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Effects of Integrating *Albizia zygia* and *Tithonia diversifolia* on Degraded Humid Alfisol for Maize Performance in Southwestern Nigeria

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Author's contribution

This work was carried out by the author MRO. Author MRO designed the study, wrote the protocol, and wrote the first draft of the manuscript, managed the literature searches, analyses of the study and read and approved the final manuscript.

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ABSTRACT

The combined effects *Albizia zygia* and *Tithonia diversifolia* biomass on a degraded humid alfisol and maize yield were studied. The experiment was laid out as a randomized complete block design (RCBD) with five treatments and three replicates. The experiment was conducted at the Teaching and research farm Joseph Ayo Babalola University, Ikeji-Arakeji, Nigeria from 2009 to 2011. The treatments were: Control (no treatment), *Abizia zygia* at 5 tons/ha, *Tithonia diversifolia* at 5 tons/ha, *Albizia zygia* + *Tithonia diversifolia* at 2.5 tons/ha each, 0PK at 250 kg/ha of single superphosphate (SSP) and 90 kg/ha of murate of potash (KCl). Soil was sampled before planting, 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 exchange bases, cations exchange capacity, Total soil porosity, Water holding capacity and soil bulk density) were determined. Maize yield at the end of the growing seasons as well as the profitability of the treatments were determined. Soil properties such as: Total porosity, water holding capacity, soil nitrogen, soil pH, organic matter, available phosphorous, total exchange bases and cations exchange capacity were significantly improved by treatments over the control. Maize yields (3.25 tons/ha, 4.25tons/ha and 2.21tons/ha in 2009, 2010 and 2011 cropping seasons respectively)

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were found to have increased significantly in the plot treated with *Albizia* + *Tithonia* over other treatments. In the same vein, the same treatment (*Albizia* + *Tithonia*) was found to have returned more net profit {(N155, 487 (US$ 1003.1) and N257, 469 (US$1661.1)} to the farmer over other treatments.

Keywords: Fertility; soil nutrients; Albizia zygia; Tithonia diversifolia; integrated nutrient management; mulching.

1. INTRODUCTION

In Africa, poor land management has resulted into loss of soil nutrients up to 45% due to water erosion, 38% loss from wind erosion, 12% loss from improper chemical use and 4% loss from soil compaction due to overgrazing [1]. This had lead to soil degradation in Sub-Saharan Africa. Soil degradation is the loss of production capacity of soil in terms of soil fertility, soil bio-diversity and degradation of natural resources [2]. It is also refer to the decline in soil physical, chemical, biological and hydrological potentials due to nutrients mining, erosion and desertification and these have been the threat to food production in Sub-Saharan Africa [3]. Soil fertility decline in Sub-Saharan Africa is driven by a wide range of biophysical, chemical and socio-economic factors; the first is the geologic origin of the parent materials on which soils have developed which may consist of old and weathered materials with low nutrients, the second may be attributed to nutrient depletion. Nutrient balances are negative for many cropping systems indicating that farmers are mining their soils at alarming rates. It is estimated that for 32.8 million hectares of land cultivated, soil nutrient mining amounted to a total loss of 111,000 tons of nitrogen (N), 317,000 tons of P_2O_5 and 946,000 tons of K_2O [4] equivalent to over US $ 800 million of N, P and K fertilizers.

In Nigeria however, soil degradation is associated with soil fertility depletion (mainly nitrogen, phosphorus and carbon) which is a major threat to food security and has resulted in more food importation into the country. Agriculture provides means of livelihood to about 80% population and provides raw materials for agro-based industrial sector in the country. Declining agricultural production has greatly increased the poverty level in the rural based communities and among subsistence farmers in Nigeria who depend on farming to earn their living. Farmers in the crop-based communities are becoming sensitive to the declining soil fertility. Sustaining soil fertility has therefore, become a major issue in agricultural research and crop production and should be based around affordable practices which result in higher crop production at low cost. One of such methods is a leaf biomass from some promising agroforestry species such as *Albizia zygia* and *Tithonia diversifolia* which are found along major roads, boundary hedges (*Tithonia*) and the secondary forest (*Albizia*). *Albizia* is a nitrogen fixing plant and could serve as a shade tree to Cocoa and Coffee etc. *Tithonia* is a shrub plant with fast growth rate. The abundance and adaptability of both species to various environment coupled with their rapid growth, high vegetative matter turn-over (*Tithonia*) and need for no investment cost on their production makes them suitable species for soil rejuvenation among small holder farmers [5].

