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Original Article

Effect of different rates of *Parkia* leaf litter (*Parkia biglobosa*) and poultry manure on yield and profitability of maize (*zea mays* l.) at Afaka Kaduna

M. M. Olorukooba*, R. Mohammed, T. T. A. Adeogun, J. E. Essien, R. Suleiman, O. Olukotun, J. O. Emmanuel

Department of Crop Production, Federal College of Forestry Mechanization of Afaka, Kaduna, Nigeria

ABSTRACT

A field experiment was conducted at the experimental site of Crop Production Technology Department during 2017–2018 rainy seasons at Federal College of Forestry Mechanization, Afaka Kaduna to study the effect of rates of *Parkia biglobosa* leaf litter and Poultry manure on yield, yield components, and profitability of Maize (*Zea may* L). The trial consisted of seven treatments, combination of both *P. biglobosa* leaf litter, and Poultry manure at the ratio of 1:1, 2:1, 3:1, and 4:1, respectively, and three other treatments as soil + *Parkia* leaf litter alone, soil + poultry manure alone and soil alone. The field was laid out in a Randomized Complete Block Design and replicated 3 times. The yield and yield components such as cob length, number of seed per cob, cob weight, 100 seed weight, and grain yield were observed and reading taken after harvesting. Correlation analysis was used to test the relationship between maize yield and growth parameters such as number of leaves, plant height, leaf area, and shoot girth. Gross margin analysis was also used to estimate the profitability of maize on treatment basis. The data obtained were subjected to analysis of variance (ANOVA) using SAS, means were separated using Duncan multiple range test. The result obtained from the analysis showed that treatment combination of *P. biglobosa* leaf litter + Poultry manure at ratio 4:1 performed better and produced yield and yield components such as cob length, number of seed per cob, cob weight, 100 seed weight, and grain yield than 3:1, 2:1, and 1:1, and all other treatments. The gross margin analysis also revealed that treatment combination of *P. biglobosa* leaf litter + poultry manure at ratio 4:1 had the highest value of profit of 160,900 Naira per hectare compared to other treatments. The study, therefore, recommends that incorporation of tree leaf litter and poultry manure into farm land should be encouraged among the farmers in Afaka environs to ameliorate the soil for improved growth rate which, in turn, will enhance bumper harvest of maize that will also bring about higher profit to the farmers.

Keywords: Effect, gross margin, maize, *parkia* leaf litter, poultry manure, yield component, yield

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INTRODUCTION

Parkia biglobosa popularly known as African locust bean tree belong to the *Fabaceae* family. *P. biglobosa* (Jack) has been known to be native of African savanna land and one of the most common species of parkland agro-forestry system.[1] Litter fall is a major pathway for return of organic matter and nutrient from aerial parts of plants to the soil surface.[2] Leguminous tree that is nitrogen fixing trees is known to play complementary or alternative role as sources of organic fertilizer and have the potential to sustain soil fertility.[3] It is increasingly evident that declining soil fertility is one of the limitation on low yield of maize (*Zea mays* L) compared to higher yield obtain in developed countries of the world. It has been reported that traditional practices for soil fertility management recognize this fact and employ the use of household refuse and other plants and animals waste as organic soil amendments. Maize is a heavy nutrient feeders requiring 120N, 60P, and 60K, kg/ha. For higher yield[4] presently, majority of farmers cultivate crops, mostly maize every year regardless of whether they address the soil fertility or not.[5] Soil fertility remains one of the primary constrains to productive agriculture in arid and semi-arid Africa.[6] Furthermore, due to the unpredictability of rainfall in some areas, especially northern part of Nigeria,

