Journal of Applied Biosciences (2008), Vol. 10: 442 – 448.
ISSN 1997 – 5902: www.biosciences.elewa.org

Growth of *Mucuna* accessions under fallow and their influence on soil and weeds in a sub-humid savanna environment

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ABSTRACT
Objective: To study the growth and influence of *Mucuna* species on soils and weed growth in fallow land.
Methodology and results: Growth of *Mucuna cochinchinensis, M. jaspaeda, M .pruriens* var. *utilis, M. veracruz* (black seeded), and *M.veracruz* (white seeded), and their influence on soil fertility and weed growth were studied under fallow. Over 60% of the fallow weeds were grasses of which 71% were perennials. *Andropogon gayanus, Paspalum orbiculare, Digitaria horizontalis,* and *Rottboellia cochinchinensis* were the dominant grasses, while *Tephrosea bracteolata* and *Tridax procumbens* were the dominant broadleaved weeds. Germinability differed significantly ($P \leq 0.05$) between the *Mucuna* accessions from 58% in *M. veracruz* (black seeded) to 83% in *M. cochinchinensis*. *M. cochinchinensis* had highest leaf area index (LAI, 15.5), dry matter (5 t/ha) and ground cover (80%), and its canopy persisted for 15 weeks after planting (WAP). All the accessions except *M. pruriens* var. *utilis* suppressed over 50% of the dry weed weight with the highest reduction (80%) by *M. cochinchinensis*. The soil pH was reduced, while organic matter, available P and the cation exchange capacity (CEC) were higher in soils planted with *Mucuna*.
Conclusion and application of findings: Mucuna species (*M. cochinchinensis* best bet) can be adopted by farmers for soil fertility improvement and weed suppression in traditional farming systems in the sub-humid savanna zones of the tropics.

Key words: *Mucuna* accessions, growth characters, weed suppression, soil fertility

Citation: Avav T, Shave PA. and Hilakaan PH, 2008. Growth of *Mucuna* accessions under fallow and their influence on soil and weeds in a sub-humid savanna environment. *Journal of Applied Biosciences* 10: 442 - 448.

INTRODUCTION

The typical vegetation in sub-humid savanna (SHS) consists of open woodland with tall grasses and trees, which is swept annually by fierce fires in the dry season (Keay, 1959). The situation is further aggravated by continuous cropping due to high population pressure and unsustainable farming practices. Frequent destruction of the vegetation and cultivation of the soil drastically change the habitat, which becomes harsher because the soil surface is exposed directly to the vagaries of the weather. Once agricultural operations cease, the systematic replacement of early and intermediate seral stages occur through time until a climax community, which may be similar to the original pristine one appears, with weeds occupying the earliest stages of the secondary succession (Radosevich & Holt, 1984).

Several technologies have been introduced to improve soil fertility status and to reclaim lands that are degraded and infested by weeds. These technologies include alley cropping (with agroforestry species), intercropping maize with grain legumes, and *Mucuna* (*M. pruriens* var. *utilis* planted fallows (Versteeg & Koudokpon, 1991). The benefits derived from the use of green manure cover crop system, such as *Mucuna* for West Africa are well summarized by Vissoh *et al.* (1998).The technology consists of planting *Mucuna* in a relay cropping with food crops. *Mucuna* seeds are sown 30 days after planting food crops (mainly maize) in the first cropping season. *Mucuna* remains in the fields after maize is harvested until the end of the second cropping season, thereby precluding the planting of a second crop. This allows ground cover to fully develop for biomass accumulation and nitrogen fixation while weeds such as *Imperata cylindrica* are smothered. During the following dry season that lasts from November-March, *Mucuna* dies off and the farmer can farm the field again at the next main cropping season with minimum investment in labour to open the rows through the *Mucuna* mulch. Sanginga *et al*. (1996) reported an accumulation of about 167 kg N/ha in 12 weeks in *Mucuna* fields.

