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Effects of Wood Ash Biomass Application on Growth Indices and Chlorophyll Content of Maize and Lima bean Intercrop

Rasheedat Ajala,[1] Moses Awodun[1], Segun Oladele[2*]

[1]*Department of Crop, Soil and Pest Management, Federal University of Technology Akure, Ondo State. Nigeria*
[2]*Department of Agronomy, Adekunle Ajasin University Akungba-Akoko, Ondo State Nigeria*

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[*]Corresponding Author:
E-mail: segun.oladele@aaua.edu.ng

A B S T R A C T

Wood ash generated from wood industries have enormous potential which can be utilized due to its properties which influences soil chemistry and fertility status of tropical acidic soils. Field experiments were conducted on an acidic sandy loam alfisol to investigate the effects of wood ash on the growth indices and chlorophyll content of maize and lima beans intercrop during the late and early seasons of 2014 and 2015 at Akure in the rainforest zone of southwestern Nigeria. The treatments were 100% sole maize with ash, 100% sole maize without ash, 75% maize + 25% lima beans with ash, 75% + 25% lima beans without ash, 50% maize + 50% lima beans with ash, 50% maize + 50% lima beans without ash, 25% maize + 75% lima beans with ash and 25% maize + 75% lima beans without ash. Wood ash was applied at 2.4kg/plot. Wood ash increased chlorophyll content in all amended treatments except in amended 25:75% maize-lima beans intercrop and 25:75% maize –lima beans intercrop without ash, however 75:25% maize-lima beans amended with wood ash significantly ($P \geq 0.05$) recorded the highest chlorophyll content. Growth parameters such as plant height, number of leaves, leaf area, leaf area index, leaf length, stem diameter, number of flowers, number of pods, weight of plant and total biomass of amended maize-lima beans intercrop were significantly ($P \geq 0.05$) increased by wood ash application. Based on experimental findings, 25:75% maize-lima beans intercrop and 75%:25% maize-lima beans intercrop amended with wood ash was concluded to be more recommendable in the study area.

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Introduction

Soils in the tropics are characterized by low pH, low cation exchange capacity, low organic matter content, low percent base saturation and low nutrient holding capacity (Agboola and Omueti,1982), these important soil properties are required absorption and effective use of nutrients by crops and also the retention of these nutrients in the soil. Sustaining efficient utilization of nutrients with minimum nutrient losses has been a major task in tropical agriculture. Intercropping is the growing of two or more crops on the same piece of land within the same year to promote their interaction and to maximize chances of productivity by avoiding dependence on only one crop (Sullivan, 2003). Intercropping of legumes with non-legumes is a very common practice in many parts of the world and particularly in the developing countries aimed at improving and maintaining nutrient balance in soils, improved yield of crops in terms of quality and quantity. Intercropping offers farmers the opportunity to engage nature's principle of diversity on the major source of protein for both humans and animals and they also contribute nitrogen to non-legume components when grown in mixture (Tsubo et al., 2003). Intercropping of maize and legumes is widespread among smallholder farmers due to the ability of the legume to cope with soil erosion and with declining levels of soil fertility. The principal reasons for smallholder farmers to intercrop are flexibility, profit maximization and risk minimization against total crop failure. Other reasons are weed control, balanced nutrition, soil conservation and improvement of soil fertility (Andersen et al., 2013). Maize (*Zea mays* L.) is one of the oldest cereals in the world and it is a fully domesticated plant. Humans and maize have lived and evolved together since ancient times. Modern maize does not grow in the wild and is completely dependent on human husbandry (Doswell et al., 1996). Nigeria produced about 8 million metric tons of maize in 2013 and is the current largest producer in West Africa (Kasim et al., 2014). Maize is the third most widely grown crop in Nigeria, following sorghum and millet. It is highly productive, cheap, less rigorous to produce and adapts to wide range of agro ecological zones (Babatunde *et al*, 2008). About 50% of the green maize produced in Nigeria comes from the southwestern Nigeria (Ikem and Amusa, 2004). Maize is of great economic significance worldwide, both for human and animal consumption and is the source of a large number of industrial products. The cereal has multifarious uses and the diversity of environments under which it is grown, is therefore, unmatched by any other crop (Doswell et al., 1996). Lima bean (*Phaseolus lunatus L.*) is a legume food plant native to South America grown for its edible seeds. It is commonly known as the butter bean (Carolyn, 2013). Lima bean is cultivated in Nigeria mainly for the dry seeds like other grain legumes. It is an important source of vegetable protein and a N_2-fixing legume that sheds its leaves copiously thus, valuable for restoring soil fertility (Ibeawuchi, 2007). The bean is well adapted to the humid rain forest environment of southern Nigeria. Despite the great potential of this crop, it is highly underutilized in the country and it has not received much attention in terms of crop improvement thus, local cultivars are still being grown by the farmers (Lyman et al., 2001). Lima bean is cultivated in only about 4% of the land area devoted to grain legume production in southwest Nigeria without improved technology targeted towards the production of the crop resulting in low yield. It is usually intercropped with cassava, maize, yam, cocoa yam and pepper. Lima bean is mainly produced for consumption as only 35% of the grain produced is sold (Saka et al., 2004). In improving soil fertility with minimal damage to the plants, Ojeniyi (2007), reported that application of wood ash to a tropical alfisol increased the contents of soil organic matter (SOM), N, K, Ca, Mg and pH. Also, it increased maize cob length, weight and cob diameter. Similarly, Mbah and Nkpaji (2009) observed that when synthetic fertilizers were not applied, the use of wood ash produced significant effects on the growth and yield of many crops, particularly maize. Several research works have been reported on maize-cereal intercropping, however, there are limited literatures regarding the effect of wood ash biomass application on the growth performance of maize and lima beans in an intercrop. The aim of this research is to determine the growth performance and chlorophyll content of sole maize, sole lima bean and maize-lima beans intercrop as affected by wood ash biomass application.