Address for correspondence: M. M. Olorukooba, Department of Crop Production, Federal College of Forestry Mechanization of Afaka, Kaduna, Nigeria. E-mail: oolugoke@yahoo.com

farmers consider inorganic fertilizer application as risky.[7] The quality and quantity of organic resources available to farmers are usually low, and therefore, the effectiveness to supply nutrients to the crops is limited. Lack of soil fertility restoring resources, soil erosion, and unequal soil fertility management have been reported to contribute to soil fertility depletion in arid Africa.[8] An infertile soil is bedeviled by many problems. The most prominent of these problems include the inability to support plants growth and agriculture in general. However, several researchers have reported that leguminous crops that are nitrogen fixing trees are known to play complementary or alternative role as sources of organic fertilizer and have potential to sustain soil fertility.[3] In addition, cultivation of leguminous tree crops or biomass transfer is reported as the main possibility for soil enrichment with nutrients, especially nitrogen in many tropical agriculture systems with limited access to fertilizer, because tree biomass is often used to meet nitrogen (N) requirement of annual crops.[9] According to Jama *et al.*,[10] leaf litter will show great potential in benefiting poor African farmers, especially in staple food crop production industries. In addition, incorporation of poultry manure in the leaf litter will accelerate rate of decomposition and could also enhance nutrient release. It is evident as suggested by Oyebamiji *et al.*[5] that leaf litter from forest tree could be a cheap source of ameliorating the low fertility level, and characteristic nutrient content of savannah soil, where maize is produce extensively. Therefore, these practices will ameliorate soil nutrient and, thereby, improve on the low yield obtained and sustain the livelihood of farmers within northern Guinea zones. This study, therefore, aimed at determining the effect of different rates of *Parkia* leaf litter (*P. biglobosa*) and poultry manure on yield and profitability of maize (*Zea mays* l.) at Afaka Kaduna.

METHODOLOGY

Experiment Site

The experiment was conducted at the experimental site of Crop Production Technology Department Federal Collage of Forestry Mechanization Afaka Kaduna State. It is located at latitude 10° 37′ N and longitude 7° 21′ E within the northern guinea savanna agro ecological zone.

Soil-Sampling Analysis

The soil sample at the experimental site was randomly collected diagonally on the site at the depth of 0–15 cm using hand augur. The soil sample was bulked, mixed thoroughly and air dried, put in a sealed envelope for analysis. The analysis was to determine the physical and chemical properties of the soil.

Leaf Litter and Poultry Manure Analysis

The sample of *P. biglobosa* leaf litter droppings was collected within the college premises. This was air dried at room temperature in the soil science laboratory. The air dried sample was crushed, cured, and collected into a marked envelope. Poultry manure sample was collected from the college poultry farm, the poultry manure collected was air dried and crushed to powder form. The sample was collected into another marked envelope for analysis.

Experimental Treatments and Design

The experimental treatments comprised seven. *Parkia* leaf litter in combination with poultry manure at varying ratio of 1:1, 2:1, 3:1, and 4:1, respectively, Soil + leaf litter, soil + poultry manure, and soil alone. The treatment was replicated 3 times and was laid out in a randomized complete block design.

Field Layout and Plot Size

The field laid out comprises gross size of 4.5 m × 1.5 m plot dimension per treatment. The net plot size was 1.5 m × 1.0 m. The spacing between each replicate was 1 m and within plots was 0.5 m. The total area required for the experiment was 127.5 m^2 which was equivalent to 0.0126 ha.

Cultural Practices

Seed selection and seed treatment

Extra early maize variety (Sammaiz 22) was purchased from Institute of Agricultural Research (IAR) Seed Unit Ahmadu Bello University Zaria. It was treated with Apron star at the rate of 10ga.i/ha. The seed was poured into the gourd and mixed thoroughly with Apron star until uniform color is attained.

Land Preparation

The experimental site was cleared of debris, ploughed, harrowed, and ridged. The plot was labeled according to treatment specification as contained.

Nutrient Application

Both the *Parkia* leaf litter and the poultry manure were crushed separately into powder, 1 kg/m^2 of *Parkia* leaf litter and 1 kg/m^2 of poultry manure, respectively, were taken for uniformity and measured at the treatment ratio. The *Parkia* leaf litter was mixed with poultry manure and water was applied sparingly 7 days before incorporation into the soil to facilitate decomposition process. The mixture was broadcast and incorporated into the soil to ensure uniformity in the application. On the control plot, no treatment was applied.

Planting

The treated maize seed was planted within the prepared soil 2 weeks after nutrient application. The seed was planted at recommended rate of two seed per hole during the rainy season on the experimental plot.

