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USE OF TREE (*Terminalia cattappa*) LEAF RESIDUE AS FERTILIZER MATERIAL ON GROWTH AND NUTRIENT AVAILABILITY TO MAIZE AND SOIL PROPERTIES OF ACID SOIL

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ABSTRACT

A pot experiment was conducted under green house conditions to study the effect of tree leaf residue on the growth of maize and nutrient status in acid infertile soil. The experiment was laid out in a completely randomized design (CRD) and replicated three times. Nine treatments from ground dried sources with and without phosphorus were compared. Ground dried residue from *Terminalia cattappa* was incorporated into the soil a day before planting while P as single super phosphate and a basal application of 50kgN/ha as urea and 50kgK_2O/ha was applied one week after planting. Result showed that highest plant height was obtained at $P_1R_{11}$and maize dry matter yield were obtained at P_1R_{22} amongst the treatment combinations and were significantly different ($P \leq 0.05$) from all other treatments. Highest leaf area was obtained at $P_1R_{22.}$ However, maize growth and dry matter yield were better with the dried ground tree leaves. The addition of inorganic fertilizer with plant residue showed an improvement in growth and dry matter yield of maize. Combination of tree leaf residue with phosphorus fertilizer resulted in nutrient accumulation better than where only tree leaf residue was incorporated into the soil. Soil properties after harvesting maize revealed that pH, P and Mg values were better when compared to initial level at the onset of the experiment. It is apparent that concentration of P in soil could be related to sorption capacity. The beneficial effect of the combination of leaf residue with fertilizer P was important considering the interactions under the dynamics of nutrient release from treatments and this would assist in soil fertility improvement.

Key words: Tree leaf residue; *Terminalia cattappa*; Maize; nutrient availability; soil properties

INTRODUCTION

Soil factors that hinder maize performance in tropical soils are related to the deficiency of major element like nitrogen and phosphorus. The use of chemical fertilizer to correct these deficiencies is not economical to low resource farmers in Nigeria. The use of organic plant residue to supply plant nutrients has been recognized as a cheap alternative of nutrient source which can be beneficial to the traditional farmers (Baggie *et al*., 2000). This is because elements like Fe and Al can be chelated, N can be supplied and soil properties improved. The use of this alternative nutrient source which is locally available and relatively cheap can serve as a better alternative to the use of chemical fertilizer which is costly and not readily available to farmers.

The availability of some nutrients for plant growth with the use of plant residue such as potassium, phosphorus, nitrogen, zinc, organic matter and their retention without readily having them washed away and overall soil fertility have been shown by Holtz *et al*. (2003). However, not much has been done using tree litter (*Terminalia cattappa*) as a source of plant nutrient. But many beneficial effects following litter mass decomposition have been identified and these include increase in organic matter content, nutrient recycling and improved soil structure (Binkley, 1986; Ogeh, 2010).

To optimize the use of nitrogen from leaves it is necessary to understand their mineralization rate and their effect on indigenous soil N availability (Mulongoy and Gasser, 1993). Stevenson (1986) has earlier shown that N concentration or the C/N ratio of incorporated plant material is often the best predictor of the plant N mineralization. Some indices on quality of plant residue are related to lignin, cellulose and phenolic content and their ratios (Becker *et al*., 1994). Materials with increased N contents and decreased lignin content are reported to undergo rapid mineralization. Power and Legg (1978) found that, for N mineralization to occur, a level above N critical level must be attained. In the use of plant residue, traditional farmers would prefer the residue that are around their environment as well as available all the time.

Almond (*Terminalia cattappa*) tree is a common tree in the University of Benin environment and can also be found in most of the villages and cities in southern Nigeria. This tree sheds a very high litter of leaves every year. The leaves are gathered and burnt every year around the tree stands or carried to dumpsites and burnt. Most of the available literature on this leaf is for medicinal purposes and animal feed. This could justify further exploration for use of the tree and its bi-products. Based on the nutrient composition of the leaves, a need to explore the potential use of this tree leaves as a fertilizer material becomes necessary. Therefore a green house experiment was conducted to study the contribution of this tree leaf to soil fertility and maize growth.

