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Research Paper

Use of prunings of selected agroforestry species as nitrogen source for maize *(zea mays* l.) Production for environmental stability in igboora, oyo state, Nigeria

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ABSTRACT
Low soil fertility coupled with the high cost and scarcity of mineral fertilizers are the major causes of poor crop yields on farmers' fields. Nitrogen (N) is the most limiting nutrient affecting maize yield in Nigeria. As alternative to the scarce and costly mineral N fertilizers as well as environmentally friendly additions, prunings of agroforestry species as Nitrogen source for maize was evaluated in Igboora, Oyo State, Nigeria. The field experiment was carried out at the Research Farm, Oyo State College of Agriculture and Technology, Igboora in 2015. Three Agroforestry tree species; *Gliricidia sepium*, *Leucaena leucocephala* and *Acacia albida* were used. Different quantities of their prunings based on their N content were incorporated into appropriate plots at two weeks before planting to supply N at the rate of 120 kg/ ha. Urea fertilizer was also applied at 120 kgN/ha. A control (Neither prunings nor Urea) was included for comparison. Oba Super 2 maize variety was planted at 0.75 × 0.25cm with 1m spacing between plots. The experiment was laid out in Randomized Complete Block Design with three replicates. Data collected include plant height (cm), number of leaves, leaf area (cm^2), stem girth (cm), maize grain yield (kg) and the Nitrogen fertilizer replacement index (%). Pre and post planting soil samples were collected and analysed for pH, Organic Carbon, Nitrogen, Phosphorus, Potassium, Calcium and Magnesium. Data generated were analysed using Analysis of Variance and Least Significant Difference at 5% probability. The treatments had no significant ($p \leq 0.05$) effect on plant height and number of leaves. G. sepium (3.8 cm) and Urea (3.4 cm) supported significantly more robust stem girth than the control (1.9 cm), *L. leucocephala* (2.0 cm) and *A. albida* (2.3 cm) which were not significantly different from each other. Similar trend was observed for leaf area. *G. sepium* (5.7t/ha) and Urea (5.3t/ha) influenced significantly higher grain yield than the control (2.8t/ha). *L. leucocephala* (3.1t/ha) and *A. albida* (4.4t/ha) produced higher grain yield than the control though not significantly so. Application of G. sepium increased post-harvest soil pH level by 0.51 unit. Other treatments had no effect on pH. *G. sepium* also increased post-harvest soil Mg content slightly (from 1.49 to 1.92 cmol/kg) and K (from 0.27 to 0.40 cmol/kg). A. albida and the control reduced soil K content. All the treatments including the control, reduced soil Ca content. Post-harvest soil N, Organic Carbon and available P were not different from the initial values. The Nitrogen fertilizer replacement index (NFRI) for G.sepium (1.15)) is the best replacement, followed by *A. albida* (0.63) and the least was obtained from L.leucocephala (0.11). In conclusion, *G. sepium* had the potential to serve as an alternative to Urea as N source for maize production. It also improved soil chemical properties and exhibited environmental friendliness.

Introduction

Maize (*Zea mays* L.) is the second most cultivated crop in Nigeria in terms of area harvested (5.8million ha, second to Cassava' s 7.1 million ha, FAOSTAT, 2014). Nigeria is the second largest maize producer in Africa, after South Africa, with an estimated 10.79 million metric tonnes produced in 2014 (FAOSTAT, 2014). Despite its high production volumes, Nigeria' s average maize yield of 1.8 metric tonnes /ha (FAOSTAT, 2014) is one of the lowest among the top 10 maize producers in Africa. It lags behind countries such as Egypt and South Africa where the yields are 7.7 metric tonnes/ha and 5.3 metric tonnes/ha respectively (FAOSTAT, 2014). Simply by addressing this low yield issue, Nigeria could become the largest maize producer in Africa and one of the largest producers in the world without increasing the area currently used for its cultivation.

In Nigeria, the largest volumes of maize are produced in the Northern region, particularly in Kaduna, Borno, Niger, and Taraba and in the South -Western states including in Ogun, Ondo and Oyo. Maize in Nigeria is mainly produced by smallholder farmers, each cultivating an average of 0.65 ha (Sahel Reports, 2014).