Herbicide Application

Pre-emergence herbicides (Atrazine) was applied using knapsack sprayer, with green deplete nozzle at recommended rate of l/ha at a pressure of 2.1 kg/m^2 to 250 l/ha spray solution.

Thinning
Thinning was carried out to one plant per stand 2 weeks after planting (WAP).

Weeding
Supplementary hoe weeding was carried out at 6 WAP when weeds are observed.

Harvesting
Harvesting was carried out on observation of corn maturity, exhibited by dark brown ear on husk tip and leaves dropping, and shattered with high brown coloration. The cobs were picked manually, air-dried to minimum moisture content. Net plot yield was considered separately from the gross plot. The cobs shelled, cleaned, and weighed until uniform weight was attained.

Observation and Data Collection
Growth parameters
The assessment of growth parameters such as number of leaves, plant height, leaf area, and shoot girth was taken from randomly sampled plants (four) tagged from each net plot.

Number of Leaves
The number of leaves from each tagged plants was counted and recorded.

Plant Height (cm)
The plant height was measured from the tagged plants in each net plot from the base of each plant to the highest growth point using meter rule at 3, 6, 9, and 12 weeks after planting. The mean was also determined and recorded.

Leaf Area (cm^2)
The leaf area was determined by measuring the length and the widest point of function leaf at 3, 6, 9, and 12 weeks after planting. The leaf area was calculated using the constant equation of L × B × 0.75 as suggested by Horper.[11]

Shoot Girth (mm)
The shoot girth of each tagged plant was measured with Vernier caliper at 3, 6, 9, and 12 weeks after planting to determine the plant diameter at the base close to the ground level. The mean was determined and recorded.

Yield and Yield Components
Number of cobs per plant\plot
The number of cobs harvested per tagged plant was counted; the mean was calculated and recorded.

100-seed weight (g)
100 Seed from tagged plant was weighed in (g) and the mean weight was recorded accordingly.

Cob weight per plant (g)
The cob weight per plant was taken and the mean was recorded.

Length of cob per plant (cm)
The length of cob per plant was measured using a meter rule and the mean was recorded.

Grain yield per hectare (ton/ha)
The yield was obtained from the net plots size and this was further extrapolated to yield per hectare.

Statistical Analysis
All data collected were subjected to Statistical Analysis of Variance [ANOVA] using the F-fest as described by Snedecor and Cochran (1994). Means separation was done, at 5% level of probability using Duncan multiple range test (DMRT) as described by Duncan.[12] The relationship between maize yield and other parameters were determined using simple correlation coefficient analysis as suggested by Little and Hill.[13]

Correlation Coefficient Analysis
Correlation coefficient analysis was used to evaluate how some selected growth parameters influence on maize yield. The equation used for the correlation coefficient is given as:
$Y = f(X_1, X_2, X_3, X_4)$

Where
Y = Maize yield in tons
X_1 = Number of leaves
X_2 = Plant height
X_3 = Leaf area
X_4 = Shoot girth

The hypothetical equation for the correlation was given as:

$$r = \frac{\sum XY}{\sqrt{(\sum X^2)(\sum Y^2}}$$

Where
X = (X_1–X_4) as stated above
Y = Maize yield in tons
r = Coefficient of correlation
r can take any value between −1 and +1
if r = 0, there is no relationship between X and Y
r = −1, there is poor correlation between X and Y
r = +1, there is strong correlation between X and Y

Gross Margin Analysis
Fixed cost arising from simple tools such as hoe, cutlasses, and sprayers are negligible as such can be ignore when calculating profitability of small scale maize production as suggested by Olukosi and Enhabor.[14] Gross margin analysis was employed to estimate the profitability of different rates of *Parkia* leaf litter

(*P. biglobosa*) and poultry manure applied to the maize plants (*Zea mays* l.) at Afaka Kaduna. The gross margin analysis is expressed as:
GM = GI-TVC

Where
GM = Gross margin of maize yield per treatment (N/ha)
GI = Gross income realized from maize per treatment (N/ha)
TVC = Total variable cost of maize yield per treatment (N/ha)

RESULTS

Nutrients Analysis

The result of mean soil sample, poultry manure, and *Parkia* leaf litter analysis for the experiment site is as contained on Table 1, for the study carried out on influence of rates of *Parkia* leaf litter and poultry manure on growth, yield, and profitable of maize during 2017–2018 rainy seasons at Afaka. The result showed that the pH = 6.40, 7.85, and 6.40 for leaf litter and poultry manure, respectively. The result of analysis indicated that the total nitrogen is 0.03%, 1.26%, and 0.69% and cumulative total nitrogen of 1.98% from all the nutrient sources, while organic matter is 0.65%, 6.69%, and 13.39% for leaf litter and poultry manure, respectively.

