Research Article

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Effect of Plant Population Density of Velvet Bean (*MUCUNA COCHINCHINENSIS*) for Weed Control at Makurdi, Southern Guinea Savanna of Nigeria

Shave PA*, Magani EI and Hiiorga HP

Department of Crop and Environmental Protection, University of Agriculture, PMB 2373, Makurdi, Nigeria

***Corresponding author**
Shave PA, Department of Crop and Environmental Protection, University of Agriculture, PMB 2373, Makurdi, Nigeria, Tel: 08103912404, E-mail: kumedula@gmail.com

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Abstract

Field trials were conducted in 2013 and 2014 raining season on a fallow field at the University of Agriculture Makurdi Teaching and Research Farm ((07 ^{0} 41'N, 08 ^{0} 37'E and 106.4 m above sea level) using Velvet bean (Mucuna cochinchinensis) to control weeds. Four Mucuna populations were used: 400 plants/ha, 800 plants/ha, 1600 plants/ha and 0.00 plants/ha (control). The experiment was set up in a Completely Randomized Design (CRD). Prominent weeds at the site were identified in the field in 2013. The four different Mucuna populations were screened for their effects on weed (density, composition), growth characteristics (ground cover, nodulation) and canopy duration. Out of the 4 Mucuna populations, 800 plants/ha had the highest effect on weed density, composition and control percentage, ground cover, canopy duration and nodulation. And 0.00 plants/ha had the lowest effect on weed density, weed composition, weed control percentage, ground cover, canopy duration and nodulation. From the results obtained from the study, it can be concluded that farmers in Makurdi, Southern Guinea Savanna can adopt the planting of Mucuna at 800 plants/ha for weed control.

Introduction

Weeds constitute a major constraint to agriculture including yam production. It is estimated that total losses in Florida due to weeds was approximately $431 Million [1]. Also Oerke et al. (1994) reported yield loss of about 70-91 % in yam production. According to Falade (2016) uncontrolled weed growth in yam farms cause 70-91% losses [2,3]. According to Avav (2008), *Impereta cylindrica* alone causes tremendous losses in major crops in West Africa causing 0-80 % yield loss [4]. Research finding also revealed that in small scale production systems which dominate Nigerian Agriculture, it has been estimated that weeding alone consumes approximately 30 to 50 % of the total labour budget depending on the crop and the level of other available resources [5,6].

Nkakini et al. (2006) recorded that, farmers in Rivers State used 40.0 man days/ha for general weeding [7]. Recent studies revealed a sharp decline in crop productivity in the tropics in Nigeria and the Guinea Savanna ecological zone of Nigeria, in particular due to infestation by noxious weeds such as *Imperata cylindrica* [4]. Resource-poor farmers suffer more from the problem of noxious weeds because they do not have sufficient resources to purchase inputs (herbicides) to control weeds [4].

To reclaim lands infested by weeds, Green Manure Cover Crops (GMCC) is used. The benefits from the use of GMCC are well summarized by Vissoh et al. (l998) [8]. *Mucuna* has been the most researched green manure cover crop (GMCC) of the tropics [9]. It grows well in diverse environments usually producing the highest biomass among green manure cover crops tested, has very positive impact on weed incidence even the most noxious one such as *Imperata cylindrical* [10-14]. To determine the optimum plant population of *Mucuna* for better weed suppression in yam production Weeds reduce yields, crop quality and also interfere with farming operations such as harvest for example *Imperata cylindrica* is one of the most abundant and difficult weeds to control where land is cultivated intensively or in areas exposed to recurrent bush fires [15]. It is a strong competitor that causes tremendous losses in major crops in West Africa causing 0-80% yield loss [4]. They do so by competing with crops for nutrients, light, water and allelopathic effect.

Weeds also reduce the quality and quantity of harvested agricultural products. For example the quality of yam tubers is reduced by perforations made by *Imperata cylindrica* rhizomes [4]. According to Oerke et al. (1994), total yield loss of yam due to weeds infestation in Nigeria stands at 70-90%. Similarly harvested maize and rice quality can be reduced through contamination by *Roettboellia cochinchinensis* and red rice, respectively [2].

The cost of controlling weeds is equally high. It is estimated that the use of herbicides comprises more than 76% of total pesticides sales in the United States [1]. In Nigeria it has been estimated that weeding of *Imperata cylindrica* infested fields consumes more than 50% of total labour budget [16]. According to Falade (2016) uncontrolled weed growth in yam farms causes' 70-91% losses [3].

Weeds also interfere with harvest operations thereby increasing the cost of harvest both in large and small scale farm holdings. For example fields' infested with *Roettboellia cochinchinensis* makes manual harvesting of maize a difficult operation in maize farms.

Cassava, yams, cocoyams, Irish potatoes and a host of other crops have slow rate of initial growth and this makes them poor weed competitors. They are susceptible to severe weed competition at their early stages of growth [17]. According to Milthrope (1967) three phases of growth may usually be recognized in root crops as follows:

In the humid tropical environment where rainfall, humidity and other favorable factors are available in abundance, weeds grow fast and become well established before the initial slow growing tuberous crops get established [18,19].