Maize (*Zea mays* L.) is an annual crop which thrives on most diverse environmental conditions. Maize is among the special and popular arable crops rapidly attaining a reasonable position in crop production due to its higher yield ability and short life cycle. It boosts the economy of any country significantly due to its various uses. It is an important food for man, fodder and feed for farm animals and serves as raw material for the agro-based industries. Lately, corn oil is now being used by many people for its low cholesterol content. In addition, some of its products like corn starch, corn flakes, gluten germ cake, lactic acid, alcohol and acetone are either taken as a food by man or used by paper, textile, foundry and fermentation industries. Khalil and Jan (2004), reported that overall World maize production is being used to feed farm animals or for industrial starch and oil production. Maize has become indispensable for food security in Nigeria. Much of the maize produced is consumed in a range of commercial sectors. About 50% of the maize produced is consumed by the animal feed sector, with poultry claiming as much as 98% of the total feed produced in Nigeria between 2005 and 2010 (Sahel report, 2017)

In spite of the importance of maize to the World economy and its numerous uses, many difficulties are being faced by maize farmers which include: high cost of fertilizer, poor agronomic practices and poor extension services (Fakorede, 2001), use of local varieties that have poor yield, poor soil fertility, drought, incidence of pests and diseases and weed problems. There are various ways of recovering soil fertility basically for maize production. These are: crop rotation (by planting maize after legumes), intercropping (planting maize with other crops that can fix atmospheric Nitrogen), bush fallow, alley cropping, incorporation of prunings, adequate and sufficient use of chemical fertilizer such as Urea and complete fertilizer (NPK), application manure and compost are the methods adopted by farmers to replenish soil fertility.

Chemical fertilizers play an important role in maintaining or boosting soil fertility in most parts of the world but farmers in Sub-Sahara Africa use insufficient amount of chemical fertilizer. Fertilizer is known to be a ‘ lead’ practice, which enables the farmers to welcome other new and updated technologies, thus, identified as a basic ingredient in boosting production of food. It is known to be the ‘ pillar’ of agricultural extension projects in many countries. Considering the exorbitant price of synthetic fertilizer in the market and the degradation of most agricultural lands due to addition of synthetic fertilizer which increase the toxicity of the soil, hence, researchers are exploring organic materials that are natural and environmental friendly (Crawford *et al*., 2006).

Agroforestry is referred to as the system of land use management whereby trees or shrubs are planted around or within arable crops or grazing land. (NAC, 2015). It incorporates shrubs and trees in agriculture and takes advantage trees for different uses; by increasing soil fertility through the nitrogen fixing ability of leguminous shrubs and by extracting nutrient element from the deeper soil layer to the top soil. Agroforestry is similar to intercropping. They both have several crop varieties that have intact relationship and produce various utility outputs, also greater total outputs is recorded because just one input plan is used, costs is saved. Above all, there are benefits peculiar to agroforestry. In a simple term, agroforestry is the growing of trees and arable crops or animals on a single farm land. The crops can be planted together concurrently, in rotation, or may even be planted on separate farm lands when materials from one are used to sustain others. (Franklin and Scott, 1992).

Several authors have described tree species used to supply animal feeds to different categories of livestock. Emmanuel and Tsado (2011) noted that in all fodder development works, legumes play the major role as they enrich the soil with nitrogen and produce highly digestible and protein rich fodder. The potential of leguminous fodder trees can be seen in their multipurpose nature and their ease of integration into existing farming systems. According to Jamala ((2013), leguminous fodder trees can be used for the improvement of both crop and livestock production and thus offer a means of linking livestock production with arable crop production. They are therefore immensely suitable for the improvement of farming systems through soil fertility maintenance (for crop production) and increased availability of high-protein feed for livestock. Generally, the inclusion of leguminous trees in tropical land-use systems offers many advantages at minimum expense. The potentials of fodder trees and shrubs remain vital in the support of rural livelihoods and food security. Fodder legumes are of considerable nutritional importance as livestock feed during the dry season of the year. Their leaves are green all year round and many are well known to herdsmen who frequently cut down their branches for stock feeding. Most nomads and smallholders know them and therefore use them for their livestock (Aregheore, 1996; Onwuka *et al*., 1992). Jamala *et al.*, ((2013) reported that browse legumes are found from north to south; and west to east in Nigeria, he mentioned the selected agroforestry species (*Leucaena leucocephala*, *Gliricidia sepium*, and *Acacia albida* among many others. *Leucaena* is widely accepted as the best browse legume and has naturalized in some parts of Nigeria. *Leucaena* and *Gliricidia* foliage yields are higher in the wet season.

Agroforestry systems have many benefits over conventional agriculture and forest production methods. They bring about increase in overall output, nation’ s economy and revenue; they also provide varieties of produce for exportation and employment. (ART, 2015). Using leguminous shrub prunings as mulch in agroforestry system is a common practice to sustain soil humus and improve soil fertility in the tropics (Duguma *et al*., 1988). In organic farming system, prunings applied as mulch are expected to supply parts or most of the plant nutrients to the annual crop.

