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Effects of Time of Intercropping of Mucuna (*Mucuna cochinchinensis*) in Maize (*Zea mays*) for Weed and Soil Fertility Management

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ABSTRACT

A two years study was carried out on degraded soil at Makurdi in the southern Guinea Savanna agro-ecological zone of Nigeria in 2005 and 2006 to identify a suitable niche for the intercropping of *Mucuna* into maize to suppress weeds and reclaim degraded soils. *Mucuna* was intercropped into maize at 6 and 9 weeks after planting (WAP) and plots without *Mucuna* were included as control. Intercropping of *Mucuna* had a positive impact on the chemical properties of soil especially when it was introduced 6 WAP of maize. In 2005-2006, clay, organic matter, total N, available P and CEC were improved by 14-8, 27-25, 50-43, 70-83 and 24-26%, respectively as compared with control, whereas sand and pH (H_2O) declined by 4-17 and 6-3%, respectively during these years. Intercropping of *Mucuna* did not significantly affect the yield and yield components of maize. *Mucuna* reduced weed density by 52% and 16% when introduced at 6 and 9 WAP, respectively. The study showed that degraded soil infested by weeds could be reclaimed by intercropping maize with *Mucuna*. The legume could be introduced six weeks after planting maize. © 2012 Friends Science Publishers

Key Words: *Mucuna*/maize intercropping; Yield; Weed suppression; Degraded soils

INTRODUCTION

Maize (*Zea mays* L.) is the world's third most important cereal after wheat and rice (Lagoke *et al*., 2002). It is currently replacing the more traditional crops such as sorghum and millet in the farming systems of West and Central Africa. It is important especially in the Guinea Savanna, where it is one of the two major crops in about 40% of the area under agricultural production (Smith *et al.,* 1997). In Nigeria, maize has gained prominence in the Savanna as the most important cereal crop (Lagoke *et al*., 2002).

Maize is highly exhaustive crop with rapid nutrient depletion from soil. The soils for example must supply about 50-60 kg N ha^{-1} (usually nitrate) and 30 kg P ha^{-1} in plant available forms for each ton of grain produced (Weber, 1998). Most of these requirements are not met by farmers because of limited use of inorganic fertilizers due to high cost and availability. Poor soil fertility, particularly nitrogen supply and *Striga hermonthica* parasitism in the Guinea Savanna constitute two major constraints to increasing maize yield.

Theleguminous cover crops have been a good source of improving soil fertility because of their ability to fix atmospheric nitrogen. The crops can form ground cover rapidly and also produce sufficient biomass that is easily decomposed in the soil (Carsky *et al*., 1998). Besides, they serve as live-mulch and protect the soil from heat of the sun and impact of rainfall, reduce soil erosion and help improve soil structure and water infiltration capacity (Okigbo & Lal, 1977; Akobundu, 1980; Wilson *et al*., 1982).

Mucuna, a cover crop was found to maintain soil productivity and crop yields for 25 years in a rotation experiment on an IITA experimental farm in Southwestern Nigeria. *Mucuna* at full establishment produced high biomass which suppressed weeds (Fujii *et al.,* 1992) and increased soil fertility (Le Mare *et al*., 1987; Yamoal *et al.*, 1996). Addition of nutrients by *Mucuna* was substantial, and soil improvement after *Mucuna*-fallow or in rotation led to significant increase in crop yield (Burle *et al*., 1992; Becker & Johnson, 1998).

Despite practical benefits associated with the intercropping of *Mucuna* in crop production, the adoption of *Mucuna*-based soil management approach by farmers has not been realized in many parts of Africa. One of the possible reasons is the adjustment of *Mucuna* in the existing cropping systems. *Mucuna*-maize rotation has been reported to increase yields and reduce infestation of obnoxious weeds such as *Striga* and *Imperata cylindrica* in Benin (Versteg & Koudokpon, 1998), Kenya (Mureithi *et al.,* 2003) and Nigeria (Shave, 2008). This low input technology has not been adopted by farmers merely because it did not fetch

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immediate economic benefits to them, nor it is used as human food or livestock feed in Nigeria so that the farmers are rarely willing to give way to its cultivation for the indirect benefits associated with it. Present studies were carried out to find a suitable niche for the intercropping of *Mucuna* in maize for weed management and fertility concerns.

MATERIALS AND METHODS

Experimental site: The study was carried out in 2005 and 2006 on a degraded field at the University of Agriculture Teaching and Research Farm, Makurdi (07^{o}4'N, 08^{o}37'E & 92M above mean sea level) in the southern Guinea Savanna agro-ecological zone of Nigeria. Two sites lying side by side were used in succession in 2005 and 2006. The sites were cropped to sorghum prior to the trial year. Total rainfall received from May to November at the site was 1247and 1401 mm in 2005 and 2006, respectively. The soil was sandy loam and physico-chemical characteristics of soil samples taken at the end of each cropping season are given in Table I.