MATERIALS AND METHODS

The experiment was conducted in pots under green house conditions at the Faculty of Agriculture, University of Benin, Benin City, Nigeria. Mean day and night temperatures were 31^{o}C and 23 ^{o}C respectively. The relative humidity was between 65 and 70 percent.

Preparation and Analysis of Almond Leaves

The almond leaves (*Terminalia cattappa*) fall and dry up around February – April and are left under the tree leaving a very large accumulated litter in the university environment. These were gathered together outside the tree stands. This is to make sure only almond leaves were gathered and other foreign material were removed. The gathered tree leaf collected all over the campus were milled to fine powder. The milled residue was analyzed in the laboratory as described by IITA (1979). The result of the analysis is presented in Table 2.

Preparation and Analysis of Soil Sample

The experiment was conducted using acid infertile soil from the university farm. Samples of the soils were air dried and passed through a 2mm sieve. Particle size analysis was done by hydrometer method as described by Bouyoucos (1951), soil pH was determined potentiometrically in a soil-solution ratio of 1:1 water. Total N was determined using steam distillation technique by Bremmner (1965), available P was extracted in dilute acid-fluoride and determined using molybdenum blue colorimetry as described by Bray and Kurtz (1945). Exchangeable cations were extracted using ammonium acetate; Ca and Mg was determined using atomic absorption spectrophotometer, while exchangeable K was determined on the flame photometer. The characteristics of soil in the study area are presented in Table 1.

In this study dried ground leaves of almond tree were used as the source of plant residue. 2kg each of soils collected were weighed into each pot. The treatments were 3 levels of P and 3 levels of milled leaves. Phosphorus was added at 0 kg P_2O_5/ha(Po), 30 kg P_2O_5 /ha(P_1) and 60 kg P_2O_5/ha(P_2). Milled leaf residue at 0 tons/ha (Roo), 2.5 tons/ha (R_{11}), 5 tons/ha (R_{22}). The following treatment combinations were laid out in the pot as follows:

PoRoo, PoR_{11}, PoR_{22}, P_1Roo, P_1R_{11}, P_1R_{22}, P_2Roo, P_2R_{11}, P_2R_{22}

Experimental Design and Management

The experiment was laid out in a completely randomized design and replicated 3 times. The plant residues were incorporated into the soil a day before planting while P and a basal application of 50 kgN/ha as urea and 50 kgK_2O/ha was applied one week after planting. Maize variety ACR TZCE – Y from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria was planted into all the pots. The pots were watered regularly to make sure the soils are moist for 10 weeks. Data collected were plant height, leaf area and the plants were harvested 8 weeks after planting. Maize stover nutrient content was measured. Total N was determined using acid digestion followed by distillation and titration; available-P was determined colorimetrically, Ca and Mg by titrimetry while K was by photometry as described by IITA (1979). Soil nutrient status after harvest was measured as earlier on described in this paper.

All data were subjected to statistical analysis using ANOVA and Duncan's multiple range tests for evaluating significant differences between treatments.

RESULTS AND DISCCUSSION

Soil Properties Prior to Planting

Soil properties before planting are presented in Table 1. The soils were slightly acidic and the texture was loamy sand. The nutrient status indicates low available phosphorus, magnesium and potassium compared to the critical levels of these elements.

Table 1: Soil properties prior to planting at 0 – 15cm soil depth

Parameter	Unit	Level
pH H_2O (1:1)		5.34

Total Nitrogen	g/kg	3.00
Available Phosphorus	Mg/kg	3.21
Exchangeable Magnesium	$cmolkg^{-1}$	0.50
Exchangeable Calcium	$cmolkg^{-1}$	1.20
Exchangeable Potassium	$cmolkg^{-1}$	0.82
Exchangeable Sodium	$cmolkg^{-1}$	0.08
Sand	g/kg	832.00
Silt	g/kg	94.00
Clay	g/kg	74.00
Textural Class		Loamy Sand

Chemical properties of Almond Leaves

Properties of the Almond leaves are shown in Table 2. The leaves were high in calcium and magnesium. The micronutrient content was also high.