Others are organic carbon 0.38%, 3.87%, and 7.74%. Potassium (K_2O) are 0.03 (cmol/kg), 0.21% and 0.15% soil, *Parkia* leaf litter and poultry manure, respectively. The available phosphorus includes 7.41 mg/kg in poultry manure and 0.23 mg/kg in *Parkia* leaf litter. The textural class was loamy sand. Both soil and *Parkia* leaf litter had lower pH values than poultry manure indicating slight acidity. The percent nitrogen in the soil and other nutrient sources is low. However, the cumulative total is quite moderate on the recommendation of 2.0% Nitrogen per plant.[15] All other nutrient elements could cause increase in nutrient status of the crop that is beneficial to crop uptake. The effective cation exchange capacity was also available and relevant in soil fertility that could sustain the soil due to continuous cultivation. Both *Parkia* leaf litter and poultry manure had considerable amount of organic matter of (13.39% and 6.69%) and organic carbon of (7.74% and 3.87%) that could ameliorate the soil content that was initially poor, as indicated in Table 1. Due to the texture of the soil of sandy loam, it could enhance better drainage and structure required for good root penetration.

Yield and Yield Components

Yield component of maize plant on influence of rates of *Parkia* leaf litter and poultry manure obtained at harvest during the 2017–2018 rainy seasons which are indicated in Table 2. The yield component of cob length (cm), cob weight (kg/m^2), 100-seed weight (g), and grain yield (t/ha) was all significant. Both cob length and cob weight produced comparable significantly higher values at different ratio of 1:1, 2:1, 3:1, and 4:1 with combination of *P. biglobosa* leaf litter + poultry manure (1kg/m^2 each) compared to the least values obtained with soil + leaf litter (1kg/m^2) and soil alone. The significant 100-seed weight resulted in higher mean value of 1466.70g of 4:1 and was comparable to mean value of 1166.70g obtained with 3:1. The least value of 416.70 was observed with 100-seed weight of

Table: 1 The mean value for physicochemical and physical characteristic of soil sample, poultry manure, and *Parkia* leaf litter on influence of rates of *Parkia* leaf litter and poultry manure on maize plant during the sampling periods of 2017–2018 rainy seasons at Afaka

Chemical Characteristic	Soil	Poultry Manure	*Parkia* leaf litter
pH (H_2O)	6.40	7.85	6.40
Total Nitrogen (%)	0.03	1.26	0.69
Calcium (cmol/kg) (%)	0.71	0.52	0.19
Magnesium (cmol/kg) (%)	0.06	0.08	0.07
Organic Matter (%)	0.65	6.69	13.39
Organic Carbon (%)	0.38	3.87	7.74
Potassium (K_2O%)	0.03	0.21	0.15
Phosphorus (mg/kg)	----	7.41	0.23
Exchangeable acidity (cmol/kg)	0.50		
Effective cation exchange capacity (cmol/kg)	1.35		
Electrical Conductivity (ds/m)	0.09		
Sand	80.40		
Clay	3.60		
Silt	16.00		
Textural Class	Sandy loam		

Sources: Federal Department of Agriculture and Climatic Change Management Services 2019

Table 2: Effect of rates of *Parkia* leaf litter and poultry manure on mean yield and yield components of maize plant during the 2017–2018 rainy seasons at Afaka