Materials and Methods

Experimental Site and Conditions

Field experiments were conducted during the 2014 and 2015 growing seasons at the Teaching and Research Farm of the Federal University of Technology, Akure. The area lies between latitude 7°16 N and longitude 5°12 E within the tropical rain forest vegetation zone of Nigeria with an average annual rainfall of about 1613 mm per annum and an annual mean temperature of about 27°C. The first trial was carried out from September to December 2014 while the second trial was conducted between April and July 2015 for late and rainy season crops respectively.

Pre-planting Soil and Ash Content Analysis

Soil samples were randomly collected over both trial sites prior to planting and after harvesting to a depth of 0-20 cm. Samples from the relevant depths were combined and used to determine soil chemical and physical properties. The results of the analysis are presented on Table 1.Wood ash samples were air dried and sieved through a 2 mm sieve. The samples were analyzed for total nitrogen, available P, K, Ca, Mg and Na (Table 2). Soil organic matter was determined using Walkley-Black (1934) wet Oxidation method, Total nitrogen in the soil and wood ash was analyzed using Kjeldahl method (Bremner, 1960), Available phosphorus was determined using Bray 1-P extraction method (Bray and Kurtz, 1945), Potassium (K^+), Calcium (Ca^{2+}), Sodium (Na^+), and Magnesium (Mg^{2+}) were extracted by 1M Ammonium acetate (NH_4OAC), at pH 7 and the extracts were determined on a flame photometer while Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) were determined by ethylene di-amine tetra acetic acid (EDTA) titration (AOAC, 1997).

Table 1 Physical and Chemical properties of experimental site

Properties	2014 Late season		2015 Early season	
	Before planting	After harvest	Before planting	After Harvest
Physical Properties				
Particle size analysis (g kg^{-1})				
Sand	40.80	47.10	56.87	52.54
Silt	22.00	20.00	32.29	30.37
Clay	37.20	32.80	40.11	48.87
Textural class	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy clay loam
Chemical Properties				
Soil pH	5.87	6.23	6.25	8.74
Organic Carbon (%)	1.32	0.82	1.45	0.81
Organic Matter (%)	2.27	1.41	2.49	1.39
Total Nitrogen (g/kg)	0.42	0.14	1.05	0.79
Available P (mg/kg^{-1})	26.67	7.93	37.59	19.06
Exchangeable cations (cmol kg^{-1})				
K	0.62	0.25	2.72	2.35
Ca	11.4	2.40	15.00	6.00
Mg	5.2	1.10	7.34	2.94
Na	0.46	0.34	3.40	3.12

Table 2 Chemical composition of wood ash

Nutrients	2014 Late season	2015 Early season
Total N g kg^{-1}	0.06	0.48
Available P (mg kg^{-1})	9.12	12.47
K (cmol kg^{-1})	9.70	11.74
Ca (cmol kg^{-1})	52.47	65.9
Mg (cmol kg^{-1})	3.60	5.93
Na (cmol kg^{-1})	4.20	6.00
pH	10.32	12.59

The soil pH was determined by using 1:2 of 10 g of soil to 20 ml distilled water ratio suspension. The suspension was stirred for 30 minutes and determined by glass electrodes pH meters which were standardized with a buffer of pH 7.

Sample collection

Maize and lima beans were the two crops used in this study. The early maturing yellow maize called Pop 66-SR/Arc 91 Suwan 1- SR was procured from the Teaching and Research Farm of the Federal University of Technology, Akure, while the lima bean seeds were obtained from a reputable seed store in Isua Akoko Local Government Area, Ondo state. Wood ash was obtained at a saw mill in Orita Obele in Akure south Local Government Area.