A system of *Mucuna* fallow that inhibits the utilization of a cropping season has its shortcomings since farmers may not be wiling to forego planting of crops in the second cropping season because of *Mucuna.* A system that does not interfere with the number of times farmers crop their land would be more acceptable and sustainable. Thus, in this study where land is left fallow for 2-3 years (DFID Weeds Project, 2002); a full *Mucuna* fallow was maintained during which the growth characters of the cover crop accessions and their effects on the soil and weed growth were evaluated.

MATERIALS AND METHODS

Experimental site: The trials were conducted in 2005 on land which was under fallow for three years at the Experimental Station of the University of Agriculture, Makurdi (7^0 41'N, 08^0 37'N, and 94 m above sea level). The area is located in the Sub-humid savanna (SHS) ecological zone, which is normally characterized by a bimodal rainfall distribution pattern. Total rainfall received from May to November at the site was 1247 mm. The soil type is sandy loam. The result of the analysis of soil samples taken before and after planting *Mucuna* is shown in Table 4.

Collection of *Mucuna* accessions: Seeds of five Mucuna accessions viz: *M. cochinchinensis, M. jaspaeda, M. pruriens* var. *utilis, M. veracruz* (black seeded) and *M. veracruz* (white seeded) were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Experimental design: The treatments, which included a *Mucuna* free plot as control, were arranged in a randomized complete block (RCB) design with four replications, in plots measuring 8 m x 8 m. In early May, the common weeds in each plot were identified and slashed with a machete and allowed to dry for one week and then removed to provide moderate weed free conditions for planting without tillage. Dry weed weight was estimated from each plot using a 1m x 1m quadrat. *Mucuna* seeds were soaked in warm water to improve germination (Chee & Chiu, 1997) and treated with Apron Plus (Metalaxyl) to protect them from pests. Three seeds were planted per hill at 75 cm x 25 cm in mid-May, when rain stabilized and later thinned to one seedling to give 53,333 plants/ha. *Mucuna* seedlings and the regenerated vegetation were allowed to develop and establish under competition.

Data collection: *Mucuna* establishment was evaluated 1 week after planting (WAP) by counting emerged seedlings in all plots. Ground cover of each accession was assessed by the beaded string method (Sarrantino, 1991) from 4-24 WAP. Canopy duration was derived from ground cover measurement and is defined as the time when *Mucuna* covers at least 40% of the ground. Mean nodulation was assessed at 8 WAP by carefully digging out 5 plants selected at random per plot and counting the total number of nodules per plant. Dry matter (DM) was estimated at 24 WAP by harvesting both the above and underground parts in a $1m^2$ quadrat in all treatments and oven-drying them at 80^0C for 48h. The rest of the plants were left *in* *situ* on the field until the end of the growing season. Weeds were removed from 1 m^2 quadrat per plot at the end of growing season and left to dry for one week and then weighed to obtain the dry weight.

Data analysis: The data were analysed using the GenStat Release 7.2 DE (LAT, 2007). Means were separated using the Duncan's New Multiple Range Test (DNMRT) at 5% level of probability. The trial was terminated after one year because of wild fire, which swept through the portion of the research farm under fallow in the dry season. Consequently, the data reported are for one year.

RESULTS

Over 60% of the fallow weeds were grasses of which 71% was perennials (Table 1). *Andropogon gayanus, Paspalum orbiculare*, *Digitaria horizontalis* and *Rottboellia cochinchinensis* were the most common grasses. Most of the broadleaved weeds were annuals, some with dual life cycle. *Tephrosea bracteolata* and *Tridax procumbens* were the dominant broadleaved weeds, with *T. procumbens* being identified by farmers as the most difficult to control. The parasitic weed *Striga hermonthica* and the ubiquitous *Imperata cylindrica* were also found in the fallow.

