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Evaluation of Incorporated Biomass Pruning of Selected Hedgerow Trees on Soil Physical Properties, Growth and Maize Yield for Food Security in Cross River North, Nigeria

Ingwu, Ignatius Ashiewhobel[1;] Onyemauwa, Chibuzor Kennedy[2]

[1,2]Department of Agricultural Education, (DM). Federal College of Education, Obudu, Cross River State, Nigeria.

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Abstract: The experiment is focused on the evaluation of incorporated biomass pruning of selected hedgerow trees on soil physical properties, growth and maize yield to solved food security in Cross River North, South-South Nigeria. The research area lies in latitude and longitude 60 36 '52'N and 9010'150 E southeast of derive savannah. A Randomized Complete Block Design using Azadireahta indica, Acio bateri, Adansonia digitata, Leucaena leucocephala, Gliricidia sepium and Gmelina arborea as treatments at the rate of 5 t ha-1 and Control without treatment replicated three times using maize (Oba supper 2) as test crop for the experiment. Five undisturbed core samples were collected from each plot for physical properties at soil depth 0-10 cm, 10-20 cm and 20-30 cm. Results show that at 8 weeks after planting in 2PS at soil depth 0-10 cm, soil bulk density in plot amended with Gmelina arborea and Azadireahta indica (1.47 and 1.46) relative to the Control by 7.26% and 7.60%. The highest total porosity 50.94% was found in plots amended in Leucaena leucocephala which increase over Control by 17.38%. Soil application of Leucaena leucocephala (50.30%) increase over Control by 18.92% in moisture content. The highest hydraulic conductivity (Cm min-1) was found in Acio bateri and Gliricidia sepium (2.55) which increase over control by 43.75%. The result of maize yield is Leucaena leucocephal>Gliricidia sepium>Andasonia digitata=Gmelina aborea>Acio bateri>Azaderahta indica>control. There are significant differences on soil physical properties and plant parameter due to the treatment. The treatment improves soil physical condition for better nutrient uptake, proper infiltration and aeration, increased nutrients availability for proper growth and maize yield.

Keywords: *Biomass, Hedgerow, Soil physical properties, Growth, and Maize yield.*

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I. INTRODUCTION

Maize (Zea mays L.) is also known as corn, is a cereal grain cultivated as cash crop, forage crop and staple food. Maize growth stages include germination, leaf development, stem elongation, inflorescence emergence, flowering, fruit development and ripening. Maize is a leading grain in the world with an annual production of more than 1 billion tons in 2020 (Tajamul, Kamlesh, pradyuman, and Fatih, 2022) and it constitute staple food for large groups of people in Latin America, Africa and Asia. Maize is cultivated for food, industrial uses, animal feed, soil fertility, income generation, food security, environmental practices, health benefits, research etc. Maize is important for global food security, especially in developing countries, it needs special attention for improvement which lead us to this research. The incorporation of green plant into the soil is green manure to improve crop production is still not yet commonly practiced and is the cheapest means of improving maize cultivation. These are manure, plant debris, composts and biosolid from humus which are applied to agricultural soils. They are high in organic and therefore, represent additional carbon inputs to soil system. Some of these recycle organics also contain a high plant nutrient content and can act as organic fertilizer in the soil. Soil is a complex matter and comprises minerals, soil organic matter, water and air. These fractions greatly influence soil physical properties such as soil texture, soil structure and soil porosity, soil color etc. These properties subsequently affect air, and water movement in the soil layers, and thus the soil's ability to function. Therefore, soil physical properties have a great influence on the soil quality. Soil texture especially can have a profound effect on many other properties. Thus, soil texture is considered one of the most important physical properties of the soil. In fact, soil texture is a complex fraction, consisting of three mineral particles, such as sand, silt and clay. These particles vary by size and make up the fine mineral fraction. Generally, the coarse mineral fraction, which consists of particle over 2 mm in diameter, is not considered in texture. But in some cases, they may affect soil physico-chemical properties such as water retention and others. The textural category of a soil is decided by the relative amount of various particles size in a soil, that is whether it is clay, 10 mm, sandy 10 mm or another etc. (Ololade, Gbadamosi, Mohammed, and Sunday, 2018). The soil offers support to plants and act as a reservoir of water and nutrients.

However, in addition to being a physical medium, the soil may be considered a living system, vital for producing the food and fiber that humans need and for maintaining the ecosystem on which all life ultimately depends (Bationo, 2017). Soil, directly and indirectly affects agricultural productivity, water quality, and the global climate through its function as a medium for plant growth, and as regulator of water flow and nutrient cycling (Gold, Rietveid, Garrett, and Fisher, 2016). The soil structure should be suitable for the germination of the seeds and the growth of the roots and must have characteristics that enhance the storage and supply of water, nutrient, gases and heat to crops. Soil chemistry can have a direct impact on soil physical conditions as in the case of sodic soils with high exchangeable sodium content. The soil also hosts a complex fauna and microbial web involved in many different biological processes, which also affects its physical and chemical properties, and ultimately the productivity of agriculture ecosystem (Okonkwo, Mbagwu, Egwu, and Mbah, 2011). low soil fertility is a common problem in a degraded, eroded or barren land. Conservation of the physical and nutritional subtract for plants requires protection of soil since most terrestrial life form their nutrients from the soil. Degradation of soil can be both of physical and chemical in nature. The purpose of the study is the evaluation of incorporated biomass pruning of selected hedgerow trees on soil physical properties, growth, and maize yield to solve food security in Cross River North, Nigeria. The specific objectives of the study are to; determine the effect of incorporated biomass pruning of selected hedgerow trees on soil physical properties, Growth, and Yield of maize.