Experimental layout and management

The experimental site was thoroughly cleared of vegetation to a depth of 30 cm with a tractor, harrowed and later sprayed with herbicide to control weeds before the seeds of maize and lima beans were sown. The experiments were laid out as a Randomized Complete Block Design (RCBD) with eight (8) plots measuring 2 cm x 3 cm and replicated three times. In order to minimize interference, there was a 1 m guard row within experimental units and between blocks. Two seeds of maize and lima beans were planted on the same day at a spacing of 75 cm × 25 cm and 70 cm x 25 cm respectively. At fourteen days after planting this was thinned down to one plant per hill to give plant populations of 88,889 and 53,333 per ha, respectively. Wood ash was also applied to the plants in form of a ring at the rate of 2.4 kg/plot, (Mbah and Nkapji, 2009) which equates to 5 t/ha at large field level scale. The treatments were based on sole cropping and varying proportions of maize and lima beans in an intercropping system. The experimental treatments were: (1) amended sole maize; (2) un-amended sole maize; (3) amended 75:25 maize-lima beans; (4) un-amended 75:25 maize-lima beans; (5) amended 50:50 maize-lima beans; (6) un-amended 50:50 maize-lima beans; (7) amended 25:75 maize-lima beans and (8) un-amended 25:75 maize-lima beans. Weeds were controlled manually at 3, 7, 9, and 12 weeks after planting while chemical control was carried out three times during the period of experimentation. The herbicide used was glyphosate and applied at the rate of 3 L/ha. Pests were controlled through application of cypermethrin (500 L/ha) and spraying commenced two weeks after germination and at regular intervals till the end of the experiment. At two weeks after planting (2 WAP) 5 plants were randomly selected from each plot and tagged for the growth indicating parameters such as; plant height, number of leaves per plant, length of internodes, leaf length, and stem diameter at 2, 4, 6, 8, 10 and 12 weeks after planting (WAP). Data were also taken on leaf area per plant, leaf area index, chlorophyll contents and total biomass. Plant height (cm) was measured from the base of the plant to the top most leaves. The number of functional leaves per plant was a visual count of the green leaves. Prior to tassel formation, samples of maize leaves from each treatment were collected and taken to the laboratory for analysis of chlorophyll contents analysis. The chemical constituents measured included N, P, K, Ca and Mg (Table 3).

The total leaf area and leaf area index of each randomly selected five maize stands per plot were estimated using the formula below (Elings, 2000 and Mauro et al., 2001).

Leaf Area	= L x B x alpha
Where L	= mean length of the leaf area (cm),
B	= mean breadth of the leaf area
Alpha	= 0.75

The leaf area index was computed by dividing the total leaf area of a maize plant stand by the total land area occupied by the single stand. Data taken on lima beans were number of flowers, length of pods, weight of plants, weight of roots and biomass. Biomass (dry matter) yield per plant (g) was determined by harvesting the leaf and stem materials at 11 and 24 WAP and oven-dried at 700C for 3 days. The mean of 5 randomly selected sampled plants was used as score for each plot.

Data Analysis

The statistical significance of the data collected on growth and yield were subjected to analysis of variance (ANOVA) to estimate the variance components due to ash application and intercropping of maize and lima beans. Treatment means were separated using Duncan’s New Multiple Range Test (DNMRT).

Results

Wood Ash Composition, Pre-Planting and Post-Harvest Soil Analysis

The soil analysis of the experimental plot before planting and after harvesting is presented on Table 1. The experimental site was a Sandy clay loam texture, it was observed that wood ash biomass application increased soil pH from initial values before planting (5.87 and 6.25) to (6.23 and 8.74) after crop harvest in 2014 and 2015 season respectively. Soil chemical properties such as organic carbon (OC), organic matter (OM), total nitrogen (TN), available phosphorus (P) and exchangeable cations showed a decreasing trend from initial values after crop harvest in 2014 and 2015 season. This decrease could be attributed to continuous cultivation of the experimental site without optimum incorporation of organic materials to increase the soil organic matter. Table 2, shows the nutrients composition of the wood ash used during the experiment. It was observed that wood ash was low in nitrogen (0.06 and 0.48 g/kg^{-1}), which indicates low plant available nitrogen for plant uptake when added to the soil. (Landon, 1991). However phosphorus, potassium and calcium content of wood ash were between medium and high level (9.12 and 12.47 mg/g^{-1}, 9.70 and 11.74 cmol/kg, 52.47 and 65.9 cmol/kg) respectively. Wood ash pH values were equally high (10.32 and 12.59) coupled with the elemental composition values affirms wood ash ameliorating liming potential for use in improving acidic tropical soils.