Table 1: Relative distribution of common fallow weeds before slashing in May 2005 at the Experimental Station of the University of Agriculture, Makurdi, Nigeria[a]

Weed	Family	Type	Height (cm)	% Spread
Grasses				
Acroceras zizaniodes Dandy	Poaceae	P	90	70
Andropogon gayanus. Kunth.	Poaceae	P	300	100
A. tectorum Schum & Thonn.	Poaceae	P	350	40
Brachiaria jubata (Fig. & De Not.) Stapf	Poaceae	P	100	60
Dactylectenum aegyptium (L.) P. Beauv.	Poaceae	P	35	10
Digitaria horizontalis Willd.	Poaceae	A	40	90
D. longiflora Willd.	Poaceae	A	50	20
Echinochloa obtusiflora Stapf	Poaceae	A	400	40
Eragrostis atrovirens (Desf.) Thrinn. ex Steud	Poaceae	P	60	30
Imperata cylindrica (L) Raeuschel	Poaceae	P	50	60
Paspalum orbiculare Forst (*P= commersanii*)	Poaceae	P	60	100
Polygonium salicifolium Brouss. ex Willd	Poaceae	P	100	30
Rottboellia cochinchinensis (Lour.) Clayton	Poaceae	A	400	80
Setaria megaphylla (Steud.) Dur. & Schinz	Poaceae	P	350	30
Broadleaves				
Commelina erecta L.	Commelinaceae	A/P	60	10
Hyptis suaveolens Poit.	Lamiaceae	A	150	50
Ludwigia abyssinica A. Rich.	Onagraceae	A/P	200	20
Poliostigma thonningii (Schum.) Milne-Redhead	Caesalpiniaceae	P	550	10
Sesamum indicum L.	Pedaliaceae	A	100	20
Sida linifolia Juss ex Cav	Malvaceae	A/P	100	40
Striga hermonthica (Del) Benth	Scrophulariaceae	A	60	60
Tephrosia bracteolata Guill. & Perr.	Fabaceae	A	150	80
Tridax procumbens L.	Asteraceae	A	40	70

[a]Based on identification by Akobundu and Agyakwa (1987): *A Handbook of West African Weeds*. International Institute of Tropical Agriculture.

The growth characters of some *Mucuna* accessions differed significantly ($P \leq 0.05$). Germinability differed from 58% in *M. veracruz* (black seeded) to 83% in *M. cochinchinensis* (Table 2). The mean germination percentage was 71%. When ranked based on germinability *M. cochinchinensis* > *M. pruriens* var. *utilis* > *M .jaspaeda* > *M. veracruz* (white seeded) > *M. veracruz* (black seeded). Nodulation ranged from 8 nodules/plant (*M. jaspaeda*) to 10.5 nodules/plant (*M. cochinchinensis*) but did not differ significantly among the accessions. *M. cochinchinensis* had the highest number of nodules followed by *M. veracruz* (white seeded). *M. cochinchinensis* also had the highest LAI, which was, however, not significantly different when compared to *M. veracruz* (black seeded) and *M. veracruz* (white seeded). *M. jaspaeda* had 53% less LAI than *M. cochinchinensis*, which together with *M. veracruz* (black seeded) had the highest dry matter.

M. cochinchinensis, M. jaspaeda and *M. veracruz* (white seeded) covered 50% or more of the ground at 6WAP (Figure 1). All the accessions attained 64 – 80% ground cover at 12-14 WAP. *M. cochinchinensis* produced the highest ground cover of 80%. The canopies decreased in ground cover from 16WAP with that of *M. cochinchinensis* persisting longest (15WAP) compared to the other accessions (Figure 2). The *Mucuna* accessions suppressed dry weed weight significantly ($P \leq 0.05$) compared to plots without the cover crop (Table 3). All the accessions (except *M. pruriens* var. *utilis*) suppressed over 50% of dry weed weight, with highest (79.7%) reduction being by *M. cochinchinensis*.

The chemical and physical parameters of the soil, before and after planting of *Mucuna* accessions, showed marginal differences (Table 4). The pH was reduced, while organic matter (OM), available P and the CEC were higher in soils planted with *Mucuna.*

Table 2: Growth characters of *Mucuna* accessions grown under fallow in Makurdi, Nigeria, 2005.

