at $P \leq 0.05$ (Table 6). Grain weight values ranged
 300 from 0.74 t/ha in the plot without amendment to 1.33 t/ha in the plot amendment with Albizia
 301 + NPK.

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

Comment [S26]: recast

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

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	

Comment [S27]: LSD

312 Means on the same column followed by the same letter are not significantly different at P <
 313 0.05.

314 ALB = Albizia,

315 **3.1.8. Profitability Analysis of maize yield, organic and inorganic fertilizers for 2009**
 316 **and 2010 planting seasons.**

Comment [S28]: Not clear

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

325 In 2010 planting season, the yield value ranged from 0.60 t/ha to 1.3 t/ha in the
 326 control and Albizia + NPK plot respectively, however, there was no significant different at P ≤
 327 0.05 between OPK and NPK plots. The yield values ranged between N42, 000 (USD 265.82)
 328 to N121, 800 (USD 770.89) in the control and Albizia + NPK plots respectively. The cost of
 329 production values ranged from N39, 218 (USD 248.22) to N48, 667 (USD 188.63) in the
 330 control plot and Albizia mulched plots. There was significant differences among the
 331 treatment at P<0.05. The net profit, values ranged from N2782 (USD 17.61) to N76204
 332 (USD 482.30) in the control and Albizia + NPK plots respectively. There were significant
 333 differences among the treatments at P ≤0.05.

334 Generally, the yields in the 2010 were higher except in the control and NPK plots.

335 Also, the net profit were higher in all the plots except in the control and NPK plots.

336 **Table 7: Profitability Analysis of Maize production, Organic and Inorganic Fertilizers**
 337 **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
	2009				2010			

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.

ALB = Albizia.

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 (source). [25] Reported that sufficient exchangeable acidity is responsible for soil acidity. Also [26] 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 (source). The lignin, polyphenols and carbon were higher which makes Albizia resistant to decomposition thereby enabling it to stay more on soil as organic humus (source). 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 Albizia 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 [27]. 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. [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 (~~water~~) 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 [28] who attributed [a similay situation to it](#) 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⁻ [28]. 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. [29] reported that litter which decomposes slowly favours the build-up of soil organic matter. They ~~went~~ further [observed to say](#) that the decomposition rate of this resistant litter was enhanced by mixing it with nutrient – rich litter [29]. This type of increase is attributed to N-transfer from nutrient – rich to nutrient poor litter [30]. 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 and the Total Soil Nitrogen

The moderate value of total ~~soil~~ 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. [31] 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 [29]. [30] 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 had](#) 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 [32]. 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]. [34] and [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 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 attached to these materials](#).

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~~ can be 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.

(c) Studies investigating the residual effects and longevity of compost, different rates of fertilizer applications and different organic sources (e.g. green manures, composting litter) should be considered in a wide range of soils.

(d) Extension research should be conducted on how best farmers would adopt the use of *Albizia Zygia*.

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Comment [S29]: State your silent recommendation from this study

Comment [S30]: Concentrate on few of these and highlight of better recommendations

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