II. MATERIALS AND METHODS

A. Description of the study area

This study was carried out in an existing experimental site of Teaching and Research Farms, Department of Agricultural Education, Federal college of Education Obudu, Cross River State in the South-South, Nigeria. The coordinate of the study area lies in latitude 60 36 '52' N, and longitude 9010'150. E Southeast of the derived Savannah zone of Nigeria (www.crossriverhub.ng/obudu). The study area has a pseudo-bimodal rainfall pattern from March to November. Total rainfall in the area ranges between 1700-2000 mm, between June to September, is colder with a means of 1850 mm and in form of intensive violent showers of short and long duration. The area is characterized by high temperatures with minimum and maximum mean daily temperature ranges between 260C (78.80 F) and 320C (89.60 F) throughout the year. Humidity is at its lowest level during the dry season, decreases from south to north. The soil is shallow with unconsolidated parent materials (shale residuum) within one meter of the soil surface. This belongs to the order Ultisol category within Ezzamgbo soil association and classified as typic Haplustult. Geographically, sedimentary rocks derived from successive marine deposit of the cretaceous and tertiary period underlie this area. The Obudu Local Government Area is bordered to the north by Vandeikya of Benue State, to the east by the commune of Akwaya in the Republic of Cameroon, and to the south and west by the Local Government Areas of Boki and Bekwarra respectively. The local government headquarters is located in Bette clan, with the Bette-Bendi occupying the central position, and the Ukpe, Alege/Ubang, Utugwang- North, Central, and South occupying the southern reach of the geo-cultural spread.

B. Materials for Sampling

The materials that were used for collecting the soil samples include; cutlass for clearing the area at each location, core samplers (5 cm2), polyethylene bags (27.5 x 18.5 cm), soil auger and meter rule (1 m). Other materials used again were penetrometer for soil strength, leather bags for soil sample, pruned hedgerows trees, knife, rainboot, weighing balance, hoe for tilling and incorporation of biomass of pruning hedgerow trees into the soil, buckets for lifting core sample to the laboratory and maize variety (Oba supper II) as the test crop. The experiment was established in a Randomized Complete Block Design (RCBD) in the existing experimental site of Teaching and Research Farms, Department of Agricultural Education, Federal college of Education, Obudu with three replications and seven treatments. The treatments were viz: 5 t ha-1 of Acio bateri pruning's, 5 t ha-1 of Adansonia digitata pruning's, 5 t ha-1 of Azadiraehta indica pruning's, 5 t ha-1 of Gliricidia sepium pruning's, 5 t ha-1 of Gmelina arborea pruning's, 5 t ha-1 of Leucaena leucocephala pruning's, and Control plots with no treatment.

C. Land Preparation and Planting

The plots in the experimental site were cleared of the existing growth and all debris removed from the field. The hedgerow trees were cut at 5 t ha-1 of each fresh hedgerow tree pruning was incorporated into seeds bed measuring 15 m x 4 m at 30 cm depth during ploughing. Maize variety (Oba supper II) was planted at 1 week after incorporation at a planting distance of 25 cm intra row spacing and 75 cm inter row spacing. Two seeds were planted per hole but were thinned down to one per stand at two weeks after planting

D. Soil sampling and Laboratory Analysis

Prior to land preparation, soil samples were taken randomly at a depth of 0-10 cm, 10 20 cm and 20-30 cm using soil auger and this was carried out on plot-by-plot basis. Soil sample from each plot were collected and thoroughly mixed to form a composite sample. This composite sample was air-dried and was passed through a 2 mm sieve and used for pre-planting soil analysis of soil properties. Five undisturbed core sample were taken plot-by-plot for the determination of selected soil physical properties. Soil sample was taken plot-by-plot at 0-10 cm, 10-20 cm and 20-30 cm depths in first planting season (1PS), second planting season (2PS), and third planting season (3PS) periods respectively at 8 weeks

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after planting. Five core samples were taken at maize 8 weeks after planting in plot-by-plot basis for the analysis of soil physical properties. Particle size distribution of the auger soil sample was determined using Bouycous hydrometer method as described by (Gee and Gauder, 1986). Whereas, the total porosity (TP) was calculated from the soils bulk density value with the particle density value that was assumed to be 2.65 gcm-3 and was measured in percentage. Gravimetric moisture content was measured by direct method as described by (Obi, 2000). Kemper and Roseau (1986) wet techniques were used to determine soil aggregate stability. Mean Weight Diameter (MWD) was determined by the calculation described by (Kemper and Roseau, 1986). Dispersion ratio was determined by the calculation:

$$DR = \frac{\text{Silt + clay in water dispersed sample}}{\text{Silt + clay in Calgon dispersed sample}} \quad \text{...... equation 1}$$

Saturated Hydraulic Conductivity (cm/hr.) was determined by the (Klute and Dirksen, 1986) method.

E. Agronomic Parameters

Percentage germination count was done at 2 weeks after planting (2WAP) using numerical system of counting objects or material things. After counting, percentage germination was calculated using the formula stated below:

$$\% \text{ germination} = \frac{\text{Number of germinated plants x 100}}{\text{Total number of plants planted}} \quad \text{...........equation 2}$$

During tasseling of maize plant (8WAP) ten stands of maize plant were tagged in each plot and plant height were taken from the base of the shoot to the apex leaf using a meter ruler.

During silking ten tagged maize plant (ear leaf) were taken from each plot. These were dried to constant weight at 70^0C for three days. These were ground and sieved through a 15 mm sieve. Nitrogen was determined using micro Kjeldahl, digestion and distillation method (Amato, 1982). Total organic carbon content was determined by the procedure described by (Amma, 1990). phosphorous and Potassium was also determined by the macro Kjeldahl method (Bremner and Mulvaney, 1982). Shoot dry weight of the maize plant was taken by cutting the maize plants at tasseling and drying to constant weight at 70^0C for three days after which the dry shoot was weighed. The average dry shoot weight was determined using Page, Miller, and Keeney (1982) and ammonium acetate using flame photometer respectively. Grain yield was measured at harvest. In each plot of (4x15 m) containing 16x11 stands per plot (176 maize plants per plot), the boarder area of 0.5 m of the four sides was discarded of which harvesting of maize were taken from the remaining 3.5x14.5 m (50.75 m^2). Ten maize plants were randomly selected and the maize grain was dried, shelled and weighed. The grain yield was calculated using the formula below;

$$\text{Grain yield} = \frac{\text{10,000 x harvested grains}}{\text{Areas of plot after discarded}} \quad \text{..............equation 3}$$

F. Statistical Analysis

Data on soil physical properties, plant biomass, and maize grain yield was analyzed using analysis of variance (ANOVA) for a randomized complete block design according to (Steel and Torrrie, 1980) and significant means were compared using the Fishers' least significant difference (FLSD) at 0.05. Regression model/equation was used to determine the relationship between measured properties.