Effect of Wood Ash on Maize Vegetative Growth

Table 4, shows the correlation between maize cropping pattern and growth parameters. An increase or decrease in the number of leaves per plant has a direct bearing effect on the yield of crops. The data regarding number of leaves per plant as influenced by intercropping and wood ash application during 2014-2015 clearly show that there were no significant differences at 2 WAP for sole maize and crop combination of 50M:50L irrespective of treatment. Lower number of leaves per plant during late season experiment in 2014 was prominent for maize plants. The lowest number of leaves was observed from the un-amended 25M: 75L with an average mean of 9.71. However, maize plants showed temporal trends in growth during the early season in 2015. The highest number of leaves was observed from the amended maize monocrop plots (14. 19 cm at 10 WAP). Un-amended 25:75 maize-lima beans intercrop recorded lower number of leaves (10.43 cm). Stem girth were significantly reduced by intercropping compared to sole cropping at all the intervals during the 2014 late and 2015 early seasons. There were smaller stem girths observed during the late season planting for all the cropping patterns and irrespective of wood ash application. The case was different for 2015 early season, stem girth of maize were significantly increased at each interval and the cropping patterns. Amended sole crops produced the biggest stem girths than any of the intercrop arrangements, while among the intercrop arrangements, 75M: 25L arrangement produced the biggest girths (22.04 cm). Statistical analysis shows that stem girths at 10 and 12 WAP were not significantly similar (Table 3). In both seasons, other maize vegetative growth parameters assessed showed that length of internodes and leaf length for amended maize monocrops increased significantly. Furthermore, significant differences were observed from all amended and un-amended intercrops. Generally, the application of wood ash gave significant improvement in these maize growth parameters. Maize leaf area (LA) and leaf area index (LAI) were lower in the late season of 2014 compared to the early season in 2015, indicating the significance of seasonal variation. The vigorous growth of leaves noticed in maize plants for all treatments could be as a result of higher rainfall during the early season of 2015 as compared to the 2014 late season which had shorter and fewer leaves. This could have resulted in high evaporation and more competition for water between the crops. Generally, maize monocrop had higher LA and LAI for both seasons, while maize intercropped with lima beans at 25% had the for both seasons.

Table 3 Growth attributes of maize as influenced by wood ash application (2014 and 2015)

Treatments	Plant height(cm)		Number of leaves		Leaf length (cm)		Stem diameter(cm)	
	2014	2015	2014	2015	2014	2015	2014	2015
T1	115.53a	184.05a	12.11a	14.97a	92.10.a	104.56ab	15.29a	21.69a
T2	107.42b	182.21b	10.33a	13.22ab	88.86b	107.76a	13.43b	20.31a
T3	104.41bc	173.89b	12.78a	14.56a	92.32a	111.44a	15.22a	19.04b
T4	103.33bc	157.11d	10.59a	13.56ab	87.39a	107.22a	14.97a	18.44ab
T5	106.49b	176.42c	12.13a	13.89ab	88.68b	114.89a	14.71a	18.67b
T6	96.00bc	170.44c	11.41a	13.93ab	84.89c	105.56ab	13.41b	15.56c
T7	82.07d	159.87d	10.98a	11.78c	78.17d	97.56c	11.60c	12.24d
T8	79.98d	152.05d	9.71b	10.43bc	76.97d	92.76d	11.07c	12.33d

T1 = Sole maize with ash, T2 = Sole maize without ash, T3 = 75:25 maize-lima beans intercrop with ash, T4 = 75:25 maize- lima beans intercrop without ash, T5 = 50:50 maize-lima beans intercrop with ash, T6 = 50:50 maize-lima beans intercrop without ash, T7 = 25:75 maize-lima beans intercrop with ash; T8 = 25:75 maize –lima beans intercrop without ash

Table 4 Correlation between cropping pattern (Y) and growth parameters (X)

Growth Parameters	2014		2015	
	Correlation coefficient	Regression equation	Correlation coefficient	Regression equation
Plant height (cm)	0.139	Y= 0. 1631x + 27.493	0.0066	Y= 0.377x + 141.95
Number of leaves	0.0784	Y= 0. 0682x + 37.654	0.0074	Y= 0.0039x + 11.695
Leaf length (cm)	0.135	Y= 0. 1134x + 20.63	0.0043	Y= 0.0162x + 81.153
Stem diameter (cm)	0.4275	Y= 0. 2307 + 82.1	0.0485	Y= 0.016x + 17.601
Length of internodes	0.0884	Y= 0.4268x + 53.507	0.0022	Y= 0. 0028x + 11.089

Table 5 Effects of intercropping and wood ash application on the growth parameters of maize-lima beans intercrop

T	Number of flowers		Number of pods		Weight of plant (g)		Total biomass (g)		Leaf area		Leaf area index	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
T1	0.00	0.00	0.00	0.00	135.37a	149.59a	35.17a	47.61a	120.25a	165.48a	0.20a	0.27a
T2	0.00	0.00	0.00	0.00	130.93ab	145.93a	33.32a	44.76ab	117.39ab	152.53b	0.19a	0.25a
T3	111.78b	123.18b	74.33ab	92.22b	125.05b	128.16b	30.14ab	37.14b	103.49b	148.64b	0.17ab	0.24a
T4	110.67ab	121.33bc	70.56b	90.56b	122.08c	124.96b	28.67ab	35.11b	95.13c	136.54c	0.15b	0.22ab
T5	94.33c	115.67c	65.11c	89.00b	117.27c	123.27c	25.13bc	30.02c	87.66cd	132.59c	0.14b	0.22ab
T6	90.68c	114.89c	60.33d	86.22ab	112.45cd	120.11cd	20.83bc	27.83c	77.94d	121.72d	0.12b	0.20b
T7	68.78d	91.43cd	55.67ef	66.11c	89.22cd	91.44d	16.64cd	25.41cd	68.06e	106.32e	0.11c	0.17b
T8	62.56d	77.58d	52.89f	61.44c	81.78d	89.22d	14.15d	22.15d	60.12e	94.66e	0.10c	0.15b