Collection of maize and *Mucuna* planting materials: Seeds of open pollinated *Striga* susceptible maize variety TZESR-W were obtained from the National Cereal Research Institute (NCRI), Yandev sub-station, in Benue State, Nigeria, while those of *M. cochinchinensis* were obtained from the International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria.

Experimental design: *Mucuna* was intercropped 6 and 9 weeks after planting (WAP) of maize and plots without *Mucuna* maintained as control in a randomized complete block (RCB) design with four replications. Plots measured 4 m x 4 m. The vegetation was slashed with a machete and then ridged 75 cm apart in June. Maize seeds were treated with Apron Plus (Metalaxyl) to protect them from pests. Two to three seeds were planted per hill at intra-row spacing of 20 cm on June 8 and 10 in 2005 and 2006, respectively. Fertilizer was applied to maize (50 kg Nha^{-1}, 50 kg P_20_5 ha^{-1} & 50 kg K_20) at 3 WAP. Weeding was done with a hand hoe 3 and 6 WAP. Harvesting was done at 90 days after planting (DAP) of maize.

Data collection and analysis: Data were collected for maize plant height, cob height, cob number, cob weight, grain yield, shelling percentage, 1000 seed weight and weed density. Maize plant height was measured with a meter ruler from the soil surface to the last leaf. Cob height was measured as the distance between the soil surface and the first cob on the maize plant, cob number was the number of cobs on each plant, cob weight was measured after sun drying of the cobs. Cobs from each plot were shelled and the grains weighed to get grain yield. Shelling percentage was calculated as the grain yield over the cob weight in each treatment. The1000-seed weight was obtained by counting and weighing 1000 seeds from each treatment. The number of weeds per quadrat (1 m^2) in each treatment was taken as the weed density at 3WAP. Percentage change in soil properties was calculated using the formula:

$$\frac{(T_2\ or\ T_3) - T_1}{T_1} \times \frac{100}{1}$$

All the data were analyzed using the PROCMIXED procedure in SAS (1999). The model was composed of maize and time of introduction of *Mucuna* as fixed effects and replicates as random effects. Treatment means were compared using the Fisher's least significant difference (F-LSD) at 5% probability.

RESULTS AND DISCUSSION

The physico-chemical properties of the soil (Table I) at the end of the cropping seasons revealed that intercropping of *Mucuna* had a positive impact on these especially when it was introduced 6 WAP of maize. In 2005-2006, clay, organic matter, total N, available P and CEC were improved by 14-8, 27-25, 50-43, 70-83 and 24-26%, respectively as compared with control, whereas, sand and pH (H_2O) declined by 4-17 and 6-3%, respectively during these years (Table I). The improved physico-chemical properties of soils with intercropping of *Mucuna* at 6 WAP might be attributed to greater biological activity (e.g., earthworm abundance & microbial biomass) that are known to occur in organically managed soils than in conventionally managed soils (Mader *et al.*, 2002). Biological activities in the soil also positively influence the plant mineral nutrition and soil aggregate stability (Avav *et al.*, 2008). In this study there was an increase in the clay content and a decrease in the sand proportion. All the chemical characteristics except pH, increased in the *Mucuna* plots. Nutrients in organic soils are less dissolved in the soil solution, and microbial transformation process may have contributed to the phosphorus supply (Mader *et al.*, 2002). High nitrogen replacement value of *Mucuna* has been widely reported (Giller *et al.*, 1987; Carsky *et al.*, 1998; Shave *et al.*, 2008). Positive contribution of *Mucuna* intercropping at 6 WAP in maize is an indication that it should be introduced early enough to capture 50% of the growing season for optimum performance.

Intercropping of *Mucuna* showed non-significant ($P \leq 0.05$) effect on maize plant height during entire growth period (Table II). Similarly, maize cob height, cob number and cob weight showed no significant differences ($P \leq 0.05$) among treatments, rather comparatively lower values were observed where *Mucuna* was present (Table III). *Mucuna* grows rapidly after establishment (Mureithi *et al.*, 2000; Chikoye & Ekeleme, 2001). In this study, *Mucuna* was intercropped at 6 and 9 WAP and by this time maize had fully established with a height advantage to compete for light and other growth resources. Consequently the introduction of *Mucuna* had no significant effect on the yield components of maize. *Mucuna* intercropped at 6 and 9

Table I: Physico-chemical characteristics soil after planting *Mucuna* during 2005 and 2006

