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Contribution of Agroforestry Tress for Integrated Nutrient Management to Improve Maize Yield on Smallholder Fields

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ABSTRACT

A major tenet of agroforestry is that trees maintain soil fertility and it is based on observation of higher crop yields near trees or where trees have been grown before. This hypothesis is based on studies of effective transfer of nutrients from litter to trees in natural ecosystem. A research was conducted at Central Agricultural Station, Kwadaso to assess the contribution of multipurpose trees and sole fertilizer to improve maize yield on smallholder fields. Six (6) treatments were applied in a Randomized Complete Block Design (RCBD) with three (3) replicates. The treatments were: T1 = Control, T2 = NPK 90-60-60, T3 = Gliricidia sepium (4t/ha), T4 = Moringa oleifera (4t/ha), T5 = Gliricidia sepium (2t/ha) + NPK 60-30-30 and T6 = Moringa oleifera (2t/ha) + NPK 60-30-30. Maize variety, Obatampa was used in the experiment. The results showed that for the three successive years of maize harvest, the performances of biomass application from the two MPTs are comparable to the full rate blanket fertilizer application rate for all ecological zones (NPK 90-60-60). There were indications that either of the two species of MPTs, Moringa and Gliricidia could be applied with or without fertilizer to raise maize yields at the rates indicated and also sustainably improve soil productivity.

Keywords: Multipurpose Tree, Moringa, Gliricidia, Agroforestry and Semi-Deciduous Rain Forest

I. INTRODUCTION

The inclusion of trees within farming systems is a traditional landuse developed by subsistence farmers throughout most of the world. In the last 40 years it has also become a subject for systematic study and improvement, and a livelihood option being promoted for use by smallholder farm families. It has come to the attention of global analysts and policy makers, for example UNFCCC (2008) and also recognized in regional and national development plans (NEPAD 2003) as an obvious component of many farming systems. Its fallow component plays a very important role in maintaining and restoring soil productivity. The traditional approach to soil fertility restoration is through the spontaneous regeneration of vegetation which is seriously under pressure due to the expansion of cropland (Amissah-Arthur et al., 2000). There is the need to intervene the long fallow period with available fast growing nitrogen fixing trees (FGNFT) to overcome the decline in soil fertility on farms and restore crop yields to appreciable levels.

Studies have reported high crop response to the application of organic materials from agroforestry trees (Kang et al., 1999, Makumba et al., 2006) and synergies between these materials and inorganic fertilizers (Kwesiga, 2001; Makumba et al., 2006). Applications of these have resulted in increases in yields on smallholder farms with improved household incomes. This is done in rotations and/ intercropping or in fallows with multipurpose trees and shrubs (MPTs) which provide enormous amount of nutrient for use by growing crops.
Smallholder farmers are also challenged with the maintenance of soil fertility and sustainability of their production because there is inadequate fertilizer usage on farmers' fields. Most farmers lack the financial muscle to purchase enough fertilizer even at government

subsidized cost. The choice of biomass material from MPTs is as a result of the limitation to the use of green manure from herbaceous legumes that are not compatible with many tropical climates, especially its susceptibility to the long drought period preceding the main planting season (Wilson et. al, 1986). The objective of the study was to assess the contribution of multipurpose trees and sole fertilizer to improve maize yield on smallholder fields.

II. METHODS AND MATERIAL

A. Location and Climate

The research was conducted at the Central Agricultural Station of Soil Research Institute Kwadaso, Ghana. The study site is located within the Semi-Deciduous Rainforest zone of Ghana