For proper growth and greater output ratio, maize needs sufficient amount of macro elements most especially N, P and K. These elements are mostly required for plant development and formation of grain in maize farming. (Onasanya *et al*., 2009).

Nitrogen is an important macro element for plant growth in cultivating maize and plays important role in determining yield. (Shanti *et al*., 1997). Plants survival depends on Nitrogen because it constitutes 1-4% of plants dry mass (Anonymous, 2000).

Nigeria is an important and famous country in Africa and she is in no way facing lesser challenges as regards reducing the country' s dependence on food importation through improvement in food self sufficiency ratio which is in turn pivoted on increased domestic food production.

In Southwestern Nigeria, especially in Igboora of Oyo State, poor soil fertility is among the main causes of crop failure to farmers. Agricultural practices that conserve soil resources and prevent degradation should reduce the need to clear additional forest land. Agroforestry is a better approach to attain sustainable land use. Broadly, agroforestry is "an act of intentional fallowing, planting or incorporation of trees and shrubs on the same piece of land used in arable crop production and rearing of animals in such a way that each benefit from the other" (MacDicken and Vergara, 1990). Examples of these include: alley cropping, multilayer tree gardens, interplanting of trees on pasture or crop land, live hedges, shelterbelts including pruning of leguminous trees into the soil. A successful agroforestry system allows synergistic interactions between woody and non-woody components to increase sustain and diversify total land output (Swaminathan, 1987). Major interrelationships include circulation of essential elements and sustenance, adjustment in ecosystem and bountiful yields. Interestingly, agroforestry practices leads to nutrient cycling in the form of tree prunings returned to the soil surface. Organic matter is particularly important in humid tropical soils because many of them have inherently low cation exchange capacity (MacDicken and Vergara, 1990). The incorporation of agroforestry tree prunings (*Gliricidia sepium, Leucaena leucocephala* and *Acacia albida*) into the soil serve as organic fertilizer to improve the soil fertility had been recommended by several authors and they may be efficient in supplying N in maize production. Also, the International Centre for Research in Agroforestry (ICRAF) approved some agroforestry trees including *Gliricidia sepium, Leucaena leucocephala* and *Acacia albida* to suit this purpose and also to enhance agroforestry research work (Nair et al., 1984). These agroforestry species can be alternative source of Nitrogen for smallholder farmers that lack financial resources to purchase sufficient inorganic Nitrogen fertilizer. Furthermore, incorporating the prunings of these agroforestry species into the soil might improve Nitrogen release into the soil thereby increasing maize yield and boosting soil fertility. These species are available in sufficient quantity in the study area and their potentials to serve as N source for maize production have not been explored, hence, they are selected for the research work. The study therefore evaluated the potentials of their prunings to serve as nitrogen source for maize (*Zea mays*) production and to know their ability to replace the expensive and scarce Inorganic Nitrogenous fertilizers in Igboora, Oyo State. The research determined the effects of the *G. sepium* , *L. leucocephala and A. albida* prunings on maize growth and yield and on soil chemical properties and determined the N fertilizer replacement Index of the prunings against inorganic fertilizers (Urea).

Plate 1: *Gliricidia sepium* trees

Plate 2: *Acacia albida* leaves (Source: DHgate.com)

Plate 3: *Leucaena leucocephala* leaves (Source: DHgate.com)

Mateials and Methods

Description of the Experimental Site

The field experiment was carried out at the Teaching and Research Farm of the Oyo State College of Agriculture and Technology, (OYSCATECH), Igboora, Oyo State, located within the College premises. Igboora is situated approximately 80 km North of Lagos and 80 km West of Ibadan. It is on latitude 7^oN, longitude 3^oE and the altitude of 140 m above sea level. Igboora climate is tropical with alfisol soil. Mean annual temperature ranges 29^oC and mean annual rainfall is 522 mm in 2015. The relative humidity is about 79% all year round except in December, January and February when there is short period of drought. (OYSCATECH, Met. Station, 2015).

The experimental site has been in use for several years for maize cultivation. The common weed species found on the land are *Chromolaena odorata, Tridax procumbens, Panicum* species and *Pennisetum* species. The three agroforestry tree prunings *Gliricidia sepium* of about three (3) months, *Leucaena leucocephala* of about six (6) months, and *Acacia albida,* was collected from a mother tree (age not certain). *Gliricidia sepium* and *Leucaena leucocephala* prunings were obtained from OYSCATECH premises while *Acacia albida* was collected along Igboora-Iseyin expressway. They were dried at 12% moisture content, ground separately and sent to laboratory to determine the N, P and K content.