T: Treatments, T1 = Sole maize with ash, T2 = Sole maize without ash, T3 = 75:25 maize-lima beans intercrop with ash, T4 = 75:25 maize- lima beans intercrop without ash, T5 = 50:50 maize-lima beans intercrop with ash, T6 = 50:50 maize-lima beans intercrop without ash, T7 = 25:75 maize-lima beans intercrop with ash; T8 = 25:75 maize –lima beans intercrop without ash

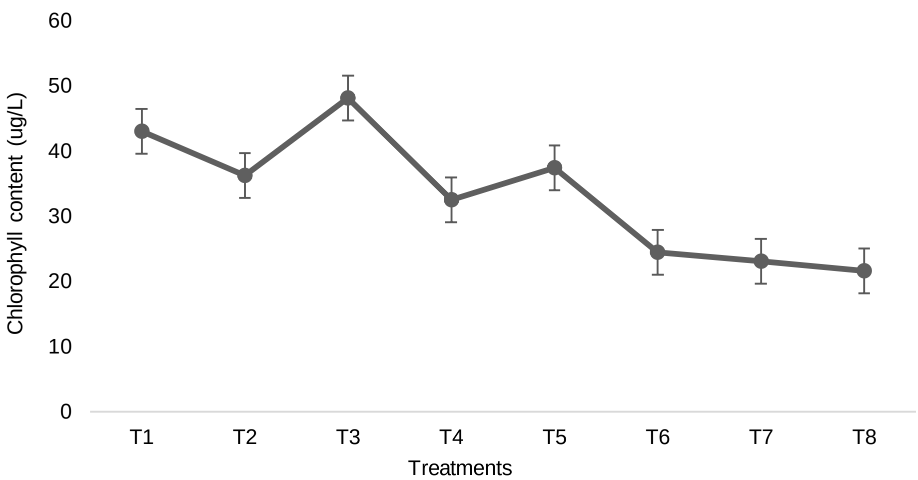

Fig. 1. Effect of wood ash on chlorophyll content of Maize-lima beans intercrop

Legend; T1: sole maize with ash, T2 = Sole maize without ash, T3 = 75:25 maize-lima beans intercrop with ash, T4 = 75:25 maize- lima beans intercrop without ash, T5 = 50:50 maize-lima beans intercrop with ash, T6 = 50:50 maize-lima beans intercrop without ash, T7 = 25:75 maize-lima beans intercrop with ash; T8 = 25:75 maize –lima beans intercrop without ash

Effect of Wood Ash on Lima Bean Vegetative Growth

In both seasons, lima beans growth parameters responded differently to cropping patterns and wood ash application. Table 5, shows that amended lima beans monocrops produced significantly higher number of flowers and length of pods (cm) than intercropped with maize during the early season in 2015 than the 2014 late season. Under the late season in 2014, lima beans had a mean pod length of 2.80 and 2.00 for ash-amended and un-amended monocrops and with decreased values observed under intercrops. Lima beans were able to produce these lengths of pods maybe as a result of its drought tolerant abilities. Similarly, amended lima beans monocrop had the heaviest weight of plant roots and biomass. On the other hand, these parameters were lower under the 75%, 50% and 25% lima beans intercrops. During the 2014, experiment the long duration lima beans plant scarcely flower and did not come to maturity early. This may be attributed to reduction in the number of rainy days in the season leading to the competition for water and nutrients. Table 6 shows the effects of treatments on lima beans LA for both seasons. It was observed that lima bean which is a long season crop had shorter leaves during the dry season. However, during the early season of 2015, higher LA was observed. Lima beans monocrop had the highest LA among all the treatments and for both seasons. The 75% lima beans intercrop also recorded high LA, while 25% had the least. Plots treated with ash recorded higher LA than their corresponding control.

Effect of Wood Ash on Chlorophyll Content of Maize-Lima Beans Intercrop

The leaf chlorophyll contents as affected by the different treatments were determined and presented in Fig. 1. It shows that ash-amended 100%Maize had 43.06ug/L, while Sole maize without ash (100%) Maize had 36.26 ug/L, amended 75:25% maize-lima beans intercrop had 48.10 mg/L while the unamended maize-lima beans intercrop recorded 32.56ug/L. 50%, amended and unamended 50:50% maize-lima beans intercrop had chlorophyll contents of 37.43 and 24.42, respectively. The least chlorophyll contents were obtained from the crop combinations of amended and unamended 25:75% maize-lima beans intercrop (23.08 ug/L and 21.60 ug/L) respectively.