Oerke et al. (1994) indicated that yield losses due to weeds infestation were substantial [2].

In order to reduce potential crop losses root crop farmers spent large proportions of resources for weed management and the investment made according to minimize weed infestation usually exceeds those on other pests combined Chikoye (2000) [20]. Chikoye (1997) earlier stated that herbicide sales world-wide were twice those of fungicides and insecticides combined. Research findings revealed that in small production systems, which dominate Nigerian agriculture, it has been estimated that weeding alone consumes approximately 40.0 man days/ha, 30 to 43.8 man days/ha for ridging and cassava planting, 57.8 man days/ha for mound making and yam planting, while root weeding using 36.7 man days/ha.

Improvement in crop yields in the industrialized countries can be partially attributed to the development of better weed control systems, specifically chemical weed control. In those parts of the world chemical control is still the cheapest means of combating weeds. However, many small scale farmers in Nigeria do not rely heavily on the use of herbicides to fight against the weed menace because of multitudes problems. According to Fadayomi (1991) these problems are the cost of herbicides which are too expensive for the resource poor peasant farmers.

Most of the peasant farmers find spray calibration and operation too complicated while adverse effects resulting from improper use of sprayers (crop injury, accidents encountered during spraying due to lack of protective wears, lack of weed control) discouraging farmers from adoption of chemical weed control. Iyagba and Gedi (2005) have recently reported low adoption to this technology in Niger, Rivers and Bayelsa States [21]. Chikoye (2000) indicated that to overcome the constraints facing the small scale farmers in adopting the herbicides use technology has suggested the following: dressing of crop seed by herbicides could reduce cost, as small quantities of herbicides would be required, packaging of chemical in quantities appropriate for small hectares, more user friendly herbicides labels, written in local languages, will enable farmers use herbicides more safely, adequate technical support in area of matching herbicides to the dominant weed communities and crops and, training farmers in proper spray calibration, time of application, and safe disposal of herbicides [20].

One of the options is the use of cover crops to smoother weeds; many researchers have demonstrated the beneficial effects of using cover crops such as *Mucuna* spp for weed control and fertility management in West Africa [8,14,22]. The use of velvet bean (*Mucuna pruriens L.*) and other legumes as cover crops to help smother weeds and reclaim abandoned farmlands have been reported [13,14,23,].

In tropical systems, Chikoye et al. (2001), planted several smother crops with various growth habits in a *Z. mays*- *Manihot esculenta* Crantz intercrop system and found that *Mucuna cochinchinensis* (Lour.) A. Chev., *Lablab purpureus* L. and *Pueraria phaseloides* (Roxb.) Benth. were effective for reclaiming fields heavily infested with the difficult-to-control perennial weed, *Imperata cylindrica* (L.) Beauv [13]. After three years, rhizome biomass of *I. cylindrica* was reduced by 94 percent by annually weeding five times, 89 percent by *M. cohinchinensis*, 77 percent by *P. phaseloides*. Akobundu et al. (2000) observed that, *Mucuna* spp. suppressed *I. cylindrica* until the subsequent cropping season when *Z. mays* yield was higher and hand weeding was reduced by 50 percent compared to plots without cover crop [23].

Materials and Methods

Experimental Site

The trials were conducted in 2013 and 2014 cropping season at the Teaching and Research Farm of the University of Agriculture Makurdi (07 ^{0} 41'N, 08 ^{0} 37'E and 106.4m above sea level.) The area is located in the Southern Guinea Savanna Agro ecological zone of Nigeria and is characterized by a bimodal rainfall distribution pattern with two rainfall peak periods.

Evaluation of *Mucuna* Population Density for Weed Suppression

Four *Mucuna* populations of 0.00 plants/ha, 400 plants/ha, 800 plants/ha and 1600 plants/ha were planted as the treatments representing T_1, T_2, T_3 and T_4 respectively. *Mucuna* seeds were obtained from the Department of Crop and Environmental Protection, University of Agriculture Makurdi, Seed Unit.

The experimental design was Complete Randomised Design (CRD) with a total of 16 plots and means separated using Least Significance Difference (LSD) at 5% level of probability. The gross plot size of the study area was 46 m x46 m (2116 m^2), while the net plot size of the study area was 10 m x 10 m (100 m^2) separated from each other by 2 m. The *Mucuna* accession used was *Mucuna cochinchinensis*. The seeds were planted in the first week of June 2013 when rain stabilized. Two seeds were planted per hill and thinned down to one seedling. Weeding was carried out two weeks after planting to enable it establish itself and no further weeding was done.

Experimental Design

	PP1	PP2	PP3	PP4
SP_1	PP_1SP_1	PP_2SP_1	PP_3SP_1	PP_4SP_1
SP_2	PP_1SP_2	PP_2SP_2	PP_3SP_2	PP_4SP_2
SP_3	PP_1SP_3	PP_2SP_3	PP_3SP_3	PP_4SP_3
SP_4	PP_1SP_4	PP_2SP_4	PP_3SP_4	PP_4SP_4

Common weeds at the experimental site

In 2013, common weeds at the experimental site were surveyed and classified into type of weed (Broadleaves, Grasses and Sedges) and level of weed infestation (Table 1). *Mucuna* establishment was evaluated 2 weeks after planting (WAS) by counting emerged seedlings in all plots.