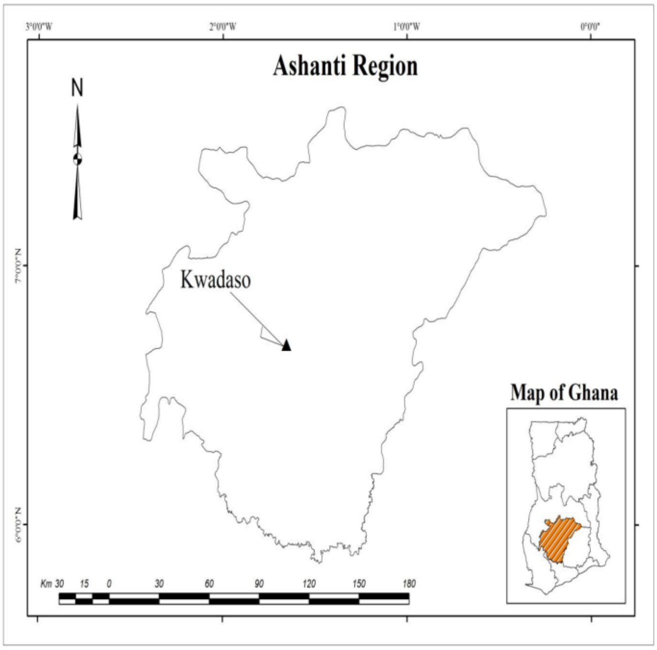

Figure 1: location of the study area (sadick et al., 2015).

The area enjoys a bimodal rainfall pattern, the minor season (August to September) and the major season (March to July). The major season normally begins in March; reaches a peak in July and drops sharply in August whilst the minor season starts in September with the lowest occurring in late November. Thereafter, there is a long dry period from December to February during which negligible amounts of rain normally (below 10mm) are received (Sadick et al., 2015).

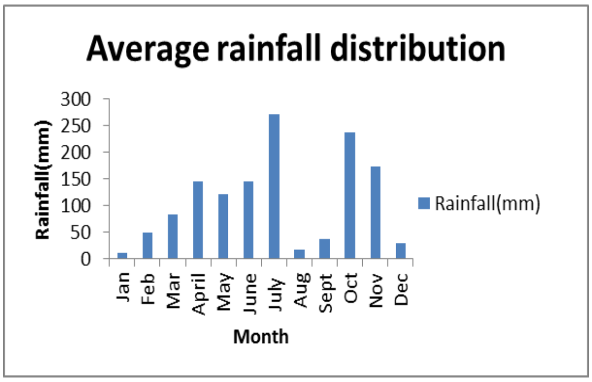

Figure 2: Rainfall Distribution of the study area (Sadick et al., 2015)

Mean monthly temperatures remain high throughout the year only falling around 24oC in August. February and March are the hottest (nearly 28°C) recorded months. Absolute minimum temperatures of around 20°C are usually recorded in December and January with absolute maximum temperature of about 33°C occurring in February and March (Sadick et al., 2015).

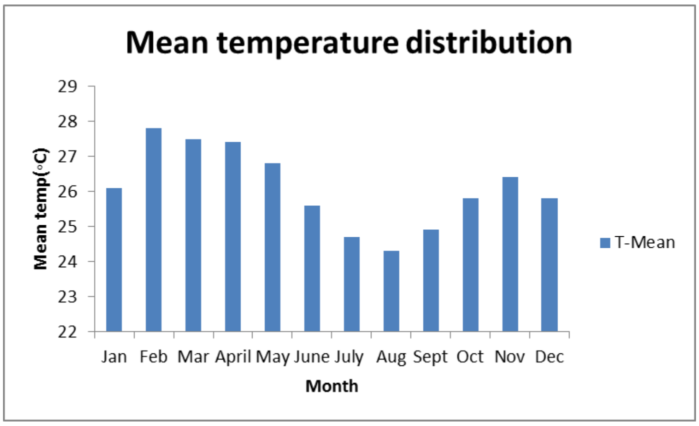

Figure 2: Temperature Distribution of the study area (Sadick et al., 2015)

B. Treatments/Experimental Design

Six (6) treatments were applied in a Randomized Complete Block Design (RCBD) with three (3) replicates. The treatments were: T1 = Control, T2 = NPK 90-60-60, T3 = Gliricidia sepium (4t/ha), T4 = Moringa oleifera (4t/ha), T5 = Gliricidia sepium (2t/ha) + NPK 60-30-30 and T6 = Moringa oleifera (2t/ha) + NPK 60-30-30. Maize variety, Obatampa was used in the experiment.