Table 6 Effects of intercropping and wood ash application on the total leaf area, leaf area index, and chlorophyll content of maize

T	2014					2015				
	LA	LAI	CC	COR.C	RE	LA	LAI	CC	COR.C	RE
T1	572.88	0.95	43.06	0.6907	Y=-264.91x+ 35.45	755.07	1.25	43.06	0.7061	y=-356.01x+978.47
T2	538.25	0.89	36.26	0.6974	y=-251x+693.79	680.25	1.13	36.26	0.7092	y=-322x+883.2
T3	449.72	0.74	48.18	0.6625	y=-200.77x+567.75	678.64	1.13	48.18	0.6943	y=-315.23x+873.11
T4	439.46	0.73	32.56	0.6917	y=-203.45x+564.48	667.54	1.11	32.56	0.7129	y=-317.49x+868.72
T5	428.39	0.71	37.43	0.6801	y=-195.48x+546.47	659.59	1.09	37.43	0.7063	y=-311.08x+854.86
T6	406.32	0.67	24.42	0.7035	y=-190.95x+525.7	653.72	1.08	24.42	0.7222	y=-314.65x+855.71
T7	393.51	0.65	23.08	0.7047	y=-185.22x+509.51	553.32	0.92	23.08	0.7187	y=-265.12x+722.68
T8	323.75	0.53	21.6	0.6979	y=-151.08x+417.44	528.66	0.88	21.6	0.7194	y=-253.53x+690.77

T: Treatments, LA: Leaf area, LAI: Leaf area index, CC: Chlorophyll Content, COR.C: Correlation coefficient, RE: Regression equation

Discussion

Soil analysis carried out before planting in the 2014 cropping seasons indicated that the soil at the experimental site are of medium acidity level (5.87). Soil with a pH range of 5.2 - 5.6 had been reported to be of medium acidity (Brady and Weil, 1999). Higher pH values of 6.3 and 8.74 were thereafter observed after harvesting in both seasons which may be attributed to the liming effects of the wood ash biomass added. Mbah and Nkapji (2009), in their findings reported that wood-ash when used as soil amendment reduced soil acidity to levels required for maize production. Hence wood-ash being a calcium containing mineral raised the soil pH. In using Cocoa pod ash as an amendment Ayeni et al. (2008) reported increased soil pH values relative to non- ash treated soil. This study adopted an alternate row intercropping in order to manipulate complementary effect and to reduce the effect of competition for maximum agronomic and physiological advantages (Silwana and Lucas, 2002). Different maize growth parameters were affected differently in the two growing seasons by cropping patterns. Data on effect of intercropping and ash application on maize plant height for both seasons show a significant difference (P=0.05). In 2014, late cropping season maize plant height for all treatments recorded low mean height, as low as 79.98 cm at 12 WAP for 25% crop combination. The highest mean plant height was recorded from amended monocrop maize plants, (117.53 cm at 12 WAP). Thobatsi (2009), reported that these differences could be attributed to low rainfall distribution of the growing season, which could have hindered growth and development of the plants. He further stated that high maximum temperatures could also have resulted in higher soil moisture evaporation and transpiration from the plants which retarded plant growth. However, during the 2015 early season, there was a temporal increase in height for sole maize and as well as the intercrops. Taller maize plants were observed at the early season when rainfall was relatively adequate for growth. The reason for vigorous growth of maize could be due to sufficient moisture apart from the availability of nutrients. Also, Silwana and Luca (2002) found that maize monocrop was taller when intercropped with beans. The highest mean height was recorded from ash plots of maize monocrop (184.05 cm) while 152.05 cm was the least plant height from intercropped maize at 25% Maize. The increment of plant height with increased population per unit area may be due to competition for light. Similar result was reported by Adeniyan et al. (2007). Plant height and length of internodes increased with increasing plant population because of competition for light. Generally, all the ash treated plots performed better than the un-amended plots (Table 3). This result was similar with the work carried out by Mbah et al. (2009) who reported that the application of poultry manure gave significant improvement in maize growth parameters. The data during 2014-2015 clearly show that number of leaves per plant was significantly affected by intercropping and wood ash application. The maximum number of leaves per plant during 2014 (12.11) and 2015 (14.97) was recorded in ash treated plots of sole crops, respectively. The higher leaf number per plant observed from the amended monocrop might be due to readily availability of nutrients during the growth period of the crop and reduced effect of competition among plants. An increase in number of leaves per plant on maize at different application rates of manure was reported by Makinde (2007). Intercropping maize with legume as late season crops and the pattern in which the crops were arranged in relation to one another had profound effect on the growth, development and productivity of the component crops (Undie et al., 2012). The maize growth attributes of length of internodes and leaf length in both years were greatly reduced in mixture compared to their sole crop performance. The effect of intercropping on these parameters in maize might be due to intra-and inter-specific competition (Silwana and Lucas, 2002). Maize biomass production was accelerated in the plots where wood ash was applied. This could be attributed to the wood ash applied to the plots and subsequently its competitive abilities were enhanced. Egbe (2005), had observed similar results in pigeon pea/maize intercropping systems and ascribed this superiority to height and biomass production advantage of the cereal component. Leaf area is a measure of size of assimilatory system of plant and is a product of leaf length and width. It is mainly important for the accumulation and partitioning of photosynthates to the economic parts of the plant (Fanuel and Gifole, 2013). Leaf Area Index (LAI) is also one of the major characteristics influencing plant productivity and it is an important determinant of dry matter production and grain yield (Subedi and Ma, 2005). Application of wood ash and intercropping influenced leaf area index of maize. Data during 2014 show that the lowest and highest LAI were 0.53 and 0.95 whereas during 2015 cropping season the lowest and highest values were 0.88 and 1.25 for amended monocrop and 25% Maize: 75% lima-beans intercrops respectively (Table 5). The order of magnitude of total leaf area and the leaf area index values which were higher in the amended monocrops could be related with more number of leaves per plant. Tilahun, (2002) and Demesew, (2002) also observed an increase in leaf area index with increase in population of maize in a mixture with faba bean. Similarly, Laekemariam and Gidago, (2012) on maize reported highest leaf area per plant and LAI on the integrated rates of compost with inorganic fertilizers. Among the intercrops, 75% maize: 25% lima beans also had a high LA and LAI while 25%maize: 75%lima-beans had the least values of LA and LAI. A similar result was obtained from Thobatsi, (2009) who reported that intercropping of cowpea and especially the longer season growers with maize may have an adverse effect on LAI of maize. The total leaf area and leaf area index had positive correlation with the chlorophyll content of maize. For both seasons (Table 5). This confirmed the assertion of Mohamed et al. (2008) that chlorophyll content and photosynthesis were biochemical processes. In this present study, it was observed that with high maize plant population there was reduction in lima beans number of flowers. Gabatshele et al. (2012) described this as the effect of shading which reduce number of flowers under high maize plants population in intercrop. The significant reduction in the number of flowers and pods could have been as a result of maize plants which shadowed lima beans reducing the amount of light required to stimulate flower production. Caruthers et al. (2000) observed that maize is usually taller with a faster growing or more extensive root system; particularly a larger mass of fine roots and is competitive for soil nitrogen. The number of flowers observed in 75L: 25M was the highest among the intercrops. This result was similar to the research carried out by Gabatshele et al. (2012). They attributed this difference to plant density between planting patterns.