Treatment	Yield and yield components					
	At harvest					
	Rates	Cob length (cm)	Number of seed/cob	Cob weight (Kg/m)	100 seed weight (g)	Grain yield (t/ha)
PLL+PM	1:1	17.67a	369.67ab	1.26a	950.00bc	3.67bc
PLL+PM	2:1	16.75a	370.25ab	1.24a	833.30bc	2.96c
PLL+PM	3:1	18.58a	470.50a	1.67a	1166.70ab	5.85a
PLL+PM	4:1	17.83a	488.17a	1.44a	1466.70a	5.96a
Soil+LL	-:1	12.92b	259.83bc	0.63b	566.70c	3.67b
Soil+PM	-:1	12.92b	210.23c	0.46b	416.70c	1.91d
Soil alone	-	11.67b	200.58c	0.51b	500.00c	2.68c
SE±		0.59	27.03	00.96	104.07	1.16

Cob weight/plant, number of seed/cob, cob weight, 100-seed weight, grain yield, mean followed by similar letters are not significantly different at $P > 0.05$ using Duncan multiple range test (DMRT)

soil + poultry manure and soil alone. During the experimental periods of 2017–2018 rainy seasons, treatment applications of 3:1 and 4:1 had higher grain yield of 5.85 and 5.69 (t/ha), respectively, compared to all other treatments application. The least grain yield was obtained with soil + poultry manure alone. The better vegetative growth performance observed during the study on number of leaves, leaf area, plant height, and shoot girth played significant role in the yield component that gave higher values of cob weight, cob length, number of seed, 100-seed weight, and yield of maize. This was probably due to nutrient sources of leaf litter and poultry manure that improved on the soil that had low nutrient content. It has been reported Oyebamiji *et al.*[5] that fertility level of savannah soils are low, inorganic fertilizers have been in used in most cases. However, the need of organic source is presently being considered due to the role play by improvement of physical characteristic. The addition of *Parkia* leaf litter and poultry manure was able to ameliorate the nutrient content of the soil thereby producing higher yield components observed in the study. The better growth performance also produced higher yield with combination of *Parkia* leaf litter and poultry manure at 4:1 and 3:1 ratio, respectively, than other nutrients application.

Correlation Analysis of Growth Parameters to Grain Yield

The relationship between number of leaves, plant height, leaf area, and shoot girth at 12 WAP with maize grain yield obtained during the sampling periods of 2017–2018 rainy seasons is shown in Table 3. The result indicated that number of leaves was positively correlated with grain yield (0.48) but not statistically significant. The relationship between plant heights at 12 WAP to grain yield indicated that plant height was highly and positively correlated with maize grain yield (0.78) and significant at 5% level of probability which shows that the height of maize plant contributes significantly to grain yield. Considering the relationship between leaf area at 12 WAP and grain yield showed that leaf area had a positive correlation with grain yield but not statistically significant. This also showed that leaf area index is an important growth parameter to be considered in getting good yield from maize. The result showed that shoot girth is highly and positively correlated with the yield of maize grain (0.67) and statistically significant at 10 % level of probability which indicates that the greater the size of the shoot girth the more the maize grains that will be produced.

Table 3: Mean value for correlation coefficient (r) analysis of growth parameters to grain yield of maize plant during sampling periods of 2017–2018 rainy seasons

	1	2	3	4	5
1	1.00				
2	0.30	1.00			
3	0.44	0.68*	1.00		
4	0.74**	0.74**	0.64*	1.00	
5	0.48	0.78**	0.41	0.67*	1.00

1. Number of leaves 12 WAP. 2. Plant height 12 WAP. 3. Leaf area 12 WAP. 4. Shoot girth 12 WAP. 5. Grain yield. *r value at 0.1 level significance. **r value at 0.05 level of significance. DF=5

Gross Margin Analysis

The average cost returns of maize production at Afaka during 2017–2018 rainy seasons from the combination of *Parkia* leaf litter and poultry manure at varying ratio of 1 ton/ha and other variable cost as chemicals, seed, fertilizers, and labor cost are contained in Table 4. Treatment combination of *Parkia* leaf litter (4 ton/ha) + poultry manure (1 ton/ha) at the rate of #20,000:00/ton resulted in #80,000.00 for ratio 4 ton/part of *P. biglobosa* leaf litter + 1 ton/part of poultry manure that gave #20,000:00 only, with all other cost being constant. Therefore, total variable cost for treatment combination of ratio (4:1) of *P. biglobosa* leaf litter + poultry manure was 60,900, while