Albizia trees can capture nutrients from atmosphere, nitrogen fixation, deep and lateral roots access where crop root cannot reach. The nutrients are re-distributed to soil system via litter and root decomposition and mineralization [6]. The application of *Tithonia* biomass produces beneficial effect on soil quality and nutrient uptake and these traits have been exploited in Kenya and Malawi and are being tested in Nigeria [7]. Soil fertility replenishment is an investment in natural resources capital and could be achieved with the use of organic, inorganic or combination of both. The latter practice is referred to as integrated nutrient management and is central to better soil fertility management [8].

Sustaining soil fertility has therefore become a major issue in agricultural research and crop production since Sub-Saharan Africa is the home of the world's poorest people of whom 80% live in villages and rely on subsistence agriculture [8], it must be based on the affordable practices such as agroforestry systems but the most promising ones have not been properly evaluated. The information on the quality of their biomass is sketchy, the economic profitability of agroforestry technology remain limited. Therefore, this study was designed to address and fill the above gaps.

2. MATERIALS AND METHODS

2.1 Site Description

The experiment was conducted on the teaching and research field of the College of Agricultural Science of Joseph Ayo Babalola University, Ikeji - Arakeji which lies between latitude 07º16[1] N and 07º18[1] and longitude 05º 09º and 05º 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. It has a gentle undulating elevation of about 1150m-1250m above sea level [5].

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 20 m x 35 m plot was demarcated at the Teaching and Research Farm of Joseph Ayo Babalola University, Ikeji - Arakeji. This was partitioned into three blocks of 5 m x 35 m each. Each block was partitioned into eight 5m x 5m plots. Each 5 m x 5 m plot was separated by buffer of 2.5 m wide. The treatments were:

a. Control (no treatment).
b. *Abizia zygia* at 5 tons/ha
c. *Tithonia diversifolia* at 5 tons/ha
d. *Albizia zygia* + *Tithonia diversifolia* at 2.5 tons/ha each
e. 0PK (no N application) at 250 kg/ha of single superphosphate (SSP) and 90 kg/ha of muriate of potash (KCl)

All the treatments were allocated to the plots in each block at random.

Albizia leaves and *Tithonia* biomas were incorporated with hoe in the top of 15cm-20cm at 12.5 kg / plot or 5 tons/ha [8] 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 [5]. 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. 0PK plot was included to measure the native or indigenous supply of nitrogen [5].

2.1.3 Nutrient concentration in the leaves of selected agroforestry species

This was carried out to determine the nutrient concentration in the leaves of selected species and other chemical parameters influencing their leaf quality and suitability for soil fertility maintenance. Mature but not senescent biomass of *Tithonia diversifolia* and *Albizia 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 [10] while total soluble polyphenols and lignin contents were determined using the method described by [11].

2.1.4 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

[12,13], where

Pp = Plant population, L = Length of the farm, B = Breadth of the farm, I = Length of spacing of the farm, b = Breadth of spacing of the farm and N = Number of fruits per farm stand

At maturity (90 DAP), maize cobs were harvested at a plot size of 3m x 3m centre point of every 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. The cobs were oven dried at 100ºC for 48hrs to a constant weight. The cobs 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.

2.1.5 Soil sample collection and analysis

2.1.5.1 Physical analysis

Soil samples were collected before planting, 40, 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 were collected and taken to the laboratory for analysis. Particle size analysis was done by hydrometer method [14] using sodium hexametaphoshate (Calgon) as dispersing agent, water holding capacity 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 This was calculated as: Total Porosity = 100 (1-Db/Dp; Where Db = bulk density, Dp = particle density (2.65g/cm^3)

2.1.5.2 Chemical analysis

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

The pH (in water) was determined using a pH meter in slurries formed from a ratio of 1g soil to 2.5 cm^3 water. The organic carbon content of the soil was determined according to [15] dichromate oxidation method. The percentage organic matter content in the samples was calculated by multiplying the values of organic carbon by the conventional Van Bammeller factor of 1.724 based on the assumption that soil organic matter contains 58% carbon. Total soil nitrogen was determined by macro kjeldahl methods [16]. Available phosphorus was extracted using Bray II method [17] and determined by spectrophotometer.

Exchangeable Na, K, Ca and Mg were extracted with $BaCl_2$ 0.1m [18] and analysed by atomic absorption. The exchangeable acidity was determined from 0.1N KCl 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). While the base saturation was calculated thus:-

Percentage Base saturation = TEB / ECEC X 100, where TEB = total exchangeable bases, ECEC = effective cations exchange capacity.

2.1.6 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.