Figure 1: Igboora map

Treatments and Experimental layout

T1 –*G. sepium* at 4 kg/plot 2 Weeks before Planting (WBS)
T2 –*L. leucocephala* at 4.5 kg/plot 2 WBS
T3 –*A. albida* at 6 kg/plot 2 WBS
T4 – Urea fertilizer at 0.4 kg/plot $^{1}/_{3}$ at planting and $^{2}/_{3}$ at 3 Weeks after sowing.
T5 – Control (Neither N fertilizer nor prunings)

SSP at 60 kg P/ha and MOP at 30 kg K/ha were applied to all plots as basal fertilizer at sowing. The prunings were applied at 120 kgN/ha based on their N contents.

Field Preparation and Agronomic Practices

Prior to sowing, two series of ploughing were done on the land. The field was then marked out into plots. After the land preparations, the agroforestry tree prunings were incorporated into each plot using hoes and cutlasses. Two weeks after incorporation of the prunings, the first weeding was carried out and planting of maize was done immediately. The maize seeds were treated with Apron plus to prevent seed and soil pathogens before planting. Two seeds were sown per hole at a spacing of 75 cm × 25 cm. Two weeks after planting, maize seedlings were thinned to one plant per stand alongside with the application of Urea, P_2O_5 and K_2O fertilizers by spot placement. Weeds were manually controlled by weeding with hoes as and when due. The field borders were kept clean to reduce insects and rodents encroachment and to prevent fire occurrence.

Seed Procurement.

Oba Super 2 maize variety was used for the experiment which was procured at Premier Seed Nigeria Limited, Ibadan. Oba Super 2 is a single cross hybrid with yellow grain and it is semi-flint in nature. It adapts to forest and savanna regions and is highly prolific. It is very good in resisting lodging. It has an average plant height and ear length of 180 cm and 15 cm respectively. Oba Super 2 is moderately resistant to rust, blight and streak. Its average yield is about 5 – 7 tonnes/ha in the Southern Guinea Savanna and has the outstanding features of Downy Mildew Resistance (DMR) and Nitrogen Use Efficiency. It has a very good grain quality. (Premier Seed Nigeria Limited, 2015).

Field layout and Experimental Design

The field was marked out into plots. The size of each plot was 4 m × 4 m with 1 m spacing between plots. The total land area was 336 m^2 (14 m × 24 m). The experiment was laid out in a Randomized Complete Block Design (RCBD). There were five treatments replicated three times. (Fig. 2)

T1	T3	T2
T2	T5	T3
T3	T1	T4
T4	T2	T1
T5	T4	T5

P_2O_5 at 60 kg P/ha and K_2O at 60 kg K/ha were applied to all plots except the control plots.

Fig.2 Field Layout.

Where, T1 – *Gliricidia sepium* plots
T2 – *Acacia albida* plots
T3 – *Leucaena leucocephala* plots
T4 – Urea fertilizer plots
T5 – Control plots

Collection and Analysis of Soil samples

Before planting and after planting, soil samples were collected from the experimental site at the depth of 0 – 15 cm was bulked and mixed thoroughly to have a homogenous sample. Sub samples were collected from the bulk and was taken to the laboratory for analysis. The sub sample was air-dried and sieved with 2 mm sieve to remove large particles, debris and stones. The sieved samples were analyzed for pH, macronutrients and organic carbon. Soil pH was determined in a 1/2.5 (w/v) soil/water suspension. Organic carbon was determined by chromic acid digestion and spectrophotometric analysis (Heanes, 1984). Organic matter was estimated as organic carbon multiplied by 1.724. Total Nitrogen was determined by the micro Kjeldahl method. Available Phosphorus was extracted by Bray’ s P1 method and read from the atomic absorption spectrometer.

Data Collection

Pre-planting and post-harvest soil sampling (Total N, pH, Organic Carbon, P, K, Ca and Mg). Collection of data commenced four weeks after sowing and was taken at two weeks interval i.e 4 WAS, 6 WAS, 8 WAS, 10 WAS and 12 WAS. Growth and yield parameters recorded were as follows: Plant height (cm), Number of leaves, Stem girth (cm), Leaf area, Ear length (cm), Ear girth (cm), Number of grains per ear, Weight of grains per ear (g) and Weight of grains per plot (g)

Plant Height (cm)

This was taken from a sample of six randomly selected maize plants marked within each plot and this was carried out using a measuring tape to measure the height of the maize plant from the ground level to the last node. The mean from the six plants were determined and recorded.

Number of Leaves

Visual counting of leaves on the six randomly selected plants was done and recorded for each plant. The mean were calculated for each plot and recorded.

Stem Girth (cm)

This was measured with vernier caliper for each plot and the values were averaged and recorded.