Table 4: Mean value for gross margin used to determine profitability of maize production with the model during 2017–2018 rainy seasons at Afaka

Treatments	Rates	*Parkia* leaf litter	Poultry manure	Chemical cost	Seed cost	Fertilizer cost	Labor cost	Total variable cost	Total revenue	Gross margin
Parkia leaf litter+poultry Manure	1:1	20000	20000	5200	5200	2500	23000	45900	270000	85900
Parkia leaf litter+poultry Manure	2:1	40000	20000	5200	5200	2500	23000	50900	310000	110900
Parkia leaf litter+poultry manure	3:1	60000	20000	5200	5200	2500	23000	55900	360000	135900
Parkia leaf litter+poultry manure	4:1	80000	20000	5200	5200	2500	23000	60900	405000	160900
Soil+*Parkia* leaf litter	-	20000	-	5200	5200	2500	23000	40900	225000	60900
Soil+Poultry manure	-	-	20000	5200	5200	2500	23000	40900	225000	60900
Soil alone	-	-	-	5200	5200	2500	23000	35900	180000	35900

total revenue occurring from maize grain sales of maize production during the rainy seasons of 2017–2018 showed that treatment combination of 4:1 gave higher total revenue of 405,000, and gross margin of 160,900 concerting the slight variation of total variable cost utilized for production of maize. Therefore, maize is adjusted to be profitable at Afaka. The better growth performance of *P. biglobosa* leaf litter and poultry manure at ratio 4:1 could be an indication that soil amendments with low organic sources could be beneficial for maize production. The higher nutrient content of this combination could have added nutrients to the soil that was beneficial for plant growth. Higher nutrient level, in combination with other growth factors, has been reported to enhance crop growth resulting in higher yield.

DISCUSSION

The soil used for the study was sandy loam with a pH = 6.40 which makes it slightly acidic. This could allow uptake of various nutrient elements as suggested in the interpretation of soil test data report (2006). The result obtained from Table 1 with low level, of soil nitrogen was enhanced by total nitrogen present in the other nutrient samples of *Parkia* leaf litter and poultry manure, and all other nutrient elements could cause increase in fertility status that will be beneficial for maize crop uptake.

The result of the study indicated that higher yield of maize obtained was influenced by the higher rates of application of *Parkia* leaf litter and poultry manure at ratio of 4:1 that produced improved cob weight, cob length, number of seed/cob, 100-seed weight, and grain yield at harvest compare to all other treatments with low nutrient applications. Furthermore, the ability of the nutrient combination of 4 ton/ha *Parkia* leaf litter and poultry manure of 1 ton/ha could improve the soil chemical properties. Poultry manure has been used as soil amendment to sustain adequate crop yield in maize.[16] Therefore, presence of poultry manure as organic manure could have been beneficial to maize producers.

Gross analysis showed that the treatments combination of *P. biglobosa* leaf litter and Poultry manure at ratio 4:1 gave higher gross margin that could be due to higher nutrient availability that enhanced crop growth and yield, thereby leading to profitability of maize production. Kankam-Boadu *et al.*[17] reported that application of synthetic fertilizers alone was not financially profitable but application of 187.5 kg of 23-10-05 NPK + 125 kg sulfate of ammonia + 4000 kg of poultry manure per hectare resulted in highest profitability ratio of 4.79.

The correlation result revealed that all the growth parameter contributes positively to the grain yield at 12 WAP and the growth parameters also showed positive correlations among each other's. However, the non-significant correlation observed between grain yield, number of leaves and leaf area could be due to flowering of the maize plant that terminated other vegetative growth except the shoot girth and plant height that are still responding at this stage of growth. The result corroborates with the work of Gardner *et al.*[18] that observed that flowering could be the reason for termination of leaf area to maximize photosynthesis in grain yield of maize.

CONCLUSION

The results showed that treatments combination of *P. biglobosa* leaf litter and Poultry manure at ratio 4:1 performed better and produced higher maize yield that was profitable. The study, therefore, recommends that incorporation of tree leaf litter and

poultry manure into farm land should be encouraged among the farmers in Afaka environs to ameliorate the soil for improved growth rate which, in turn, will enhance bumper harvest of maize that will also bring about higher profit to the farmers.

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