III. RESULTS AND DISCUSSION

A. Initial Soil Properties at 0_10cm, 10_20cm, and 20_30cm soil depth.

Table 1 represent the result of the initial soil properties collected. The soil description according to soil particle distribution under study is a sandy loamy soil. The permeability of this soil is high and it allows huge number of leachates to pass through it. As a result of high permeability of leachates, the texture of the soil is poor in nutrients content to plants. The deduction of this study is in line with the studies of (Anikwe and Nwobodo, 2002) with reference to the layers studied (0-10, 10-20 and 20-30 cm soil depth). It was observed that soil PH at soil depth of 0-10 cm significantly increase over other soil depths by 7.1% and 11.6% respectively. This implies that the concentration of the soil at 0-10 cm soil depth was reduced slightly relative to those soil depths at both 10-20 and 20-30 cm respectively. With respect to this, part of the result on soil PH, crop like maize can tolerate and survive under soil pH of 5.2 (Onyekwere, *Akpan-Idiko, Amalu, Asowalam, and Eze,* 2019). The rating organic matter explains that at 0-10cm increased more than the soil depth of 10-20 cm and 20-30 cm. The rating of 1.9 gkg at soil depth of 0-10 cm was classified to be medium rating while 0.86 and 0.43 recorded for soil depth of 10-20 and 20-30 cm were classified to be low rating. The result is in line with (Landon, 1991). The value recorded at 0-10cm soil depth for organic matter was higher than those of the 10-20 and 20-30 cm soil depth because of accumulation of organic matter at the top soil within the root zone of maize plants (Lombin, 2002). Values recorded for organic matter at 10-20 and 20-30 cm soil depth was classified to be low and the reason for these low values recorded might be as a result of low build-up of soil organic carbon pool within those layers (Onyekwere, *Akpan-Idiko, Amalu, Asowlam and Eze,*2019). Generally, total nitrogen recorded among the three-soil depth were classified to be low as in line with (Landon, 1991) even though total nitrogen recorded at 0-10cm soil depth slightly

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increase over other layers. At the three layers of soil depth (0-10, 10-20 and 20-30 cm), Available phosphorous (AP) was moderately increased. However, no statistical differences existed between the last two soil depths. The classification of AP according to Landon (1991) was medium rating. Based on the values recorded for exchangeable bases, it was observed that values recorded for Ca and Mg were classified to be medium rating while values recorded for Na and K were classified to be low in all the soil depths. With respect to the results recorded (Onyekwere, Mbagwu, Egwu, and Mbah, 2001) indicated that value for Ca and Mg was classified to be within the critical limit of nutrient classification while those for Na and K were not. These values recorded for total exchangeable acidity and effective cation exchange capacity in the three soil depths (0-10, 10-20 and 20-30 cm) were classified to be low. Though among these layers or soil depths, values of all the physical properties recorded at the initial soil analysis were higher at 0-10 cm soil depth. The reason for this may be due to previous accumulation of organic materials of other source for plant nutrients, even though values recorded among the soil depths were slightly different from each other. With respect to the values of base saturation recorded at 0-10, 10-20 and 20-30 cm were classified to be high. Particle size distribution (sand, silt and clay) was studied and the textural class at these levels of soil depths was sandy loam. The order of increase for clay particles at soil depth was 20-30 > 10-20 > 0-10 cm, for silt and sand particles was 0-10>10-20>20-30 cm respectively. Generally, majority of the soil chemical property at the initial soil properties were of low values which revealed that the soil was low in fertility before cultivation.

Table 1 Initial Soil Properties at 0-10, 10-20 and 20-30 cm soil depth

Test parameter	**Unit**	**0-10 cm**	**10-20 cm**	**20-30 cm**
Sand	gKg^{-1}	690	690	640
Silt	gKg^{-1}	200	170	170
Clay	gKg^{-1}	110	160	190
Textural class	Sandy loam			
Soil pH (H_2O)		5.3	4.6	4.2
Organic Matter	%	1.90	0.86	0.43
Total Nitrogen	%	0.08	0.06	0.04
Available P	$mgkg^{-1}$	26. 2	25.7	25.4
Organic Carbon	%	0.64	0.50	0.25
Calcium (Ca)	$cmolkg^{-1}$	4.92	4.50	4.40
Magnesium (mg)	$cmolkg^{-1}$	1.67	1.47	1.32
Sodium (Na)	$cmolkg^{-1}$	0.08	0.06	0.06
Potassium (K)	$cmolkg^{-1}$	0.15	0.12	0.10
Total EA	$cmolkg^{-1}$	1.23	1.21	1.21
Effective CEC	$cmolkg^{-1}$	5.05	4.36	4.09
Base Sat. (BS)	%	76	72	70

B. Effect of incorporated biomass pruning of selected hedgerow trees on some Soil Physical Properties.

- *Soil Bulk Density (g/cm3) and Total Porosity (%) as affected by incorporated biomass pruning of selected hedgerow trees.*