Leaf Area (cm^2)

The leaf area was determined by the non-destructive length x width method described by Subedi and Ma (2005) using the relation: Leaf area = 0.75 (length x width), where 0.75 is a constant. Six leaves were measured with a measuring tape for each plot and the average was recorded.

Ear Length (cm)

The length of six dehusked maize ear per plot was measured with measuring tape and the mean values was calculated.

Ear Girth (cm)

This was also taken from a sample of six ears per plot with the use of measuring tape and mean values were recorded.

Number of grains per Ear

The number of grains in six ears from each plot were counted after they had been dried and shelled and mean was determined from the six ears.

Weight of grains per Ear (g)

The grains of the six ears above were weighed separately and then averaged for each plot.

Weight of grains per Plot (g)

The weights of the six ears for each treatment plot were added to get the weight of grain per plot.

Nitrogen fertilizer replacement index

$$\text{N fertilizer replacement index} = \frac{MYp - MYc}{MYiNf}$$

Maize yield increase by N fertilizer = MYf – MYc

Where:

MY_P = Maize yield with prunings

MY_c = Maize yield in control plot

MYiNf = Maize yield increase by N fertilizer

MY_f = Maize yield in fertilizer plot (Tian, 2000)

Statistical Analysis

Data collected were analyzed using the Analysis of Variance (ANOVA) and the treatment means were separated using Least Significant Difference at 5% probability.

Results

Effect of selected agroforestry species on growth parameters of maize.

G. sepium had the highest N content (4.8%) while *A. albida* had the lowest (3.25)%) whereas *A. albida* had the highest P content (0.57%) followed by *G. sepium* (0.23%) while *L. leucocephala* had the least (0.20%) (Table 1) The treatments had no significant effect on plant height (except at 6 WAS when the *G. sepium* treatment was significantly taller than the other treatments). Urea was next to *G. sepium* in its effect on maize plant height (Table 2).

Application of *G. sepium* prunings to the maize plot, produced significantly more number of maize leaves than *L. leucocephala* and the control. There was no significant difference in the number of leaves at 10 and 12 WAS. It was observed that plots treated with *G. sepium* had the highest number of leaves followed by urea fertilizer, then *A. albida* and *L. leucocephala*. The least was obtained from control plot (Table 3).

All applied treatments increased the stem girth of maize at all sampling periods except *L. leucocephala* at 4 and 10 WAS. Plot where *G. sepium* prunings were added had highest stem girth in all sampling periods and was the same with plot where urea was added. *A. albida* stem girth was significantly the same with *G. sepium* and urea fertilizer at 4 and 6 WAS while control plot had the least in all sampling periods though not significantly different from plots where *L. leucocephala* prunings was applied at all sampling periods. (Table 4)

G. sepium prunings supported broader leaf production and produced highest leaf area than the control and *L. leucocephala* throughout the sampling period (Table 5).

Table 1: Nutrient concentrations of the selected agroforestry trees prunings

Tree species	N	P	K (%)
Gliricidia sepium	4.80	0.23	2.14
Leucaena leucocephala	4.30	0.20	1.82
Acacia albida	3.25	0.57	1.10

Table 2: Effects of selected agroforestry tree prunings on maize plant height (cm)

Treatment	**Time of sampling (WAS)**				
	4	6	8	10	12
Gliricidia sepium	40.1	65.0	84.3	96.7	130.0
Leucaena leucocephala	38.0	59.5	74.6	89.7	111.8
Acacia albida	39.0	59.8	75.3	89.0	112.3
Urea	38.0	60.8	78.3	89.9	114.1
Control	36.5	58.9	73.5	88.3	110.8
LSD $_{(0.05)}$	ns	5.3	ns	ns	ns

ns – not significant

Table 3: Effects of selected agroforestry tree prunings on maize number of leaves

Treatments	**Time of sampling (WAS)**				
	4	6	8	10	12
Gliricidia sepium	8.4	9.0	9.5	10.6	12.3
Leucaena leucocephala	7.1	7.7	8.2	8.9	10.5
Acacia albida	8.1	8.4	9.0	9.5	10.1
Urea	8.0	8.8	9.2	9.9	11.7
Control	6.6	7.1	7.8	8.7	9.7
LSD $_{(0.05)}$	0.7	1.1	0.9	ns	ns

ns – not significant

Table 4: Effects of selected agroforestry tree prunings on maize stem girth (cm)

Treatments	**Time of sampling (WAS)**				
	4	6	8	10	12
Gliricidia sepium	1.8	2.3	2.7	3.2	3.8
Leucaena leucocephala	1.3	1.6	1.7	1.8	2.0
Acacia albida	1.6	1.8	2.1	2.2	2.3
Urea	1.7	2.0	2.5	2.9	3.4
Control	1.3	1.5	1.6	1.8	1.9
LSD $_{(0.05)}$	0.4	0.4	0.5	0.3	0.5