2.1.6.1 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 between the yield value and the total production cost [19]

2.1.7 Statistical analysis

Data were subjected to analysis of variance using the general linear model procedure (GLM) for randomized complete Block design (RCBD) in SAS [20]. 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 soil of the area 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 and exchangeable acidity were 0.067%, 3.44 mg/kg, 0.15 cmol/kg of soil, 0.8 cmol/kg of soil, 0.35 cmol/kg of soil, 0.17 cmol/kg of soil and 1.36 cmol/kg of soil respectively. The texture of the area is sandy clay loam.

Table 1. Pre-planting physico-chemical properties of soil of the experimental site

Soil properties	Values
pH (water)	5.9
Organic matter (%)	0.8
Total nitrogen (%)	0.067
Available P (mg/kg)	3.44
Sand (%)	64.00
Silt (%)	24.00
Clay (%)	12.00
Calcium (cmol/100 g of soil)	0.80
Magnesium (cmol/100 g of soil)	0.35
Potassium (cmol/100 g of soil)	0.15
Sodium (cmol/100 g of soil)	0.17
Exchange acidity (cmol/100 g of soil)	1.36
ECEC	2.83

ECEC = Effective Cation Exchange Capacity

3.1.2 Nutrient concentration in *Albizia* and *Tithonia* leaves used for the experiment in 2009 and 2010 planting.

Table 2 shows the results of nutrient concentration in *Albizia* and *Tithonia* leaves.

In 2009 the results showed that *Albizia* leaves had higher value of nitrogen with 4.11% but there was no significant difference at $p \le 0.05$ between the two afroforestry species. In the same vein *Albizia* leaves had the higher significant values of carbon, lignin and polyphenols than that of *Tithonia* leaves at $p \le 0.05$. On the other hand, *Tithonia* biomass had higher values of phosphorus, calcium, magnesium and potassium these differences were not significant at $p \le 0.05$.

In 2010 planting season, the values of nitrogen was 4.71% and 3.91% in Abizia and *Tithonia* biomass respectively and show significant difference at $p \le 0.05$. Also significant higher values of carbon and polypenols were recorded in *Albizia* leaves over *Tithonia* biomass at $p \le 0.05$. On the other hand the values of phosphorus, calcium, magnesium and potassium were higher in *Tithonia* biomass over the *Albizia* but showed no significant difference $p \le 0.05$

3.1.3 Effect of *Albizia* and *Tithonia* biomass on total water holding capacity (%) and bulk density (g /cm^3) for 2009, 2010 and 2010 planting seasons

Table 3 shows the results of effect of *Albizia* and *Tithonia* biomass on soil total porosity, water holding capacity and soil bulk density.

In 2009 planting season, the values of soil total porosity (TP) ranged from 36.99 % to 44.58% in 0PK and *Albizia* + *Tithonia* plots respectively. Although there was higher value in the plot mulched with *Albizia* + *Tithonia* but there were no significant differences in total porosity among the plots mulched with *Albizia* + Tithnoia at $p \le 0.05$. The water holding capacity (WHC) shows similar trend with the values from 29.29% in the control and 38.93% in the plot mulched with *Albizia* + *Tithonia* and *Albizia* + *Tithonia* at $p \le 0.05$. The values of bulk density (BD) ranged from1.46 g/cm^3 to 1.66 g/cm^3 in the control plot and plot mulched with *Albizia* + *Tithonia* respectively. However, there was no significant difference between the plots mulched with *Tithonia* and *Albizia* at $p \le 0.05$.

In 2010 planting season, soil total porosity (TP) ranged from 33.93 % to 44.80% in the control and plot mulched with *Albizia* leaves. There was no significant difference between plot mulched with *Tithonia* and *Albizia* at $p \le 0.05$. The soil water holding capacity (WHC) values ranged from 29.89% to 37.75% in the control plot and plot mulched with *Tithonia* biomass. The soil bulk density (BD) values ranged between 1.45g/cm^3 to 1.57 g/cm^3 in the plot mulched with *Albizia* leaves and control plot respectively. However there was no significant difference in the bulk density between the control and 0PK plots at $P \le 0.05$.

In 2011 planting season, the soil total porosity ranged from 34.35% in the 0PK plot to 42.26% in the plot mulched with *Albizia*. However, there was no significant difference in the total porosity between the control and 0PK plots at $P \le 0.05$. The water holding capacity (WHC) values ranged from 28.37% in the 0PK plot to 33.98% in the plot mulched with *Albizia* + *Tithonia*.

The soil bulk density (BD) values show no significant differences among Tithomia. *Albizia* + *Tithonia* and *Albizia* plots at $P \le 0.05$, the values ranged from 1.53 g/cm^3 in the plot mulched with *Albizia* to 1.75 g/cm^3 in 0PK plot with no significant difference in both plots.