Values recorded for soil bulk density and total porosity were significantly improved in the amended area of study relative to the control in all the three cropping seasons, See table 2 and 3 below. Results obtained for both bulk density and total porosity, showed that bulk density decreased while total porosity increased and vice-versa. This result was also in line with the assertion made by (Obi, 2000). This study under ultisol, amended with Azadiraetha indica, Acio bateri, Andasonia digitata), Leucaena leucocephala, Gliricidia sepium and Gmelina arborea on soil bulk density and total porosity were altered to a significant level and with the decomposition and mineralization of the first and second cropping season applications may have led to an improvement in both parameters at the residual cropping season (3PS). In line with this report (Blake and Hartage, 1986) reported that decreased soil bulk density and increased soil total porosity and increased mineralization is due to the application of plant residue and animal wastes. Bulk density and total porosity were recorded best in plots of Leucaena lucecophala and among the years of study, this improvement was also better at the residual (3PS) period. In other words, the continued amendment of the soil with the organic waste in 1PS and 2PS was responsible for decreased soil bulk density and increased soil total porosity. This result corroborated with the findings of (Okonkwo, Mbagwu, Egwu and Mbah, 2011) and (Mbah and Mbagwu, 2016) reported that the low bulk density and higher porosity is as a result of increase in organic matter content of the soils. Organic wastes decrease the bulk density of the soil and increase total porosity. With decrease in soil bulk density and increase in soil total porosity that took place in the amended plots of this study, which was the vice-versa of the two parameters studied showed an indication of positive effect of organic materials applied to the soil. This result is in line with the assertion made by (Obi, 2000) and (Oguike, Woodland, Likness, and Schoeneberger,2017) that application of organic waste reduced soil bulk density and increased total porosity of the soil. Similarly, (Okonkwo, Mbagwu, and Nnoke, 2018) and (Mbah and Onweremedu, 2019) reported that low bulk density and high total porosity were beneficial to water transmission, root penetration and cumulative feeding area of the crop. The importance of bulk and total porosity lies in the fact that it may be particularly critical for crop growth and development because small changes in bulk density can cause

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major changes in root growth. In this study, the values of bulk density and total porosity recorded in the amended plots depend on the level of organic matter generated from the applied organic wastes to the soil. This implies that organic materials applied to the soil brought about low bulk density and high total porosity in the amended plots. This report is in line with the observations of (Nnabude and Mbagwu, 2019). In this study also, plots amended with Leucaena leucocephala recorded lowest bulk density, highest total porosity, the reasons for this positive improvement on soil bulk density, total porosity may be attributed to the fact that Leucaena leucocephala that contained high nitrogen may have contributed to easy and smooth decomposition of the material in the soil that led to decrease in soil bulk density and increase in total porosity. This report is in line with the observations of (Okonkwo, Mbagwu, and Nnoke, 2018) that the application of Gliricidia sepium to the soil may have helped the granulation of the soil and therefore better soil bulk density and increased soil total porosity. Thus, soil total porosity in this study depended on the improved soil bulk density which in turn depended on the quality of organic matter in the soil. The ability of Gliricidia sepium and other organic materials as applied to the soil to effect changes relative to the control is a reflection of their potentials to sustain the physical condition of the soil (Defoer, Budelima, Toulimin, and Carter, 2020).

Table 2 Effect of incorporated biomass pruning of selected hedgerow trees as affected by soil bulk density (g/cm3)

Treatment	**0-10 cm**			**10-20 cm**			**20-30 cm**		
	1PS	2PS	3PS	1PS	2PS	3PS	1PS	2PS	3PS
Control	1.69	1.70	1.70	1.70	1.72	1.72	1.70	1.72	1.72
Azadireahta indica	1.48	1.46	1.56	1.52	1.53	1.60	1.53	1.54	1.64
Acio bateri	1.25	1.20	1.41	1.42	1.26	1.40	1.50	1.30	1.44
Adansonia digitata	1.44	1.41	1.45	1.48	1.44	1.49	1.53	1.54	1.54
Leucaena leucocephala	1.45	1.36	1.48	1.53	1.40	1.47	1.58	1.40	1.50
Gliricidia sepium	1.33	1.30	1.46	1.54	1.34	1.42	1.55	1.40	1.46
Gmelina arborea	1.47	1.47	1.52	1.51	1.44	1.54	1.54	1.50	1.55
F- LSD (0.05)	0.44	0.32	0.29	0.27	0.35	0.32	0.2	0.38	0.28

NOTE:1PS =1st planting season, 2PS=2nd planting season, 3PS=3rd Planting season

Table 3 Effect of incorporated biomass pruning of selected hedgerow trees as affected by Total porosity (%).

Treatment	**0-10 cm**			**10-20 cm**			**20-30 cm**		
	1PS	2PS	3PS	1PS	2PS	3PS	1PS	2PS	3PS
Control	35.85	35.5	36.22	35.09	35.85	35.85	35.09	35.9	35.85
Azadireahta indica	41.13	44.0	44.15	39.52	42.64	42.64	38.11	41.8	42.26
Acio bateri	52.88	54.1	46.79	47.16	52.45	46.41	45.66	50.4	43.39
Adansonia digitata	45.16	46.9	4528	43.77	45.66	44.15	41.88	41.8	42.26
Leucaena leucocephala	45.28	48.7	44.15	44.52	47.16	42.26	44.91	47.6	40.37
Gliricidia sepium	49.81	50.4	44.91	46.41	49.43	41.88	44.90	47.6	41.50
Gmelina arborea	42.64	44.2	42.52	44.88	46.41	43.01	41.88	43.9	41.88
F- LSD (0.05)	1.38	1.49	1.47	1.35	1.44	1.36	1.32	1.42	1.32

NOTE:1PS =1st planting season, 2PS=2nd planting season, 3PS=3rd Planting season

- *Soil Moisture Content (%) and Hydraulic Conductivity (cm min^{1}) as affected by incorporated biomass pruning of selected hedgerow trees*