Table 5: Effects of selected agroforestry tree prunings on maize leaf area (cm^2)

Treatments	Time of sampling (WAS)				
	4	6	8	10	12
Gliricidia sepium	43.3	54.4	70.3	87.1	98.5
Leucaena leucocephala	30.5	38.8	50.0	57.8	62.2
Acacia albida	37.5	44.1	54.4	59.9	68.3
Urea	39.8	52.0	62.2	84.1	96.4
Control	28.4	35.6	44.0	55.7	60.1
LSD $_{(0.05)}$	8.35	12.0	12.6	11.2	15.25

Effect of selected agroforestry tree prunings on yield parameters of maize.

In all the yield parameters measured, *G. sepium* (5.7 t/ha) supported highest yield but these were not significantly different from the yield obtained from plots where urea (5.3 t/ha) was applied. The least yield was produced on control plot (2.8 t / ha). *L. leucocephala* (3.1 t/ha) and *A. albida* (4.4 t/ha) produced higher grain yield than the control though not significantly so. *G. sepium* (103%), urea fertilizer (90%), *A. albida* (57%) and *L. leucocephala* (10%) produced higher yield when compared with the control plot (2.8 t/ha). (Table 6).

Before planting, the soil pH 6.25 was slightly acidic with organic carbon of 1.24 and had N, P and K 0.14%, 8.28 mg/kg and 0.27 cmol/kg respectively (Table 7). After the application of the prunings, *G. sepium* prunings increased the post-harvest soil pH by 0.51 unit tending toward neutral (6.76) while other treatments did not affect the soil pH. *G. sepium* prunings also increased post-harvest soil Mg content slightly (from 1.49 to 1.92 cmol/kg) and K content ((from 0.27 to 0.40 cmol/kg). *A. albida* and the control reduced soil K content. All the treatments including the control, reduced soil Ca content. Post-harvest soil N, Organic C and available P were not different from the initial values. However, it was noticed that in all the soil parameters taken, control plot had the lowest all through and even lower than the initial soil chemical properties measured.

Maize yield in fertilized plot (MYf), maize yield in control plot (MYc) and maize yield increase by the N fertilizer (MYiNf) were the same for the treatments (Table 8). The difference comes from the maize yield from the prunings (MYp) where *G. sepium* had the highest (5.67 t) followed immediately by plot where *A. albida* was applied (4.38 t) while least was obtained from plot where *L. leucocephala* was applied (3.06 t). These reflected in Nitrogen Fertilizer Replacement Index (NFRI) where *G. sepium* (1.15) is the best replacement among others followed by plot where *A. albida* was applied (0.63) and least was obtained from plot where *L. leucocephala* was applied (0.11)

Table 6: Effects of selected agroforestry tree prunings on yield and yield components of maize

Treatments	**Ear length**	**Ear girth**	**No of grain per ear**	**Weight of grains/ear**	**Weight of grain per plot**	**Weight of 1000 grains**	**Grain yield**
	← Cm →		←		G	→	t/ha
Gliricidia sepium	15.8	15.1	435.3	113.4	9072.0	229.3	5.67
L. leucocephala	14.2	13.9	279.6	61.2	4896.0	204.2	3.06
Acacia albida	14.7	14.4	361.2	87.5	7000.0	221.5	4.38
Urea	15.3	15.2	410.7	106.0	8480.0	226.7	5.30
Control	12.9	12.7	251.0	55.7	4456.0	193.0	2.79
LSD $_{(0.05)}$	1.4	0.8	53.6	19.7	1260.8	28.4	2.8

Table 7: Soil chemical properties of experimental plot before planting and after harvesting.

Soil properties/ Tree species	**pH**	**Total N**	**Organic C**	**Available P**	**K**	**Ca**	**Mg**
		←	% →	mg/kg	←	cmol/kg	→
Before planting	6.25	0.14	1.24	8.28	0.27	6.13	1.49
After harvesting							
Gliricidia sepium	6.76	0.16	1.22	8.51	0.4	4.6	1.92
Leucaena leucocephala	6.22	0.11	1.16	8.4	0.21	3.32	1.44
Acacia albida	6.28	0.1	1.19	9.25	0.13	3.4	1.56
Urea	6.21	0.13	1.2	8.03	0.22	4	1.42
Control	6.17	0.09	1.15	8.05	0.19	3.21	1.34

Table 8: Nitrogen fertilizer replacement index of the selected agroforestry tree prunings

Treatment	MYf(t)	MYc(t)	MYiNf	MYp(t)	NFRI
Gliricidia sepium	**5.30**	2.79	2.51	5.67	1.15
Leucaena leucocephala	**5.30**	2.79	2.51	3.06	0.11
Acacia albida	**5.30**	2.79	2.51	4.38	0.63

MYf = Maize yield in fertilized plot, **MYc =** Maize yield in control plot, **MYiNf =** Maize yield increase by the N fertilizer, **MYp =** maize yield from the prunings, **NFRI =** Nitrogen fertilizer replacement index.