Accession	Germination (%)	LAI (12WAP)	DM (tha^{-1})	Nodulation ($No.plant^{-1}$)
M. cochinchinensis	83a	15.5a	4.8a	10.5a
M. jaspaeda	72a	7.3c	2.4b	8.0a
M. pruriens var. *utilis*	78a	9.2bc	2.6b	9.3a
M. veracruz (black seeded)	58b	13.1ab	3.5ab	9.0a
M. veracruz (white seeded)	62b	12.1ab	2.7b	10.0a
No *Mucuna*	-	-	-	-
Mean	71	11.4	3.2	9.4

Column means followed by same letter(s) are not significantly different ($P \leq 0.05$)

Table 3: Effects of *Mucuna* accessions on weed weight under fallow in Makurdi, Nigeria, 2005.

Treatment	Before *Mucuna* Dry weight (tha^{-1})	After *Mucuna* Dry weight (tha^{-1})	Weed reduction (%)
M. cochinchinensis	5.9a	1.2c	79.7a
M. jaspaeda	5.5a	2.5b	54.6b
M. pruriens var. *utilis*	5.7a	2.8b	49.1b
M. veracruz (black seeded)	5.8a	2.7b	54.4b
M. veracruz (white seeded)	5.9a	2.8b	52.6b
No *Mucuna* (control)	5.9a	4.9a	17.0c
Mean	5.8	2.8	51.2

Means followed by the same letter along the column are not significantly different ($P \leq 0.05$).

Table 4: Physico-chemical properties of soil before and after planting *Mucuna* under fallow in Makurdi, Nigeria, 2005.

Parameter	Before *Mucuna*	After *Mucuna*
Particle size distribution (%)		
Clay	14	12
Silt	14	18
Sand	72	71
Organic matter (%)	1.1	1.3
pH (H_2O)	6.6	6.1
pH ($CaCl_2$)	5.3	5.7
Total N (%)	0.2	0.2
Available P (Ppm)	4.4	6.5
Exchangeable Cations (Cmo/kg^{-1})		
K	0.4	0.6
Ca	4.2	4.6
Mg	3.2	2.8
Na	0.1	0.9
Cation Exchange Capacity (*Cmolkg^{-1}*)	8.8	10.7

DISCUSSION

The study showed that while *A. gayanus* is found mostly on land under fallow (Akobundu & Agyakwa, 1987), *D. horizontalis* and *R. cochinchinensis* are major weeds in farms with arable crops in the study area, and therefore smallholder farmers have to weed manually (with the hoe) several times before harvest (Avav *et al*., 1995; Avav & Okereke, 1997; Avav & Shave, 2005).

Germinability, nodulation, leaf area index and dry matter differed between the *Mucuna* accessions. The finding on germinability corroborates Chikoye and Ekeleme (2001). The high germinability in *M. cochinchinensis* may be related to its large seed size (Qi *et. al.*, 1999), which has been shown to improve germination percentages in *Mucuna* (Barbedo *et. al*., 1988). Similarly, in an earlier study in the forest zone of Nigeria, *M. cochinchinensis*, *M. jaspaeda* and *M. veracruz* (white seeded) had the highest leaf area index (LAI), while *M. veracruz* (black seeded) had the lowest (Chikoye & Ekeleme, 2001). In this study, however, *M. veracruz* (black seeded) was among the accessions with the highest LAI.

The superiority of *M. cochinchinensis* in dry matter production as observed in this study corroborates Carsky *et al.* (1998), Akobundu *et al.* (2000) and Chikoye and Ekeleme (2001). However, none of the accessions attained 100% ground cover, which was contrary to the finding of Shave (2008). The difference could be that in this study the land was not ploughed and harrowed after slashing before planting *Mucuna.* Therefore, the germinating seedlings of the cover crop faced stiff competition from the tall perennial grasses, which regenerated soon after slashing. Indeed, all the growth characters of *Mucuna* were lower compared to those obtained when land was ploughed and harrowed before planting.

Weed reduction could be higher if the cover crop lasts over a year on the land. Dovonou (1994) noticed a 54% reduction of *Imperata* shoots when *Mucuna* was planted in *Imperata*-infested fields, which is similar to the findings of this study. Lands that are degraded and infested by weeds, and having low soil fertility can be reclaimed using *Mucuna* planted fallow systems (Versteeg & Koudokpon, 1991; Vissoh *et al*., 1998).