Table 2. Nutrient concentration in *Albizia* and *Tithonia* leaves used for the experiment in 2009 and 2010 planting seasons

Properties	2009			2010		
	Albizia	***Tithonia***	**T - value**	***Albizia***	***Tithonia***	**T - value**
Nitrogen (%)	4.11	3.69	-1.23^{ns}	4.71	3.91	75.58*
Phosphorus (%)	0.19	0.33	-3.93^{ns}	0.2	0.34	-9.41^{ns}
Calcium (%)	0.27	3.33	-374.77^{ns}	0.25	3.86	-12.52^{ns}
Magnesium (%)	0.25	0.4	-18.37^{ns}	0.28	0.52	-14.12^{ns}
Potassium (%)	1.93	4.16	-273.12^{ns}	1.91	4.18	-215.03^{ns}
Carbon (%)	65.6	35.45	521.29*	57.21	28.21	314.67*
Lignin (%)	33.4	10.57	67.47*	34.24	11.33	37.08*
Polyphenols (%)	6.5	1.27	640.54*	7.2	1.3	50.93*

**= Significant at ($P < 0.05$), ns= not significant at ($P < 0.05$), Means followed by the same letter(s) within columns are not significantly different at $P < 0.05$*

Table 3. 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**
Albizia	42.92^a	34.67^b	1.48^d	44.25^c	35.65^b	1.47^c	42.36^a	30.74^b	1.53^b
Albizia +Tithonia	44.58^a	37.93^a	1.46^e	44.80^d	37.70^a	1.45^d	40.69^b	33.96^a	$1.5b^d$
0PK	36.99^b	33.21^b	1.65	37.98^b	31.48^c	1.68^a	34.35^d	28.37^c	1.75^a
Tithonia	43.88^a	38.09^a	1.48^d	44.08^c	37.75^a	1.50^b	38.88^c	31.03^b	1.57^b
Control	36.90^b	29.29^c	1.66^b	33.93^a	29.89^c	1.68^a	33.97^d	27.59^c	1.74^a

Means followed by the same letter(s) within columns are not significantly different at $P \leq 0.05$

3.1.4 The effect of *Albizia* and *Tithonia* biomass on the total soil nitrogen at different sampling time

In 2009 planting season, at 40 days after planting, Table 4, the values of total soil nitrogen ranged between 0.007% in the control plot to 0.075% in the plot mulched with *Albizia* + *Tithonia* biomass, however, there was no significant difference in the total nitrogen between *Albizia* and *Tithonia* plots at $p \leq 0.05$. At 60 days after planting, *Albizia* + *Tithonia* plot recorded the highest values of 0.073% while the least value was recorded from the control plot. At 90 days after planting the same trend was maintained with low values recorded. The highest value was from the plot mulched with *Albizia* + *Tithonia* and least value in the control plot. However, there was no significant difference between *Albizia* plot and *Tithonia* plot at $p \leq 0.05$.

In 2010 planting season at 40 days after planting the values ranged from 0.062% in the control to 0.078% in the plot mulched after with *Albizia* + *Tithonia*. At 60 days after planting the value ranged from 0.061% in the control plot to 0.073% in the plot mulched with *Albizia* + *Tithonia*. There was no significant difference between *Albizia* plot and *Tithonia* mulched plot at $P \leq 0.05$. At 90 days after planting the values ranged from 0.02% to 0.074% in the control and *Albizia* + *Tithonia* plots respectively.

In 2011 planting season, at 40 days after planting the values ranged from 0.059% in the control plot to 0.072% in the *Albizia* mulched plot as well as in the plot mulched with *Albizia* + *Tithonia* biomass plot and show no significant difference at $P \leq 0.05$ between the two plots. At 60 days after planting, the values ranged from 0.058% in the control plot to 0.071% in the plot mulched with *Albizia* + *Tithonia*. However, there was no significant difference between the plots mulched with *Albizia* and *Tithonia* at $p \leq 0.05$. At 90 days after planting, the control plot recorded the least value of 0.055% and the highest value of 0.074% was recorded from the plot amended with *Albizia* + *Tithonia* biomass. There was no significant difference between *Albizia* mulched plot and *Tithonia* mulched plot at $P \leq 0.05$.

3.1.5 Effect of *Albizia* leaves and *Tithonia* biomass on soil pH, organic matter (%) and soil phosphorous (mg/kg)

In 2009 planting season, the value of pH ranged from 5.37 in 0PK plot to 5.94 the *Albizia* plot. The value of organic matter ranged from 1.05% in the control plot to 1.77% in the plot mulched with *Albizia* + *Tithonia*. The value of soil phosphorus ranged from 3.20 mg/kg in the control plot to 13.23 mg/kg in the plot mulched with *Tithonia* biomass. However, there was no significant difference between *Albizia* + *Tithonia* and *Tithonia* plots at $P \leq 0.05$.