Discussion

Nutrient analysis of the Agroforestry pruning showed that *G. sepium* pruning had highest concentration of N and K of 4.8% and 2.14% respectively. Followed by *L. leucocephala* which had N (4.3%) and K (1.82%) while *A. albida* had the least values of N and K which are 3.25% and 1.10% respectively. Whereas, *A. albida* that had the lowest level of N and K had the highest P content. They all had varied amount of major nutrient (NPK) needed by maize for its proper growth and bountiful yield. Hence, they can serve as alternative to maize farmers that lack financial strength to purchase the expensive, unaffordable and scarce inorganic fertilizers for maize production in the study area.

From the results of the experiment, the growth of maize increased with the weeks. It was observed that addition of the selected agroforestry tree prunings improved the growth of maize so also the addition of urea. This was also reported by many researchers on the importance of the selected agroforestry tree prunings. Agroforestry tree prunings had numerous advantages by increasing productivity, economic benefits and more diversity in the ecological goods and services provided (ART, 2015). The use of legume tree pruning as mulch or incorporated into the soil in agroforestry system is a common practice to maintain soil organic matter and improve soil fertility in the tropics (Duguma *et al*., 1988). It was observed that, addition of *G. sepium* improved the growth of maize significantly even better than urea fertilizer. There was up to 100% increment in plot where *G. sepium* was added when compared to control plot in growth. This is due to the *G. sepium* pruning having more available nutrient constituent in term of N and K than the other agroforestry tree prunings. In addition to this, Nitrogen needed most by maize is sufficient in the *G. sepium* pruning. This corroborates the findings on *G. sepium* by other researchers. Liyanage *et al*., (1994) reported that *Gliricidia* could obtain some 64% of its nitrogen from the atmosphere under field conditions. Substantial amounts of N-rich organic materials are needed to make a significant impact on crop yields (Giller *et al*., 1997). Increase in growth and yield by the treatment applied was in this order: *G. sepium* < urea < *A. albida* < *L. leucocephala* and < control. Showing that, fertilizer application improved the growth of maize either organic or inorganic fertilizer. Trend obtained in growth of maize due to the treatments applied later resulted to the yield obtained.

G. sepium prunings produced the highest yield in all yield parameters taken, followed by urea, *A. albida*, *L. leucocephala* and least was obtained in control plot where no fertilizer or pruning was applied. Significant increment in maize yields following addition of legume tree prunings have also been observed in previous studies in Malawi (Maghembe *et al*., 1997; Ikerra *et al*., 1999; Phiri *et al*., 1999; Akinnifesi *et al*., 2005b). In on-farm studies in the same area, Phiri *et al*., (1999) found a threefold increase in maize yield receiving *Sesbania* pruning compared to the unfertilized maize. Chirwa *et al*., (2003) found significantly higher N concentrations in maize flag leaf with application of tree prunings than the unfertilized maize. Also, Makumba (2003) reported that application of *G. sepium* prunings significantly increased N uptake in maize.

The result of the soil analysis before planting and after harvesting showed that *G. sepium* and *A. albida* increased the soil pH tending it towards neutral that is more favourable for maize farming while *L. leucocephala* and Urea reduced the soil pH tending it towards acidity. Total N and K in plot where *G. sepium* was applied proved to increase after planting while in all other plots N and K were depleted from the soil including where urea was applied as treatment. This showed that, *G. sepium* applied had sufficient N and K needed for the growth of maize and also increased the total N in the soil after harvesting, while, other treatment cannot supply enough N and K needed for maize consumption. This corroborates the findings of Mafongoya *et al*. (1981) that agroforestry pruning or litter can supply sufficient nitrogen to demand. Also, Peoples *et al*. (1996) found that, the percentage of N fixed out of total N varied from 56 to 89% in seven consecutive forage harvests in two years for *G. sepium in* hedgerows between maize alley crops in the Philippines (Ladha *et al*., 1993).