Based on growth characters (germinability, nodulation, LAI, DM, canopy cover, persistence and weed suppressing ability) *M. cochinchinensis* was the best accession. In Kenya, farmers ranked *Mucuna* as the best green manure cover crop based on high biomass production and rapid canopy establishment (Mureithi *et al*., 2000), which supports the observations on *M. cochinchinensis* in this study. This accession can therefore be recommended to farmers for soil fertility improvement and weed suppression in traditional farming systems in the Sub-humid Savanna zone of the tropics.

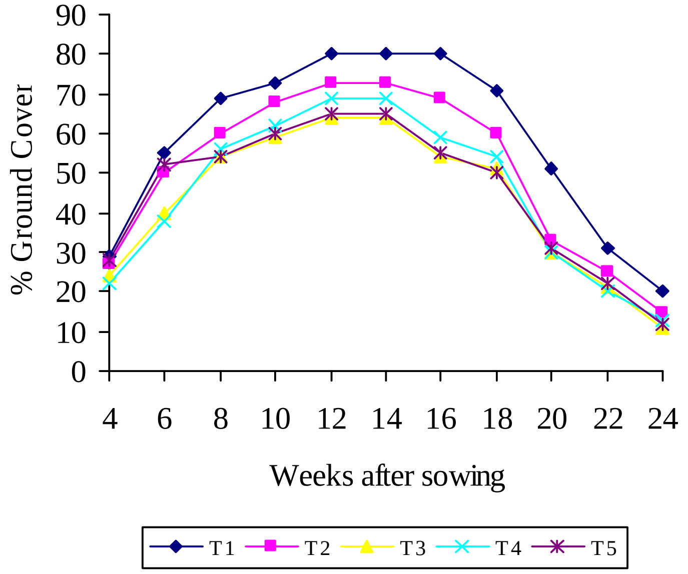

Figure 1: Percentage ground cover by *Mucuna* accessions ((T1= *Mucuna cochinchinensis*, T2 = *M. jaspaeda*, T3 = *M. pruriens* var utilis, T4 = *M. veracruz* (black seeded), T5 = *M. veracruz* (white seeded) grown in Makurdi during the 2005 cropping season.

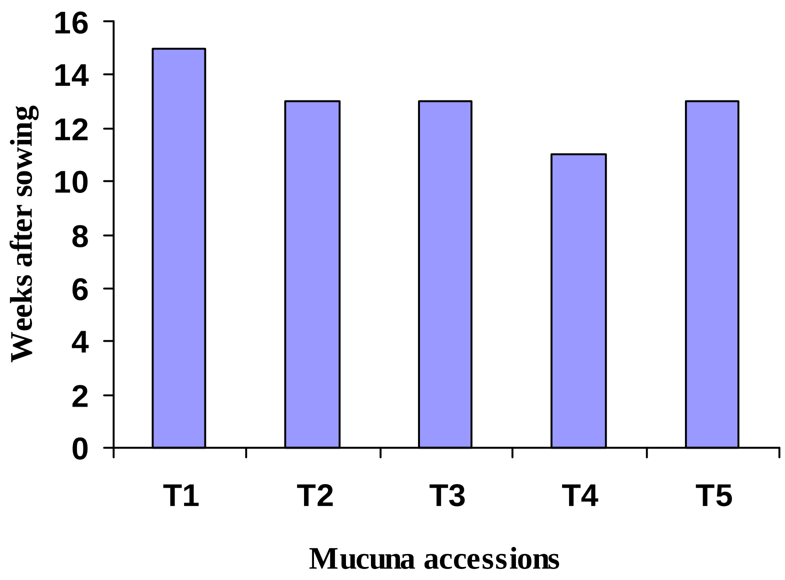

Figure 2: Canopy duration of *Mucuna* accessions (T1= *Mucuna cochinchinensis*, T2 = *M. jaspaeda*, T3 = *M. pruriens* (var. utilis), T4 = *M. veracruz* (black seeded), T5 = *M. veracruz* (white seeded) grown in Makurdi during the 2005 cropping season

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