In 2010 planting season, the value of pH ranged from 5.47 to 5.93 in the control and *Albizia* plots respectively. The soil organic matter values ranged from 1.07% to 1.79% in the control plot and plot mulched with *Albizia* + *Tithonia*. The values of soil phosphorus ranged from 3.29 mg/kg in the control plot to 14.03 mg/kg in the plot mulched with *Albizia* + *Tithonia* (Table 5).

In 2011 planting season, soil PH values ranged from 5.24 in the control plot to 5.65 in the plot mulched with *Albizia* leaves. However, the values in the *Albizia* + *Tithonia*, 0PK and *Tithonia* plots did not change significantly at $P \leq 0.05$. The soil organic matter values ranged from 0.69% in the control plot to 1.68% in the plot mulched with *Albizia*. The values of soil phosphorus ranged from 3.14 mg/kg in the control plot to 11.51mg/kg in the plot mulched with *Tithonia*. However, *Albizia* + *Tithonia* and *Tithonia* did not show any difference statistically. Also plots mulched with *Albizia* and 0PK did not show any differences statistically at $P \leq 0.05$ (Table 6).

3.1.6 Effect of *Albizia* and *Tithonia* on soil total exchangeable bases (TEBs) and cation exchange capacity (CEC)

In 2009 planting season, the total exchangeable bases ranged from 1.34 cmol/kg of soil to 2.69 cmol/kg of soil in the control and plot mulched with *Albizia* + *Tithonia* biomass respectively and they are statistically difference at $P \leq 0.05$. In the same vein, the values of cation exchangeable capacity ranged from 2.70cmol/kg of soil in the control plot to 4.38 cmol/kg of soil in the plot mulched with *Albizia* + *Tithonia* biomass.

In 2010 planting season, the values of total exchangeable bases ranged from 1.32 cmol/kg of soil to 2.71 cmol/kg of soil. Also the values of cation exchangeable capacity (CEC) ranged from 2.68cmol/kg or soil to 4.39cmol/kg of soil in the control and plot mulched with *Albizia* + *Tithonia* respectively.

In 2011 planting season, the values of total exchangeable bases ranged from 0.81 cmol/kg of soil in the control plot to1.46cmol/kg in the soil in plot mulched with *Albizia* + *Tithonia* biomass. The values of cation exchangeable capacity (CEC) ranged from 2.20cmol/kg in the control plot to 3.34cmol/kg of soil. In all the plant season, there were significant differences among the treatments at $P \leq 0.05$.

3.1.7 Effect of *Albizia* and *Tithonia* on the maize cob length (cm), cob diameter (cm) and maize grain weight (t/ha)

The cob length values show that there were significant differences among the treatments at $P \leq 0.05$. (Table 7). In 2009 the values ranged from 18.35cm to 21.83cm in the control and plot mulched with *Albizia* + *Tithonia* biomass respectively. In 2010, the values ranged from 16.70 cm in the control plot to 20.40cm in the plot mulched with *Tithonia*. However, there was no significant difference between *Tithonia* biomass mulched plot and *Albizia* + *Tithonia* plot at $P \leq 0.05$. In 2011, there was no significant difference among *Albizia*, *Albizia* + *Tithonia* and *Tithonia* plots at $P \leq 0.05$ with the higher value of 18.82 cm recorded from the plot mulched with *Albizia* + *Tithonia* biomass.

Table 4. 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	0.074^a	0.073^b	0.071^b	0.074^b	0.072^b	0.072^c	0.072^a	0.070^a	0.072^b
Albizia +*Tithonia*	0.075^a	0.073^a	0.072^a	0.073^a	0.072^a	0.074^a	0.072^a	0.071^a	0.074^a
OPK	0.069^c	0.067^c	0.066^c	0.065^d	0.064^c	0.063^d	0.061^c	0.060^c	0.058^c
Tithonia	0.074^a	0.072^b	0.071^b	0.078^c	0.073^b	0.073^b	0.072^b	0.071^a	0.072^b
Control	0.067^d	0.064^d	0.064^d	0.062^e	0.063^d	0.062^e	0.059^d	0.058^d	0.055^d

*Means followed by the same letter(s) within columns are not significantly different at $P \leq 0.05$, *=Days After Planting*

Table 5. 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	5.94[a]	1.73[b]	11.89[b]	5.93[a]	1.78[a]	12.08[c]	5.65[a]	1.68[a]	10.27[b]
Albizia +Tithonia	5.60[c]	1.77[a]	13.01[a]	5.61[b]	1.79[a]	14.03[b]	5.00[b]	1.50[b]	11.14[ab]
OPK	5.37[e]	1.23[d]	9.51[c]	5.38[c]	1.25[c]	9.91[d]	5.31[b]	1.27[d]	9.31[c]
Tithonia	5.46[d]	1.36[c]	13.23[a]	5.47[c]	1.48[b]	14.31[a]	5.43[b]	1.34[c]	11.51[a]
Control	5.85[b]	1.05[e]	3.20[d]	5.84[d]	1.07[d]	3.29[f]	5.24[c]	0.69[e]	3.14[d]

Means in the same column followed by the same letter are not significantly different at $P \leq 0.05$. OM = soil organic matter, N = Soil total nitrogen, P = available phosphorus.