Tables 4 and 5 below represent Soil Moisture Content and Hydraulic Conductivity as affected by incorporated biomass pruning of selected hedgerow trees. The changes in soil moisture content and hydraulic conductivity with the addition of organic materials showed significant differences (0.05) in the second and third year (2PS and 3PS) periods. Among all the treatments applied to the soil-on-soil moisture content and hydraulic conductivity, *Leucaena leucocephala* gave a significant improvement relative to other treatments. The results of these parameters indicate that all the plots amended with organic materials increased moisture content and hydraulic conductivity. Also, this indication positively influenced maize emergence. These organic materials applied to the soil may have increased the conserving power of moisture content in the soil thereby increasing the moisture content and hydraulic conductivity of the soil. Maintaining an adequate amount of organic matter through the application of organic waste like crop residue in the soil, stabilizes soil structure and makes it more resistant to degradation (Nmabude and Mbagwu, 2001). The application of organic materials to the soil in this study may have bounded soil minerals particles thereby reducing the bulkiness of the soil, increasing total porosity and increasing hydraulic conductivity of the soil and also influencing the mechanical strength of the soil which is the coherence of inter-particle bonds (Spaccini *and Boshi*, 2014); (Bationo*, lanwa, Waswa, and Kimeta*, 2017). Organic materials applied to the soil as a source of organic matter promotes soil faunal activities and play a major role in the buildup and stabilization of soil structure. This effect is an indication that organic materials used in this study significantly reduced bulk density, increase total porosity, Moisture content and hydraulic conductivity. This report is in line with the experiment carried out by (Mbah and Onweremadu,2019). The application of organic materials in the amended plot increased moisture content and hydraulic conductivity. These increase in moisture content and hydraulic conductivity in the amended plots, indicated

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higher water transmission, reduced erosion and lower run-off. Also, observed increased in moisture content and hydraulic conductivity in the amended plots could be attributed to the positive effect of organic matter in the soil. These reports are in line with the observations of (Nwite, Mbah, Okonkwo, and Obi, 2021).

Organic materials applied to the type of soil used in this study, contributed significantly increased soil moisture content and hydraulic conductivity. However, soil organic matter in this study may have interacts with other soil properties to influence water behavior in the soil. This study is in line with the findings of Lynne and Kruse (2001). Ranfenay, Ghoshi, and Mittra, (2023) reported that increase in soil moisture content, soil total porosity, hydraulic application of organic wastes to the soil. Also, in line with Ogbodo, 2010) who reported that soil moisture, soil total porosity and water infiltration were significantly (0.05) higher on residue treated plots relative control plots.

Table 4 Effect of incorporated biomass pruning of selected hedgerow trees as affected by Moisture Content (%)

Treatment	**0-10 cm**			**10-20 cm**			**20-30 cm**		
	1PS	2PS	3PS	1PS	2PS	3PS	1PS	2PS	3PS
Control	30.00	35.60	35.60	30.10	35.50	27.10	25.00	35.60	26.40
Azadireahta indica	43.80	45.00	44.10	36.50	40.70	39.30	37.0	37.10	37.10
Acio bateri	49.11	52.10	48.50	49.11	50.50	48.00	45.37	48.20	46.30
Adansonia digitata	44.90	46.50	44.80	40.27	43.30	49.40	39.10	40.40	39.10
Leucaena leucocephala	48.60	49.66	45.70	45.25	49.00	41.30	40.10	44.30	38.48
Gliricidia sepium	49.00	50.30	45.60	44.44	47.00	43.79	40.30	47.30	40.30
Gmelina arborea	44.30	45.70	43.90	44.30	45.10	37.20	49.20	47.00	26.80
F- LSD (0.05)	3.11	5.07	3.18	2.21	4.18	3.16	2.00	3.15	3.12

NOTE: 1PS =1st planting season, 2PS=2nd planting season, 3PS=3rd Planting season

Table 5 Effect of incorporated biomass pruning of selected hedgerow trees as affected by hydraulic conductivity (cm min^{-1})

Treatment	**0-10 cm**			**10-20 cm**			**20-30 cm**		
	1PS	2PS	3PS	1PS	2PS	3PS	1PS	2PS	3PS
Control	0.99	1.00	0.95	0.81	0.99	0.45	0.29	0.32	0.17
Azadireahta indica	1.02	1.09	1.01	0.88	0.89	0.60	0.35	0.36	0.23
Acio bateri	2.60	2.55	2.50	1.90	2.00	1.50	1.00	1.08	1.00
Adansonia digitata	1.57	1.59	1.50	1.00	1.10	0.89	0.60	0.99	0.50
Leucaena leucocephala	2.63	2.61	2.54	2.11	2.16	2.11	1.00	1.02	1.00
Gliricidia sepium	2.55	2.55	2.54	2.30	2.27	2.26	1.03	1.05	1.00
Gmelina arborea	1.27	1.30	1.20	0.94	0.99	0.80	0.53	0.54	0.45
F- LSD (0.05)	0.6	0.16	1.5	0.6	0.15	0.05	0.7	0.8	0.8

NOTE: 1PS =1st planting season, 2PS=2nd planting season, 3PS=3rd Planting season

- *Aggregate Stability (%) and Dispersion Ratio as affected by incorporated biomass pruning of selected hedgerow trees*

Tables 6 and 7 below represent Aggregate Stability (%) and Dispersion Ratio as affected by incorporated biomass pruning of selected hedgerow trees respectively. Values of aggregate stability and dispersion ratio show significances (0.05) in the 2PS and 3PS studied periods. Aggregate stability indicates the ability of the aggregates to resist disintegration when disruptive forces associated with tillage and water or wind erosion are applied. Aggregate stability of the soil for all the three planting seasons (1PS, 2PS and 3PS) and soil depths of 0-10cm, 10-20cm and 20-30cm result showed significantly higher values of aggregate stability in order of *Leuceane lucecophala* >Gliricidia sepium >*Acibateri*>*Adansonia ditigitata*> *Azadereahta indica*>*Gmelina arborea* relative to Control in all the planting seasons (PS). The aggregate stability was observed to decrease with increase in depth. The soil sample from *Leuceane lucecophala* in the three seasons recorded highest values of soil organic matter, total porosity and hydraulic conductivity and aggregate stability. This shows that incorporation of organic matter in the soil influence the aggregate stability of a soil and increase it total porosity and hydraulic conductivity. This report agrees with (Anikwe, 2000) and (Martone, 2000) that incorporation of organic waste and inorganic increase biological activities for improvement of aggregate stability of the soil. Lal (2004b) also observed similar results, that addition of farm yard manure to the soil caused better aggregation which later result to an increase in effective pore volume of the soil that gave a direct positive influence on decreased soil penetration resistance and increase infiltration rate. (Hagarti and Tel, 2005) observed that the application of farm yard manure to the soil improved soil aeration, lowered bulk density and penetration resistance thereby promoting better root proliferation. (Okonkwo, Mbagwu, Egwu, and Mbah ,2011) affirmed that values obtained in the amended plots represented improvement in soil water retention at 10 Kpa over the control plots by 20%.