Year	Treatment	Particle size distribution			pH (H_2O)	OM (%)	Total N (%)	Available P (ppm)	Exchangeable cations (cmol/kg)				CEC (cmol/kg)
		Clay	Silt	Sand					K	Ca	Mg	Na	
2005	T_1	14	14	72	6.60	1.10	0.20	4.40	0.40	4.20	3.20	0.10	8.80
	T_2	16	15	69	6.20	1.40	0.30	7.50	0.70	4.40	2.80	0.70	10.90
	T_3	15	15	70	6.40	1.25	0.24	7.10	0.50	4.30	3.50	0.40	9.70
2006	T_1	12	14	74	6.65	0.77	0.14	4.00	0.29	2.60	2.20	0.05	8.40
	T_2	13	14	73	6.30	0.96	0.20	7.30	0.90	0.30	2.40	0.10	10.60
	T_3	13	14	73	6.35	0.87	0.18	6.00	0.50	2.80	2.30	0.10	9.90

CEC: cation exchange capacity; T_1: no *Mucuna*; T_2: *Mucuna* intercropped six weeks after planting of maize; T_3: *Mucuna* intercropped nine weeks after planting of maize

Table II: Effect of time of intercropping of *Mucuna* in maize on maize plant height during 2005 and 2006 (average)

Treatment	3 WAP (cm)	6 WAP (cm)	9 WAP (cm)
T_1	3.70	74.00	210.00
T_2	3.57	72.00	203.00
T_3	3.45	73.55	197.00
C.V.	10.26	10.66	10.46
	NS	NS	NS

WAP =Weeks after planting; T_1: no *Mucuna*; T_2: *Mucuna* intercropped six weeks after planting of maize; T_3: *Mucuna* intercropped nine weeks after planting of maize; NS = non-significant ($P > 0.05$)

Table III: Effect of time of Introduction of *Mucuna* in Maize on maize cob height, cob number and cob weight (average for 2005 & 2006)

Treatment	Cob height (cm)	Cob number ha^{-1}	Cob weight (t ha^{-1})
T_1	112.75	34,250	3.81
T_2	99.25	29,750	3.26
T_3	100.25	30,500	3.65
C.V.	13.72	24.80	32.64
	NS	NS	NS

T_1: no *Mucuna*; T_2: *Mucuna* intercropped six weeks after planting of maize; T_3: *Mucuna* intercropped nine weeks after planting of maize; NS = non-significant ($P> 0.05$)

Table IV: Effect of time of intercropping of *Mucuna* in maize on maize grain yield, shelling percentage, 1000 seed weight and weed density (average of 2005 & 2006)

Treatment	Grain yield (t ha^{-1})	Shelling %	1000-seed weight (g)	Weed density (m^{-2})	Weed reduction (%)
T_1	2.98	80.35	267.10	27.50	-
T_2	2.83	78.90	262.00	13.25	-52
T_3	2.50	77.60	249.00	23.00	-16
C.V.	27.39	12.24	4.40	2.70	
	NS	NS	NS	2.33	

T_1: no *Mucuna*; T_2: *Mucuna* intercropped six weeks after planting of maize; T_3: *Mucuna* intercropped nine weeks after planting of maize; NS = non-significant ($P> 0.05$)

WAP resulted in slightly lower maize grain yield (2.83 & 2.50 tha^{-1}), respectively when compared to the control treatment (2.98 tha^{-1}) and non-significant differences ($P\leq0.05$) were observed amongst these treatments (Table IV). A similar trend was observed for shelling percentage and 1000-seed weight. This is the first attempt (in this region) to evaluate the time of intercropping of *Mucuna* in maize in order to improve soil fertility, arrest land degradation and increase maize yields under small farm holdings. There is need to popularize low-input and sustainable technologies among farmers, especially for those that have limited access to credit facilities, and are unable to purchase the expensive and imported inorganic fertilizers. Its long term aspects need to be further investigated in the region. It was reported that when *Mucuna* biomass was incorporated into the soil, application of minimal dose of fertilizer had higher effects on crop performance than when *Mucuna* was solely incorporated into the soil (Adediran *et al*., 2004). This suggests *Mucuna* and fertilizer application could complement each other in improving soil fertility and increasing crop yields.

Intercropping of *Mucuna* also helped in suppressing weeds. Data (Table IV) revealed that weed density was reduced by 52% and 16% in *Mucuna* intercropped at 6 and 9 WAP, respectively as compared with control. Other authors (Mureithi *et al*., 2000; Avav *et al*., 2008) also reported that *Mucuna* has the ability to suppress weeds.

The study concluded that degraded soils infested by weeds could be reclaimed by intercropping maize with *Mucuna* at 6 weeks after planting maize. The crop remains in the field after harvesting of maize and serves as a protective cover for soil against environmental hazards.

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