Table 7 shows the results of the maize cob diameter. In 2009, the value ranged from 3.14cm to 5.67cm in the control and *Albizia* + *Tithonia* biomass mulched plots respectively. However, *Tithonia* and *Albizia* plots did not different statistically at p $\leq$ 0.05. In 2010, the values ranged from 4.05cm in the control plot to 5.80 cm with plot mulched with *Albizia* + *Tithonia*. *Tithonia* and *Albizia* + *Tithonia* plots did not show any difference statistically at $\leq$ 0.05. In the same vein, *Albizia* and OPK plot did not show any difference statistically at P <0.05.

In 2009 the values of maize grain weight ranged from 1.74 t/ha in the control plot to 3.25 t/ha in the plot mulched with *Albizia* + *Tithonia*. However, there was no significant difference between *Tithonia* and *Albizia* + *Tithonia* plot at P $\leq$ 0.05. In the same vein, *Albizia* and OPK did not show any appreciable difference statistically at P $\leq$ 0.05.

In 2010, the values of maize grain ranged from 1.67 t/ha in the control plot to 4.86 t/ha in the plot mulched with *Albizia* + *Tithonia* biomass. There was no statistically difference between *Albizia* mulched plot and OPK plots.

In 2011, the values ranged from 1.33 t/ha to 2.21 t/ha in the control and *Albizia* + *Tithonia* plots respectively.

3.1.8 Profitability analysis of *Albizia* leaves and *Tithonia* biomass on soil fertility and maize production

In 2009 the maize yield (discounted at 10%) ranged from 1.57 t/ha in the control plot to 2.93 t/ha in the plot mulched with *Albizia* +*Tithonia* biomass. However the plots mulched with *Albizia* + *Tithonia* and *Tithonia* biomass were not statistically different at P $\leq$ 0.05.The values of yield ranged from 109,900 Nigeria Naira (USD 695.57) to 205,100 Nigeria naira (1303.16) in the control and *Albizia* + *Tithonia* plots respectively (Table 8).

The cost of production range from 39,690 Nigeria Naira (USD 251.20) to 50,085 Nigeria Naira (USD 316.99) in the control plot and *Albizia* plot respectively. However, there was no significant difference in the plots mulched with *Albizia* and *Tithonia* at P $\leq$ 0.05.

The net profit ranged from 70,210 Nigeria naira (USD 444.368) to 155,487 Nigeria naira (USD 984.09) in the control and *Tithonia* biomass mulched plots respectively. However, the plots mulched with *Albizia* + *Tithonia* and *Tithonia* did not show any significant difference at P $\leq$ 0.05.

Table 6. Effect of organic and inorganic fertilization on soil total exchange bases & cation exchange capacity

Treatments	2009		2010		2011	
	TEB	CEC	TEB	CEC	TEB	CEC
	(cmol / kg of soil)					
Albizia	2.24^c	3.65^b	2.26^c	3.67^c	1.37^b	3.05^b
Albizia +*Tithonia*	2.69^a	4.38^a	2.71^a	4.39^a	1.48^a	3.34^a
0PK	1.65^d	2.77^c	1.65^d	2.91^d	0.96^d	2.33^d
Tithonia	2.35^b	3.88^b	2.40^b	3.93^b	1.18^c	2.73^c
Control	1.34^e	2.70^d	1.32^e	2.68^e	0.81^e	2.20^e

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

Table 7. 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^a	4.14^b	4.86^b	3.11^c	2.17^b	2.06^b	2.13^b
Albizia +*Tithonia*	21.83^a	20.38^a	18.82^a	5.67^a	5.86^a	3.66^a	3.25^a	4.86^a	2.21^a
OPK	19.90^c	18.98^c	16.67^b	4.05^c	4.57^b	3.04^c	2.15^b	2.05^b	2.04^c
Tithonia	21.85^a	20.40^a	17.43^a	4.17^b	5.85^a	3.17^b	3.24^a	3.84^a	2.04^c
Control	18.35^e	16.70^d	15.27^c	3.14^d	4.05^c	3.05^d	1.74^c	1.67^c	1.33^d