The results of the dispersion ratio of all plots were higher at 0-10 cm soil depth compared to others in 1PS, 2PS and (residual year) 3PS with *Leuceana leucecephala* recording the highest value, see table 7. (*Defoer, Budelima, Toulimin, and Carter,* 2020) indicated that the dispersion

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ratio predicted erodibility very accurately in some Ohio soils in the United States than the other parameters like the particles size distribution. (Igwe, 2015) opines that this parameter predicts the erodibility of rainforest soil in Nigeria. If dispersion ratio is accepted therefore as an estimator of potential soil erosion hazard, it will be taken that erosion prediction is by using dispersion ratio, this under-study will erode in the following order Leuceana *leucecophala*>*Gliricidia sepeium*>*Acio bateri*>*Adansonia ditigitata*>*Gmelina arborea*> *Azadereahta indica*> Control at 0-10 cm depth for the three planting seasons. This prediction is based on the value of the indices on 0-10 cm layer. Practices like grazing, burning, excess tillage, continuous cultivation of soil operation should be avoided as they lead to soil erosion. In soil depth at 0-10 cm, 10-20 cm and 20-30 cm, the differences in the flow and movement and absorption of these parameters and other plant nutrient within or the soil varied with layer of soil. In line with this report, (Bationo, *Budelima, Toulimin and Carter, 2017*) reported that organic materials incorporated into the soil decreased its content and values will decrease in the level of soil depth such as reducing nutrient elements from top soil to soil depth of about 25-30 cm.

Table 6 Effect of incorporated biomass pruning of selected hedgerow trees as affected by aggregate stability (%)

Treatment	**0-10 cm**			**10-20 cm**			**20-30 cm**		
	1PS	2PS	3PS	1PS	2PS	3PS	1PS	2PS	3PS
Control	11.20	12.20	11.18	9.10	9.14	10.10	9.10	7.00	8.25
Azadireahta indica	16.79	18.90	19.01	15.00	17.00	17.80	13.11	16.50	16.90
Acio bateri	19.07	19.80	20.00	18.00	18.00	18.90	14.10	14.70	17.35
Adansonia digitata	18.00	19.53	19.64	17.20	18.51	18.10	14.00	15.10	16.40
Leucaena leucocephala	18.05	19.60	19.72	17.70	18.70	17.90	12.30	16.10	17.00
Gliricidia sepium	18.92	19.70	19.00	17.70	17.90	18.72	13.40	16.10	17.00
Gmelina arborea	15.06	17.25	18.07	15.60	15.10	17.10	11.70	12.80	14.50
F- LSD (0.05)	0.15	0.18	0.19	0.3	0.4	0.16	0.7	0.1	0.13

NOTE: 1PS =1st planting season, 2PS=2nd planting season, 3PS=3rd Planting season

Table 7 Effect of incorporated biomass pruning of selected hedgerow trees as affected by dispersion ratio

Treatment	**0-10 cm**			**10-20 cm**			**20-30 cm**		
	2.77	2.78	2.88	2.00	2.20	2.88	1.65	2.00	2.30
Control	3.72	3.70	3.90	3.10	3.39	3.91	2.90	3.10	3.20
Azadireahta indica	4.48	4.85	4.90	4.94	4.70	4.00	3.90	4.20	3.80
Acio bateri	3.85	3.85	3.90	3.10	3.50	3.55	2.10	2.20	3.00
Adansonia digitata	3.90	4.00	4.10	4.12	3.41	3.50	2.70	3.32	3.40
Leucaena leucocephala	4.09	4.51	4.79	3.95	4.00	4.32	3.00	3.78	3.70
Gliricidia sepium	3.09	3.75	3.00	2.77	2.10	2.14	2.00	2.10	2.20
Gmelina arborea	0.76	0.9	0.32	0.45	0.70	0.16	0.34	0.42	0.10
F- LSD (0.05)	2.77	2.78	2.88	2.00	2.20	2.88	1.65	2.00	2.30

NOTE: 1PS =1st planting season, 2PS=2nd planting season, 3PS=3rd Planting seasons.

- *Effect of incorporated biomass pruning of selected hedgerow trees on Biochemical Properties of Dry Shoot Weight (g) Organic Carbon and Nitrogen of Maize*

Effect of biochemical properties on dry shoot weight of maize is observed in table 8. 0n these parameters, thus; Plant height (PH), Fresh weight (FW), Dry weight (DW), Organic Carbon (OC) and Nitrogen (N) which showed significant at (0.05) difference among treatments. In 2PS and the residual year of cropping (3PS), PH, FW, OC and N were only significantly at (0.05) difference among treatments. Biochemical properties of both plants and soil can be studied at different levels, the most relevant are those involved in the transformation of organic materials into different forms of nutrient element supplied to the plant for growth and development (Martone, 2000). Also, biochemical properties are more sensitive to environmental stress which plays a major role in degradation of organic materials, provide rapid and accurate information of soil quality (Kerenhap, *Tniagaraian, and Kumar*, 2015). With reference to the above discussion, amended plots of the organic materials used in this study was observed to have enhanced soil microbial activities which in turn gave rise to increase in fresh weight, plant height and other chemical properties. In relation to this report, (Pandey and Sequi, 2011) reported that combinations of decomposed crop residues applied to the soil, increased root weight, fresh weight of maize plant and its twigs and also in his experiment, it was observed that maize dry weight were generally decreased.(Chukwu, 2011) reported that the use of wood ash compost and sludge and a combination of them as an amendment to the soil can positively change plant body weight, soil microbial communities and chemical properties related to plant growth and development.