C. Land Preparation

The vegetation on the land was slashed manually and the land later ploughed and harrowed to a fine tilth. The field was then lined and pegged to demarcate it into blocks and plots. The total field area was of dimension 35 m x 17 m. The field consisted of 3 blocks with 6 plots each. The plot area measured 5 m x 5 m. Spacing between blocks was 1 m and 1 m between plots as shown in Figure 3. Two pruning and biomass application regimes were followed. The first application was done after land preparation and prior to planting and the second application a week before top dressing with N.

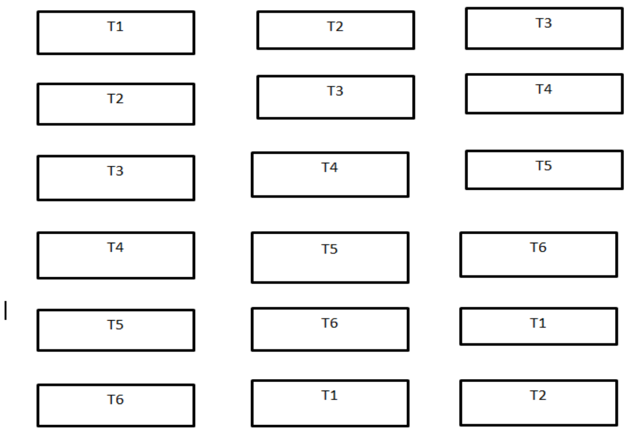

Figure 3: Layout of plot showing treatments allocation (not drawn to scale).

D. Leaf Harvesting and Soil Sampling

Leaf samples were harvested (fresh) from growing shoots of the five MPTs species where soil samples have previously been taken in each of the three blocks and sub sample collected for laboratory analysis. Air-dried sub-samples milled and passed through a 2mm mesh sieve before analyses for various nutrients elements. Standard protocols were used to determine levels of nutrient in leaves.

Data collected were subjected to analysis of variance (ANOVA) and inference made. Standard protocols were used for the determination of the laboratory analysis. Soil pH was determined in 1:1 soil water ratio using a glass electrode (1119017 microprocessor) pH meter. Soil organic carbon was determine by the modified dichromate oxidation method of Walkley Black and digested by Nelson and Sommers (1982).

Total nitrogen was determined by the Kjeldahl digestion and distillation procedure as described by Bremmer and Malveney (1982). The readily acid-soluble forms of phosphorus were extracted with HCl:NH4F mixture (Bray's No. 1 extract) and determined calorimetrically by aerobic reduction and described by Bray and Kurtz (1945) and Olsen and Sommers (1982). Available potassium was determined by flame photometry.

III. RESULT AND DISCUSSION

Table 1: Initial soil nutrient status of the project site

SOIL PROPERTIES	SOIL DEPTH (CM)	
	0 -15	15 – 30
pH	6.3	6.5
Organic matter (5)	1.50	1.38
Total nitrogen (%)	0.09	0.08
Ca (cmol(+)kg	1.34	3.20
Mg (cmol(+)kg	0.53	1.07
K (cmol(+)kg	0.26	0.20
Exch. Acidity	0.07	0.06
ECEC	2.27	4.58
Base saturation (%)	96.9	98.9
P (ppm)	3.75	26.15
K (ppm)	23.0	41.93

Table 2: Nutrient levels of leaf resource material

RESOURCE MATERIAL	N	P	K	Ca	Mg
Gliricidia Sepium	3.41	0.26	0.54	1.26	0.25
Moringa oleifera	3.91	0.30	0.48	2.3	0.14