Conclusion

Based on findings from this study, wood ash amendment resulted in better growth attributes of maize-lima beans intercrop and higher chlorophyll content which indicates high rates of photosynthesis and a potential crop yield increase. However, for optimum realization of wood ash application effect on growth performance of maize-lima beans intercrop grown in an acidic soil in tropical regions of the world, Wood ash should be applied at the rate of 2.4kg/plot which equates to 5t/ha to an intercrop ratio of 25% maize: 75% lima beans intercrop and 75% maize: 25% lima beans intercrop for higher crop growth rate and better yield return.

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References

Adeniyan ON. Akande SR. Balogun MO. Saka JO. 2007. Evaluation of crop yield of African yam bean, maize and kenaf under intercropping systems American-European Journal of Agriculture 2 (1): 99-102.

Agboola AA. Omueti JA. 1982. Soil Fertility Problems and its Management in Tropical Africa. In: Proceedings of the International Conference on Land Clearing and Development. International Institute of Tropical Research (IITA), Ibadan, Nigeria, Pp 161 – 162.

Andersen MK. Hauggaard-Nelson H. Weiner J. Jensen ES. 2013. Competitive dynamics in two-and three-component intercrops. Journal of Applied Ecology 23: 435-450.

AOAC. 1997. "Official methods of Analysis of the Association of Official" Analytical Chemist International, 16th ed. AOAC International Arlington, VA, pp 43.

Ayeni LS. Oso OP. Ojeniyi SO. 2008. Effect of sawdust and wood ash application in improving soil chemical properties and growth of cocoa (*Theobroma cacao*) seedlings in the Nurseries. Medwell. Agric. J. 3(5): 323 - 326.

Babatunde RO. Fakayode SB. Obafemi AA. 2008. Fadama maize production in Nigeria: Casa study from Kwara State. Res. J. Agric. Biol. Sci., 4: 340-345.

Brady NC. Weil RR. 1999. The Nature and Properties of Soils. (12th Edition). Prentice Hall Inc. New Jersey pp. 881.

Bray RH. Kurtz LT. 1945. Determination of Total, Organic and Available Forms of Phosphorus In: Soil Science 38: 617-628.

Carolynn LA. 2013. Survival gardening- effective method to replenish nutrients in soil. http://offthegridnews.com

Carruthers K., Prithiviraj B, Cloutler D, Martin RC, Smith DL. 2000. Intercropping corn with soybean, lupin and forages: yield component responses. European Journal of. Agronomy 12:103–115.

Demesew M. 2002. Effect of plant density of haricot bean and nitrogen fertilization on productivity of maize and haricot bean additive inter crop system. An MSc Thesis Presented to the School of Graduate Studies of Haramaya University. 50p.

Dowswell CR. Paliwal RL. Cantrell RP. 1996. Maize in the Third World. Westview Press, USA. Pp:268.