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Table 8 Effect of incorporated biomass pruning of selected hedgerow trees on Dry Shoot Weight (G) maize and nutrient contents in 1PS, 2PS, and 3PS.Cropping periods

Years	1PS							2PS							3PS						
Parameter	PH	FW	DW	OC	N	P	K	PH	FW	DW	OC	N	P	K	PH	FW	DW	OC	N	P	K
	cm	g	g	%	%	%	%	cm	g	g	%	%	%	%	cm	g	g	%	%	%	%
Treatments																					
Control	110	120	18	9.10	0.63	0.25	0.28	110	30	19	9.4	1.65	0.23	0.22	120	110	18	9.6	1.85	0.23	0.26
Azadereahat indica	130	235	46	17.3	2.65	0.31	0.65	150	270	52	18.2	2.70	0.33	0.93	150	225	50	21.2	4.50	0.29	0.86
Acio bateri	160	190	38	20.43	2.74	0.42	0.70	178	360	65	30.92	3.00	0.45	0.70	156	262	55	24.0	2.46	0.44	0.56
Adansonia digitata	157	415	101	16.7	2.38	0.43	0.82	170	284	66	28.7	2.56	0.58	0.98	170	450	142	26.2	2.75	0.50	0.96
Leucaena leucocephala	170	340	60	10.1	2.68	0.50	0.58	180	573	125	12.2	3.50	0.54	0.65	170	355	62	16.7	3.10	0.46	0.59
Gliricidia speium	165	260	50	15.53	2.74	0.36	0.40	180	500	110	18.8	3.50	0.39	0.98	168	280	56	17.2	2.80	0.38	0.86
Gmelina arborea	135	450	110	20.2	2.40	0.56	0.78	158	250	64	20.1	2.47	0.49	0.98	170	470	120	17.8	2.55	0.63	0.85
F - LSD (0.05)	1.49	1.72	1.39	0.23	0.18	NS	NS	1.22	1.49	NS	0.62	1.42	NS	NS	1.45	1.28	NS	0.41	1.41	NS	NS

Where: 1PS =1st planting season, 2PS=2nd planting season, 3PS=3rd Planting season, PH = Plant height, OC = Organic Carbon, FW = Fresh Weight, N = Nitrogen, DW = Dry Weight, P = Phosphorou

- *Effect of incorporated biomass pruning of selected hedgerow trees on Percentage Germination and Maize grain yield*

In 1PS, 2PS and 3PS periods, effects of incorporated biomass pruning of selected hedgerow trees on percentage germination and maize grain yield were observed. (see table 9) below. The values showed significant differences at (0.05) among treatments in 2PS and 3PS periods. In all the cropping seasons, amended plots of *Leucaena leucocephala* recorded highest germination count. Among all the treatments, plots of Control recorded lowest values of percentage germination of maize in all the planting seasons. This result on germination count indicates that this organic materials *Leucaena leucocephala* that recorded highest moisture content and hydraulic conductivity may have increased soil temperature and moisture content in the soil which positively influenced maize emergence and growth. With references to the results of percentage germination count of this study, (Lianga, Nikolic, Peng, Chen, and Jiana, 2015) found that higher temperature and moisture content of the tropical soil was observed when organic materials of residue plant were applied to the soil. In this study, the treatments applied to soil has helped to maintain optimum soil moisture contents, aids seed establishment and promotes excellent maize plant growth throughout the seasons. All these are positive productivity indicators for good crop management with organic wastes. In line with the report above (Anikwe, 2016) revealed that application of plant residues to the soil can help to maintain soil moisture content, promotes seed emergence and excellent crop growth. There was significant at (0.05) differences that existed among treatments on maize grain yield in all the cropping seasons. Highest values were obtained in amended plots of *Leucaena leucocephala* in all the cropping seasons. The significant improvement among treatments of *Leucaena leucocephala* indicates that there was an access to high release of nutrients availability by the applied material to the soil. According to (Hagarti and Tel, 2005), high yield of maize was observed and recorded in amended plots as a result of high release of nutrients to the soil and high metabolic rate by presence of microbial activities. The application of these organic wastes *Azadereahta indica* to *Gmelina arborea* to the soil, was able to reduce bulk density, increased total porosity, hydraulic conductivity, moisture content and organic carbon of the soil. This positive improvement by the organic materials on the above-mentioned parameters in this study may have attributed or responsible for the positive result obtained under the agronomic parameters such as plant emergence, plant growth and height, shoot dry weight and crop yield.

In collaboration with this study, (Edmeades, 2013) and (Anikwe, Eze, and Ibudialo, 2015) reported that increase in porosity of the soil, reduced soil bulk density, increased moisture content and hydraulic conductivity respectively resulted to significant improvement in maize germination, plant height, root penetration, shoot and root dry weight and maize yield. With an increase in the accumulation of organic materials in 1PS and 2PS cropping seasons, organic matter of the soil was also increased at the residual year of cropping (3PS). This increase in organic matter may have led to the improvement in shoot dry weight in the amended plot in 3PS period. In line with this observation, (Ranfenay, Ghoshi, and Mittra, 2023) reported that application of organic materials in the first and second cropping seasons, gave rise to a significant increase in the third year of cropping. Similar findings were also observed by (Romero-Aranda, Sona, and Cuarter, 2020) that soil organic matter accumulated in the soil supported positive performances of root penetration, shoot dry weight and crop yield. Lower bulk density according to (Nnabude and Mbagwu, 2001) is positive productivity indicator as it helps in easing root penetration for easy access to nutrient that will be provided for crop growth, production

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and yield. The application of organic residue materials to the soil in this study, resulted in higher seed germination, plant heights and maize grain yield in the amended plots relative to the control. Also, these residues materials applied to the soil improved soil water relations thus enhancing nutrient cycling and release to plants. This report is in line with the experiment carried out by (Misra, Tiwari, and Saiprasad, 2017).

Table 9 Effect of incorporated biomass pruning of selected hedgerow trees on percentage germination and maize grain yield in 1PS, 2PS, and 3PS.