Table 2: Chemical properties of Almond Leaves (*Terminalia cattappa*)

Parameter	Unit	Level
Available P	mg/kg	0.29
Organic Carbon	g/kg	54.9
Nitrogen	g/kg	3.3
Calcium	g/kg	48.3
Magnesium	g/kg	17.3
Sodium	g/kg	0.43
Potassium	g/kg	1.23
Manganese	g/kg	168.80
Iron	g/kg	230.40
Copper	g/kg	74.90
Zinc	g/kg	116.60
Lignin	% of dry weight	12.5
C/N ratio of residue		17
Polyphenols	% of dry weight	1.64
Cellulose	% of dry weight	30.31

Plant Growth

Maize plant height and leaf area are shown in Table 3. Highest plant height of 26.63cm was obtained with the combination of 30kg P_2O_5 /ha and 2.5 tons/ha milled residue (P_1R_{11}) and was significantly different ($P \leq 0.05$) from all other treatments and the control plot. Highest leaf area was obtained at the combination of 30kg P_2O_5 and 5tons/ha (P_1R_{22}). From the data it is very clear that the leaf residue gave an improvement in the growth of maize at the treatment levels P_1R_{11} and P_1R_{22}. This may be attributable to the high N content in the residue which may have been mineralized to release N into the soil for plant growth.

Table 3: Effects of milled residue treatment and P on maize plant height (cm), leaf area (cm^2) and dry matter yield

Treatment	Plant Height (cm)	Leaf area (cm^2)	Dry matter yield (g/plant)
PoRoo	18.26ab	94.18a	12.96b
PoR_{11}	21.37ab	124.97a	22.09a
PoR_{22}	22.40ab	138.05a	21.92a
P_1Roo	18.42ab	106.22a	14.64b
P_1R_{11}	26.63a	123.70a	18.99ab
P_1R_{22}	19.60ab	148.82a	26.71a
P_2Roo	21.53ab	127.92a	18.83ab
P_2R_{11}	16.42b	130.59a	21.99a
P_2R_{22}	22.43ab	146.95a	20.70ab

Dry Matter Yields

Highest maize dry matter yield of 26.71 g/plant was obtained with the combination of 30kg P_2O_5 /ha and 5tons/ha (P_1R_{22}). A positive response to inorganic fertilizer application was also shown at this treatment combination. The lowest dry shoot yield of 12.96 g/plant was obtained from the control treatment. However, there was significant difference ($P \leq 0.05$) among the treatment means in dry matter yield at $P_1R_{22,}$ $P_2R_{11,}$ PoR_{11} and PoR_{22} compared to the other treatments (Table 3). The addition of inorganic fertilizer with plant residue showed an improvement in dry matter yield of maize. This suggests that additional fertilizer was required to prevent loss of yield where low N plant residue was incorporated into the soil.

P_1R_{11} (30 kg P_2O_5 /ha and 2.5 tons/ha) gave the highest leaf area which was significantly different from the other treatments. P_1R_{22} produced the highest dry matter yield. Similar findings were reported by Cannell (1984) who incorporated straw and inorganic fertilizer into the soil. However, Neue and Bloom (1989), who worked on the nutrient kinetics in flooded rice found out that anaerobic conditions does not favour rapid decomposition of organic materials. Other workers like Ladha *et. al*. (1992), also concluded that residue decomposition was enhanced in their experiment using nodulating rhizobium which resulted in nitrogen release and supply. But in this experiment where tree leaf residue was used as fertilizer material, they consist of complex compounds whether sole applied or when mixed with inorganic fertilizer and it is expected that no single characteristic will control N mineralization throughout the season as observed by Clement *et. al*. (1995)

Nutrient Accumulation in Maize Shoot

Treatment that had combination of plant residue and inorganic fertilizer accumulated more nutrients than leave residue or inorganic fertilizer was applied singly (Table 4). However nutrient accumulation in all the treatment was better than the control plots. Highest N accumulation was in 30kg P_2O_5 /ha and 5tons residue /ha (P_1R_{22}) while highest P accumulation was at same treatment combination (P_1R_{22}). For K, Ca and Mg, highest accumulation of this element in maize shoot was at $P_2R_{11,}$ PoR_{22} and PoR_{11} respectively. This nutrient accumulation of maize further confirms greater modification of soil fertility by supply of nutrient required for plant growth and also indicates faster decomposition of leaf residue coupled with inorganic fertilizer. This was also in agreement with the findings of Ogeh (2010) who also got similar results where leaf decomposition was faster when in addition with inorganic fertilizer..