Egbe OM. 2005. Evaluation of some agronomic potentials of pigeon pea genotypes for intercropping with maize and sorghum in Southern Guinea Savanna Ph.D. Thesis, University of Agriculture, Makurdi, Nigeria. Pp 200

Elings A. 2000. Estimation of leaf area in tropical maize. Agron. J. 92: 436 - 444.

Fanuel L. Gifole G. 2013. Growth and Yield Response of Maize (*Zea mays* L.) to Variable Rates of Compost and Inorganic Fertilizer Integration in Wolaita, Southern Ethiopia. American Journal of Plant Nutrition and Fertilization Technology, 3: 43-52.

Gabatshele ML, Teko KM, Witness M. 2012. Effects of Intercropping on the Performance of maize and cowpeas in Botswana. International journal of Agriculture and Forestry, 2(6): 307-310.

Ibeawuchi II. 2007. Landrace legumes: Synopsis of the culture, importance, potentials and roles in agricultural production systems. Journal of Biological Science 7 (3): 464-474.

Ikem JE. Amusa NA. 2004. Maize research and production in Nigeria. African Journal of Biotechnology. 3(6): 302-307.

Kasim I, Mad N. Shamsudin R, Yacob-Alias BR. 2014. Technical Efficiency in Maize Production and its Determinants: A Survey of Farms Across Agro-Ecological Zones in Northern Nigeria. Trends in Agricultural Economics, 7: 57-68.

Laekemariam F, Gidago G. 2012. Response of maize (*Zea mays* L.) to integrated fertilizer application in Wolaita, South Ethiopia. Adv. Life Sci. Technol., 5: 21-30.

Laekemariam F. Gidago G. 2013. Growth and Yield Response of Maize (*Zea mays* L.) to Variable Rates of Compost and Inorganic Fertilizer Integration in Wolaita, Southern Ethiopia. American Journal of Plant Nutrition and Fertilization Technology, 3: 43-52.

Landon JR. 1991. Booker Tropical Soil Manual. A Handbook of Soil Survey and Agricultural Land Evaluation in the Tropics and Sub-Tropics. 1st Edn., Longman, London. pp: 185.

Lyman SM, Baudoin JP, Hildalgo R. 2001. Lima bean (*Phaseolus lunatus*) in grain legume crops. Edited by Summerfield RJ, Roberts EH. Pp 350.

Makinde EA. 2007. Effects of an organol-mineral fertilizer application on the growth and yield of maize. J. Applied Sci. Res., 3: 1152-1155.

Mauro A, Homem A, Elizabeth A, Walter-Shea AM. 2001. Test of an extended mathematical approach to calculate maize leaf area index and leaf angle distribution. Agricultural and Forest Meteorology 108(1): 45 - 53.

Mbah CN, Nkpaji D. 2009. Response of maize (*Zea mays* L.) to different rates of wood ash application in acid ultisols in south east Nigeria. Journal of America Science 6 (1): 53-57.

Mohamed SA, Ewees SA, Sawsan A, Seaf EY, Dalia MS. 2008. Improving maize grain yield and its quality grown on a newly reclaimed sandy soil by applying micronutrients, organic manure and biological inoculation. Res. J. Agric. Biol. Sci. 4: 537 - 544.

Ojeniyi SO. 2007. Tropical soil management and agriculture in Nigeria. Bash Moses Publishers, Ibadan, Nigeria. Pp84.

Saka JO, Ajibade SR, Adeniyan ON, Olowoyo RB, Ogunbodede BA. 2004. Survey of under-utilized grain legume production system in South-west Agricultural zone of Nigeria. Journal of Agriculture and Food Information 7: 93-108

Silwana TT, Lucas EO. 2002. The effects of planting combinations and weeding on the growth and yield of component crops of maize/bean and maize/pumpkin intercrops. Journal of Agricultural Science, 138: 193-200.

Subedi KD, Ma BL. 2005. Ear Position, Leaf Area and contribution of individual leaves to grain yield in conventional and leafy maize hybrids. Crop Science 45: 2246 - 2257.

Sullivan P. 2003. Intercropping principles and production practices**.** National Center for Appropriate Technology (NCAT). ATTRA Publication. p. 135.

Thobatsi M. 2009. Growth and yield response of maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) in an intercropping system. International Journal of Agriculture and Crop Sciences 34: 68-78.

Tilahun T. 2002. Effect of planting density and arrangement of component crops on productivity of maize/faba bean intercropping system. An MSc Thesis Presented to the School of Graduate Studies of Alemaya University. 113p.

Tsubo M, Mukhala E, Ogindo HO, Walker S. 2003. Productivity of maize-bean intercropping in a semi-arid region of South Africa. Water Journal 29: 381-388.

Undie UL, Uwah DF, Attoe EE. 2012. Effect of intercropping and crop arrangement on yield and productivity of late season maize-soybean mixtures in the humid environment of South Southern Nigeria. Journal of Agricultural Science 4 (4): 37-50. http:dx.doi.org/10.5539.

Walkley TA, Black IA. 1934. An estimation of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 37: 29-38