	Percentage germination (%)			Maize grain yield (t ha-1)		
Treatments	3PS	2PS	1PS	3PS	2PS	1PS
Control	64	72	72	3.20	3.65	3.55
Azadereahta indica	79	82	80	4.2	4.82	4.44
Acio bateri	88	90	84	4.24	4.92	4.60
Adanosonia digitata	84	95	90	4.9	5.8	5.10
Leucaena leucocephala	98	100	100	5.99	6.62	6.47
Gliricidia sepium	94	100	98	6.24	6.60	6.40
Gmelina arborea	80	98	94	5.65	5.8	5.68
F- LSD (0.05)	11.5	7.24	5.22	1.06	1.72	1.82

Note: 1PS =1st planting season, 2PS=2nd planting season, 3PS=3rd Planting season

- *Regression mode (T) of some conventional parameters studied from 1PS, 2PS, and 3PS residual year*

Table 10 below Showed the regression analysis of models that were used to predict the impact of dependent variables (Y) on independent variables (X). This regression models described the co-existence between soil moisture content and organic carbon, Total porosity and organic carbon, Bulk density and Total porosity and between maize yield and total nitrogen. With respect to the regression equation which described the co-existence between moisture content and organic carbon there were linear relationship between both parameters of which the equation were adequate in predicting moisture content at any given organic carbon particularly, under similar experimental conditions as observed in 1PS, 2PS and 3PS periods which coefficient of determination (r^2) were 40%, 51% and 48% supported by high correlation coefficient (r) of 0.49, 0.85 and 0.72 respectively. According to the regression of total porosity and plant height the regression models described the co-existence between total porosity and plant height. There was linear relationship between total porosity and plant height and this relationship were adequate for determining total porosity at any given plant height especially under similar conditions of experiment as recorded in 2PS and 3PS periods. In these seasons, the coefficient of determination (r^2) was 59% and 48% and was supported by high correlation coefficient (r) of 0.91and 0.85. Relationship between bulk density and total porosity using a regression model determine in 1PS, 2PS and 3PS periods as presented in Table 10. The regression models described the coexistence as linear relationship and the equation were adequate in predicting bulk density at any given experimental conditions in 2PS and 3PS periods. In the course of this regression, average coefficient of determination for the two seasons recorded 54% and 45%. These values recorded for (r^2) were supported by high coefficient correlation (r) of 0.77 and 0.67 respectively. Finally, the regression equation describing the relationship between maize yield and total nitrogen as shown in Table 10. In this case there were linear relationship and the equations were also adequate in predicting maize yield at any given soil total nitrogen, most especially under similar experimental conditions in 2PS and 3PS cropping of which the coefficient of determination (r^2) of 61% and 45% were recorded and the correlation coefficient (r) were 0.91 and 0.88 respectively

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Table 10 Regression mode (T) of some conventional parameters studied from 1PS, 2PS and 3PS residual year

Parameters Dependent Variables	Independent Variables	a(Metercept)	b(Solop)	Regression equation	R^2(%)-Coeff of determinant	1-r^2(%)coef .of alient	R (correlation Coefficient)
MC	OC-1PS	6.104	0.674	Y=6.104+0.674x	40	0.78	0.49
MC	OC-2PS	9.12	0.390	Y=9.120+0.390x	51	45	0.85
MC	OC-3PS	9.47	0.190	Y=9.470+0.190x	48	35	0.72
TP	PH – 1PS	31.65	-0.94	Y=31.65-0.94x	28	70	0.53
TP	PH – 2PS	58.48	-6.41	Y=58.48-6.41x	59	88	0.91
TP	PH – 3PS	42.52	-8.21	Y=42.52-8.21x	48	52	0.85
BD	OC-1PS	51.19	0.111	Y=51.17+0.111x	0.68	77	0.47
BD	OC-2PS	59.02	0.342	Y=59.02+0.342x	54	49	0.77
BD	OC_3PS	42.70	0.221	Y=42.70+0.221x	45	57	0.67
MY	TN – 1PS	0.525	2.456	Y=0.525 +2.456x	21	42	0.39
MY	TN – 2PS	0.925	3.341	Y=0.925+3.341x	61	51	0.91
MY	TN – 3PS	0.775	2.456	Y=0.775+2.456x	45	45	0.88

Where: 1PS =1st planting season, 2PS=2nd planting season, 3PS=3rd Planting season
MC = Moisture content, TP = Total porosity, BD = Bulk density, MY = Maize yield,
PH =Plant Height, OC = Organic Carbon in maize
TN = Total Nitrogen in maize.

IV. CONCLUSION /RECOMMENDATIONS

The availability of biomass of hedgerow trees in the field in the test agro-ecological zone can augment inorganic fertilizer as green manure and save cost of expensive and scarce chemical fertilizers (inorganic manure). On the other hand, soil fertility could be influenced by different biomass of hedgerow trees. *Acio bateri, Azadireatha indica, Gliricidia Sepium, Leucaena leucocephala, Andasonia digitata and Gmelina arborea* store large quantities of nutrients as compared to the control which is attributed to the regular addition of organic amendments (hedgerow) and the cultivation of crops in the site encouraged the organic matter storage in the soil. Lowest bulk density was recorded in *Leucaena leucocephala* in all studied seasons and the nature of bulk density, reflected on the total porosity, hydraulic conductivity and perhaps the moisture content of the soil. The soils were high in clay and silt content and were not easily degraded leaving behind soils with high nutrient and organic matter content. The results of this study shows that all biomass of hedgerow tree being incorporated significantly improve the soil physical properties, and agronomic parameters as compared to the control. Due to these developments, it is recommended that, the pruned hedgerow trees and every other green plant be incorporated as green manure to improve soil quality for better crop yield. It is recommended again that 5 t ha^{-1} of the hedgerow be incorporated in a plot of 4m x 15m of the soil one week before planting of crops so that the heat generated by green plant will be eliminated before planting. Leguminous hedgerows like Leuceana leucocephala and Gliricidia sepium etc. should be incorporated in the soil hence decomposition is easily done

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and more nutrients are added to the soil for its fertility. Continuous tillage without organic amendment and exposing the soil surface should be avoided as these activities lead to loss of nutrients. The application of hedgerows in the soil encourages microbial activities which lead to soil aeration and enhances soil physical properties.

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