Means followed by the same letter(s) within columns are not significantly different at P $\leq$ 0.05

Table 8. Profitability Analysis of Maize production, Organic and Inorganic Fertilizers for 2009 and 2010 planting Seasons

Treatments	Yield (t/ha)	Value of yield (N)	Cost of production (N)	Net profit (N)	Yield (t/ha)	Value of yield (N)	Cost of production (N)	Net profit (N)
			2009				2010	
Albizia	2.0[b]	140,000[b]	50085[a]	89,915[b]	1.85[b]	129,500[c]	48667[a]	80,833[b]
Albizia +Tithonia	2.93[a]	205,100[a]	49613[a]	155,487[a]	4.37[a]	305,900[a]	48431[a]	257,469[a]
OPK	1.95[b]	135,800[c]	43942[b]	86,660[c]	1.85[b]	129500[c]	44415[c]	80,5085[b]
Tithonia	2.92[a]	204,400[a]	49140[a]	155,260[a]	3.46[b]	242,200[b]	48195[b]	194,005[b]
Control	1.57[c]	109,900[d]	39690[c]	70,210[d]	1.5[c]	105,000[d]	39218[d]	65,782[c]

Means in the same column followed by the same letter are not significantly different at P ≤ 0.05

In 2010 the yield values were higher in all plots except in the control plots. It ranged from 1.5 t/ha in the control plot to 4.37 t/ha in the plots mulched with *Albizia* + *Tithonia*. The yield values ranged from 105,000 Nigeria naira (USD 664.56) to 305,900 Nigeria naira (USD 1936.07) in the plot mulched with *Albizia* + *Tithonia*. *Tithonia* biomass and *Albizia* + *Tithonia* did not show any significant difference at $P \leq 0.05$.

The cost of production ranged from 39,218 Nigeria naira (USD 248.22) in the control plot to 48,667 (USD 465.05) in the plot mulched with *Albizia* + *Tithonia*. However, there was no significant different between the plots mulched with *Albizia* + *Tithonia* and *Tithonia* at $P \leq 0.05$.

The net profit ranged from 65,782 Nigeria naira (USD 416.34 in the control plot to 257,469 Nigeria naira (USD1629.55) in the plot mulched with *Albizia* + *Tithonia*. However, there was no significant difference between *Albizia* and OPK plots.

3.2 Discussion

3.2.1Pre-planting physic-chemical properties or 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 [21] and [22]. Nitrogen, phosphorous, potassium and magnesium were moderate while, organic matter, calcium and effective cations exchange capacity were low in the study area [23]. 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. The low value of organic matter in the area may be due to continuous cropping without the addition of organic manure (Table 1).

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

In 2009 and 2010 cropping seasons, the concentration of nitrogen in the leaves showed that both *Albizia* and *Tithonia* leaves could be good sources of nitrogen to the soil, although, *Albizia* was higher in nitrogen content than *Tithonia* which may be due to the nitrogen fixing ability of the former. *Tithonia* leaves had higher phosphorus content than *Albizia* and this is in agreement with earlier findings of [7]. Higher values of Ca, Mg, and K, were obtained for *Tithonia* than *Albizia* which implies that *Tithonia* could be a better source of these nutrients. However, the leaf content of carbon, lignin and polyphenols show that *Albizia* leaves may be more resistant to decomposition than *Tithonia*. *Albizia zygia* with high carbon, lignin and polyphenols is more resistant to decomposition because they are high fibers which needed more time and energy for its decomposition. Also, *Tithonia diversifolia* with low carbon-to-nitrogen ratio than *Albizia zygia* is prone to decomposition and tend to release more nutrients rapidly [10].

3.2.3 Effect of *Albizia* and *Tithonia* biomass on total soil porosity water holding capacity (%) and bulk density (g /cm^3) for 2009, 2010 and 2010 planting seasons

The moderate to higher values of soil total porosity and water holding capacity in most of the organic matter 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 [24]. 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. Soil organic matter contributes to improving soil structure, aggregate stability, decrease soil bulk density and increase the percentage of pore spaces [25].

3.2.4 Effect of organic and inorganic fertilization and the total soil nitrogen

The moderate to higher values of total soil Nitrogen in all the sampling days (40, 60 and 90 DAP) and across the years may be due partly to mineralization of the materials used as the amendments and in part to the soil organic matter distribution. [26], (7) Made similar observation and they reported that *Tithonia* leaves and organic composite increased the nitrogen level significantly at ($p \leq 0.05$). Also, [27] 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* + *Tithonia* had the highest nitrogen content at 90 DAP due to build-up of nitrogen by *Albizia* components of the treatments because of its slow nutrient releasing nature [28,29] Submitted that the build-up of soil nutrients may be attributed to N-transfer from nutrient-rich litter to nutrient-poor litter.