Table 4: Nutrient accumulation in maize shoot from milled residue treatment

Treatment	N (g/kg)	P (mg/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)
PoRoo	5.6	0.05	0.56	3.23	3.73
PoR_{11}	12.6	0.06	0.58	3.40	5.50
PoR_{22}	7.3	0.05	0.79	4.35	4.20
P_1Roo	8.9	0.05	0.48	2.47	4.12
P_1R_{11}	14.5	0.05	1.08	3.00	4.15
P_1R_{22}	18.6	0.07	0.54	3.40	5.22
P_2Roo	13.6	0.03	0.58	3.20	3.22
P_2R_{11}	14.0	0.06	1.33	3.30	4.73
P_2R_{22}	15.6	0.04	0.59	3.23	3.92
LSD(0.05)	2.1	0.01	0.22	0.12	0.11

Soil properties after maize harvest

Soil properties after harvesting maize in the treatments as presented in Table 5 showed that soil properties like pH, P and Mg were significantly better ($p \leq 0.05$) at the end of harvest than at the beginning of the experiment. In their soil analysis after experiment Holtz *et al* (2003) found that while using wood chippings of almond prunings Ca, Mg, Zn, Cu, P and K were significantly higher. The percent carbon, NH_4-N, cation exchange capacity, electrical conductivity and the percent organic matter were increased. This suggests that additional fertilizer prevented loss of yield where low level of leaf residue and fertilizer was incorporated. Result also reveals that N uptake was more than what was left in the soil after harvest. This may be due to the fact that the plants utilized the N that was made available from the residue. This may have probably caused N and also K to be lower after harvest than the initial levels. This may have been due to high uptake by maize of these elements. High P in the soil after harvest probably may have been due to contribution from the fertilizer material even after the maize plant P uptake. Considering the findings of Baggie *et al* (2000), Ogeh (2010) it can be that P_1R_{22} treatment under study had more pronounced effects on the conditions of P availability and other nutrients in the study. It is apparent that concentration of P in soil could also be related to the soil been saturated with P. High Ca in the soil at the end of experiment may have contributed to the pH levels.

Table 5: Soil properties from milled residue treatment after maize harvest

Treatment	pH	N (g/kg)	P (mg/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Org.C (g/kg)
PoRoo	5.99	1.8	5.53	0.11	0.74	0.93	0.73
PoR_{11}	6.16	2.2	8.07	0.12	0.92	1.25	1.21
PoR_{22}	6.68	2.9	7.24	0.13	1.25	1.63	1.25
P_1Roo	6.52	1.7	5.90	0.12	1.06	0.86	0.67

P_1R_{11}	6.63	2.9	8.43	0.13	1.24	1.36	0.73
P_1R_{22}	6.68	3.2	12.31	0.15	1.25	1.77	1.19
P_2Roo	6.38	2.7	9.25	0.12	0.64	0.76	1.13
P_2R_{11}	6.39	2.9	9.46	0.13	0.79	0.84	1.21
P_2R_{22}	6.72	2.8	12.20	0.14	1.37	0.88	1.17
LSD(0.05)	0.52	1.5	1.23	0.14	0.31	0.13	0.21

CONCLUSION

Results from this study have shown the high potentials of almond leaves residue. Addition of 5 tons/ha almond leaves residue with 30kg P_2O_5 /ha was better and improved soil fertility compared to other treatments. Between treatments where there was incorporation of only almond leaves and where they were incorporated alongside with inorganic fertilizer, leaf applied served as a source of fertilizer material. From this experiment a combination of 5 tons/ha almond residue and 30 kg P_2O_5 /ha (P_1R_{22}) could reduce farmer inorganic fertilizer needs. In terms of dry matter yields, maize also did well with the (P_1R_{22}) treatment. Therefore, the leaf residue amendments had other beneficial effects on the soil including improvement of soil organic matter, pH, available phosphorus and calcium.

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