Table 3 : Maize yields under planted fallows

TREATMENT	2012	2013	2014
T1. Control	2.34	2.01	1.98
T2. NPK 90-60-60	3.48	3.36	3.40
T3. Gliricidia sepium (4t/ha)	3.54	3.39	3.75
T4. Moringa oleifera (4t/ha)	3.37	3.23	3.60
T5. Gliricidia sepium (2t/ha) + NPK 45-30-30	4.27	3.87	4.02
T6. Moringa oleifera (2t/ha) + NPK 45-30-30	3.46	3.31	3.38
SE	0.47	0.28	0.14

Means in the same column followed by the same litter are not significantly different from each other ($P \leqslant 0.05$)

Results from harvested maize crop were promising, the biomass application and inorganic fertilizers application (full rate) showed improved yields over the control as reported in Table 2 and Figure 1

Maize yields in the 2012 major season were in the order Gliricidia sepium (2t/ha) + NPK 45-30-30 = Gliricidia sepium (4t/ha) = NPK 90-60-60 = Moringa oleifera (2t/ha) + NPK 45-30-30 = Moringa oleifera (4t/ha) > Control (T5=T3=T2=T6=T4>T1). Yields in T2, T3, T4, T5 and T6 were significantly higher than T1 which recorded the lowest yield as indicated in Table 1. With the exception of the control T1 (2.34t/Ha) all the other treatment performed significantly equal to the yields in T2 inorganic fertilizers (NPK 90:60:60). Yields were in the range 2.34 – 4.27t/ha. Yields in the amended fields were 44 – 82% higher than those in the control fields with the highest in the combination of Gliricidia and half rate of NPK 45 – 30 -30 (Table 3)

There was a general decline in yields recorded in 2013. The trends in the treatment followed the same pattern as in 2012. Similarly the yields were in the order Gliricidia sepium (2t/ha) + NPK 45-30-30 = Gliricidia sepium (4t/ha) = NPK 90-60-60 = Moringa oleifera (2t/ha) + NPK 45-30-30 = Moringa oleifera (4t/ha) > Control (T5=T3=T2=T6=T4>T1). All the treatment performed better than the Control and statistically equal to the yield in the inorganic fertilizers (NPK 90:60:60). Maize grain yield were between 2.01 – 3.87t/Ha.

Yields recorded in 2014 were between 1.98 and 4.02t/Ha. The trends in the treatment yields changed but similarly the biomass applications were comparably better than that of the treatment with the inorganic fertilizer, yields were in the order Gliricidia sepium (2t/ha) + NPK 45-30-30 = Gliricidia sepium (4t/ha) = Moringa oleifera (4t/ha) NPK 90-60-60 = Moringa oleifera (2t/ha) + NPK 45-30-30 > Control (T5=T3= T4=T2=T6> T1). All the treatment performed better than the Control and statistically equal to the yield in the inorganic fertilizers (NPK 90:60:60).

In the first year yields in the amended fields showed an increase of 44 – 82% over those of the control fields with the highest occurring fields with the combination of Gliricidia and half rate of NPK 45 – 30 -30. The second year saw a 59 – 92% increase of yields in the amended fields compared to the control. At the end of the third year the amended fields out-yielded the control by a 71 – 100%.

The levels of major soil nutrients especially N in the leaves 3.41 and 3.91% for Gliricidia spp and Moringa spp. respectively were above critical values 2.00 – 2.50% (Palm et al, 2000) an indication of net N-mineralization and a relatively faster organic matter turnover is expected on application of biomass to the soil. This resulted in a consequential benefit of the growing maize crops. Thus confirming the claim by Myers et al. (1997) that the application of Gliricidia at suggested rates could meet the N requirements of the maize crop could increase yields.

IV. CONCLUSION

For the three successive years of maize harvest, the performances of biomass application from the two MPTs are comparable to the full rate blanket fertilizer application rate for all ecological zones (NPK 90-60-60). There were indications that either of the two species of MPTs, Moringa and Gliricidia could be applied with or without fertilizer to raise maize yields at the rates indicated and also sustainably improve soil productivity.

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