3.2.5 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 [30] who attributed it to the proton exchange between the soil and added *Albizia* which contains more phenolic, humic like material than *Tithonia*. Other workers such as [6] reported that *Tithonia* did not increase soil pH significantly when compared with the control plot. In 2011 planting season, the absence of amendments may have contributed to the acidic nature of the plots. The moderate values of organic matter recorded in 2009 and 2010 planting season in most of the plots treated over the control plots may be due to the decomposition of the mulch materials used which gave rise to the build-up of soil organic matter in this study. Higher 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 *Albizia* + *Tithonia*. [28] Reported that litter which decomposes slowly favours the build-up of soil organic matter. They went further to say that the decomposition rate of this resistant litter was enhanced by mixing it with nutrient – rich litter. This type of increase is attributed to N-transfer from nutrient – rich to nutrient poor litter [29]. Addition of phosphorus from both *Albizia* and *Tithonia* sources was statistically different at ($p < 0.05$) and increased over the control. The magnitude of the increase, however, depends on the treatment. In 2009 and 2010 planting seasons, *Tithonia* supplied the highest phosphorous than other treatments. This may be due to large percentage of phosphorus in the *Tithonia* tissue over the *Albizia*. This finding is in line with the observation of scholars like [7], who reported that application of *Tithonia* biomass improved soil phosphorous.

3.2.6 Effect of organic and inorganic fertilization on total exchange bases and cation exchange capacity

The higher total exchangeable bases in *Albizia* + *Tithonia* during 2009 and 2010 planting seasons were partly due to high percentage of exchangeable bases in the tissue of *Tithonia*. It may also be due to the distribution of soil organic matter as well as high concentration in the tissue of *Tithonia*. As organic matter has been proved to influence cation exchange capacity and total exchangeable bases [31]. [7] and [32] reported that application of *Tithonia* significantly increased total exchangeable bases. The values of cation exchange capacity were significantly higher in the plot amended with *Albizia* + *Tithonia* over other treatments partly due to high concentration of cations in the *Tithonia* tissue in 2009 and 2010 planting seasons. Also, soil organic matter may be partly responsible for its distributions. This result is similar to the results obtained by [33]. They maintained that soil organic matter influences nutrient retention and release and cation exchange capacity. In 2011 planting season, the plot mulched with *Albizia* + *Tithonia* also gave the highest value. This may partly be due to build-up of cations over the years as *Albizia* component of the treatments is a slow decomposing material.

3.2.7 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* + *Tithonia* and *Tithonia* biomass in 2009 and 2010 planting seasons while in 2011 planting season, *Albizia* + *Tithonia* had the highest. This may be due to the supplying of large quantities of needed nutrients as well as improving the soil physico - chemical properties [25]. 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 [34]. These results were supported by the work of [35] who used nine soil components to quantify the effect of erosion on the productivity of a Nigerian soils and found that the yield of maize on these soils were determined by soil properties such as bulk density, organic carbon, top thickness, texture, pH and gravel content of the topsoil and also by base saturation, organic carbon, and exchange acidity in the sub-soil.

3.2.8 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 and 2010 planting seasons, the low net benefit recorded in the control plot may be due to low yield as a result of non amendments. The high net benefit recorded in the plots amended with *Albizia*, *Albizia* + *Tithonia* and *Tithonia* could be attributed to their positive effect on soil as well as their ability to supply nutrients needed for the growth and productivity of maize crop. [36] analyzed the cost-benefit of *Tithonia* biomass on maize and the results showed that although yield increases were recorded for both short and long term seasons, the average net productivity value (NPV's). In 2009 and 2010 planting seasons, although there was increase in the net benefit, the high non-labour cost of *Albizia* might put its use alone at a disadvantage.

4. CONCLUSION

Soil quality improvement and crop production on farm remain an important issue for agricultural research. This work has contributed to knowledge on the importance use of organic manure (*Albizia zygia* and *Tithonia diversifolia*). It was shown that there is a potential to improve yield of maize by combining *Albizia zygia* and *Tithonia diversifolia*. Also, there was increase in soil nitrogen, organic carbon, calcium, magnesium, phosphorus, potassium and cation exchange capacity. Soil pH was reduced by the use of *Albizia zygia*. Thus, the slowly-decomposing litter of *Albizia zygia* can be useful contribution to improve soil fertility, rather than being burnt as currently practiced by the farmers. The management of nutrient resources is essential to improve soil productivity and crop performance. 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.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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