Available P was also improved by all the prunings while plots where *A. albida* was applied even had the highest available P in the soil after harvesting. This was in support of Makumba (2003) who reported that, 12 - 20 kg P ha^{-1} have been recycled annually in the gliricidia-maize. Mweta *et al*. (2007) in their own report said, this suggests that P removal during maize harvest and by tree uptake might have been higher than the P input through recycling. On the other hand, this result is contrary to previous report of Mafongoya *et al*. (1981) that, agroforestry prunings or litter cannot supply sufficient P that can meet crop demand. Where urea was used and control plot showed depletion of available P. Depletion of urea in plot where urea was applied was because urea is a Nitrogen based fertilizer that supplied only N and there is possibility of leaching. So, during the period of the crop production (Maize), P consumption must have taken place without replacement and this may be responsible for the shortage in the available phosphorus after the experiment. Wendt *et al*. (1996) found in Malawi a similar response when he combined inorganic P and *L. leucocephala* leaves. Increase in extractable P following inorganic P addition confirms that soil P replenishment can be achieved through application of inorganic P fertilizers (Nziguheba *et al*., 1998). The mean soil available P decreased with the addition of inorganic N fertilizer, with the lowest levels occurring at 46 kg N ha-1. This observation could have possibly resulted from increased P uptake by plants at the optimum level of inorganic N rate of 46 kg N ha-1 (Akinnifesi *et al.*, 2006).

It was also observed that both organic Carbon and Calcium were highly depleted from the soil after planting. This might be that all the prunings are low in the supplying Carbon and Calcium to the soil. Also, urea does not supply organic Carbon and Calcium, it is purely Nitrogen fertilizer. This result is contrary to the findings of Mweta *et al*., (2007) that, pruning application had increased the mean soil organic Carbon by 82% in gliricidia-maize compared to maize plot. Also, this result was not in line with the findings of Makumba (2003) who reported increase in soil organic carbon due to addition of *G. sepium* tree prunings.

From the maize grain yield in tonnes / ha, the Nitrogen Fertilizer Replacement (NFRI) was calculated. It was observed that, *G. sepium* had the highest NFRI followed by *A. albida* and the least was obtained from *L. leucocephala.* In other words, *G. sepium* has the ability to replace the Urea fertilizer by 1.15%. Farmers in the study area can adopt the use of *G. sepium* as an alternative source to the Inorganic N fertilizer (Urea).

Conclsion and Recommendations

Among the selected agroforestry tree prunings used for this research, *G. sepium* pruning had the highest concentration of major nutrient (N and K) above other two prunnings. *L. leucocephala* had higher N and K than *A. albida* whereas *A. albida* had highest P than the other prunings. Maize growth increased with the weeks, Addition of Agroforestry pruning improved the growth of maize so also the addition of urea though *G. sepium* improved the growth of maize extensively even above where urea fertilizer was used. There was up to 100% increment in plots where *G. sepium* was added when compared to control plot in growth. What happened in growth later resulted in the yield obtained. The order of growth was still maintained in yield. *G. sepium* had the highest yield in all yield parameters taken followed by urea, *A. albida*, *L. leucocephala* and least was obtained in control plot where no fertilizer or pruning was applied. The result of the soil analysis before and after planting showed that *G. sepium* and *A. albida* increased the soil pH moving it towards neutral that is more favourable for maize farming while *L. leucocephala* and Urea reduced the soil pH tending it towards acidity. On the plot where *G. sepium* was applied, Total N and K increased while in all other plots N and K were depleted from the soil including where urea was applied as treatment. Available Phosphorus was also improved on plot where *A. albida* was applied, it even had the highest available P in the soil after harvesting. On urea and control plots, there was depletion of available P. It was also observed that both organic Carbon and Ca was greatly depleted from the soil after harvesting.

The Nitrogen Fertilizer Replacement Index (NFRI) obtained from this study showed that *G. sepium* has the ability to replace the inorganic N fertilizer (urea) in the research area. These recommendations were made:

- *G. sepium* is rich in mineral elements (NPK) required for better growth performance and yield of maize. Also, it improved the soil chemical properties
- *G. sepium* has the potential to serve as alternative source to the expensive, unaffordable and scarce inorganic N fertilizer (urea) for maize farmers in the study area.
- Farmers should be encouraged to use these agroforestry tree prunings since they are natural, environmentally safe, leaving no toxic residue in the soil and in food chain.

- Government should support and encourage farmers and herdsmen to adopt the growing of these selected agroforestry shrubs for the improvement of both arable crop and livestock production and thus offer solution to farmers-herdsmen clashes in the country.
- Finally, this study revealed that very little or no research work has been done on the potentials of prunings of these agroforestry tree species to serve as N source for maize production, therefore, further studies should be carried out in the study area so as to establish these findings.

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