Agronomic Practices

Land preparation: The site was ploughed and harrowed after two weeks in May 2013 using a tractor and no herbicides were used on the study area.

Seed Sowing: *Mucuna* seeds were sown in the first week of June 2013 when rain stabilized. Two seeds were planted per hill and thinned down to one seedling except the control plot where *Mucuna* was not sown.

Weeding: Weeding was carried out two weeks after sowing to enable *Mucuna* to establish itself and no further weeding was done. There was no insect control measure in all the plots under study.

Harvesting: At the end of 2013 cropping season, the entire *Mucuna* biomass was incorporated in the soil after the seeds were harvested.

Data Collection

Common weeds at the experimental site

In 2013 common weeds at the experimental site were surveyed and classified into type of weed (Broadleaves, Grasses and Sedges) and level of weed infestation (Table 1).This was done before ploughing and harrowing the field.

Weed Density: Weed density was assessed at 3, 6 and 9 weeks after sowing *Mucuna*. A 1 m x1 m quadrate was randomly thrown three times per plot and the overall average was determined in No/m^2.

This data was used to calculate the Weed Control Percentage (WCP) thus:

$$WCP = \frac{A-B}{A} \times \frac{100\,\%}{1}$$

Where A= Weed Density in control plot

B= Weed Density in treated plots

Weed Composition: Weed composition was assessed in 2013, at 3, 6 and 9 weeks after planting *Mucuna*. Data was collected by throwing a 1m x 1m quadrate three times at random per plot and the number of weeds within the quadrate were counted and separated into broadleaf, grass and sedge [4].

Weed Composition (WC) was derived from weed density thus:

$$WC = \frac{\text{No of weed class} \times 100\%}{\text{Weed Density}}$$

This was done for broad leaves, grasses and sedges.

Persistent weeds at the end of cropping season

Persistent weeds were assessed at the end of 2013 cropping season. Weeds that escaped suppression by *Mucuna* in each plot were taken to be persistent weeds at the end of the cropping season.

Number of nodules per plant

Nodulation was assessed at 4, 6 and 8 WAP by carefully digging out 3 plants at random using a hand trowel. They were carefully washed in clean water and the nodules floating and hanging on the plants counted, the overall averages were taken for each plant.

Canopy Cover of *Mucuna*

Canopy cover of each treatment was assessed using a measuring tape to measure the horizontal distance covered by the vines from left to right hand at each point facing eastward, for a duration of 2-24 WAS. It was measured in m2. Canopy duration was derived from canopy cover measurement, which is defined as the difference between the time when *Mucuna* covers at least 40 % of the ground and the time about 40% had died.

Data Analysis

All data collected were analyzed using SAS and means were separated using Fisher's Least Significant Difference (F-LSD) at 5% level of probability.

Results

Common Weeds at the Experimental Site before Planting *Mucuna*

Results of weed infestation on the experimental site in 2013 showed that the field was dominated by grasses due to the fallow nature of the study area, followed by broadleaves while sedges were the least dominated (Table 2). The grasses with high level of site infestation were *Andropogon gayanus Kunth*, *Imperata cylindrica* (L.) Raeuschel, *Echinochloa colona* (Linn) while *Seteria pumila* Roem & Schult showed low infestation. Avav (2008) established that grasses are dominant in uncultivated fields [4].

Amongst the broadleaves was *Hydrolea palustris*, *Ludwigia abyssinica* A Rich, *Ludwigia hyssopifolia* (G don) Excel, *Vernonia ambigua* Kotschy & Peyr which showed high infestation while *Ipomea eriocarpa*, *Ancanthospermum hisipidium* and *Heterotis rotundifolia* showed low infestation. The sedges *Cyperus haspan* Linn and *Cyperus iria* showed high infestation.

Table 2: Common weeds at the experimental site before planting Mucuna (2013)

Weed Type	Scientific Name	Level of infestation
Grasses	*Andropogon gayanus* Kunth Var. gayanus	+++
	Acrocera zizanoides Dandy	++
	Brachiaria deflexa	++
	Imperata cylindrica (Linn) Raeushel *Val. Africana*	+++
	Echinochloa colona (Linn.) Link	+++
	*Eleusine indica Gaer*in	++
	Roettboellia cochinchinensis (Lour) Clayton	++
	Agerantum conzoides Linn	+++
	Tephrosia bracteolata Guill & Perr	++
	Panicum maximun Jacq	++
	Seteria pumila (poir) Roem & Schult	+
	Paspalum scrobiculatum Linn	++
	Pennisetum polystachion (Linn)	++
	Hydrolea palustris (Aubl) Rausch	+++
	Ludwigia abyssinca A. Rich	+++
	Ludwigia hyssopifolia (G.Don) Excell	+++

Broadleaves	*Sida linifolia* Juss ex cav	+
	Vernonia amibgua Kotschy & Peyr	+++
	Commelina benghalensis L.	++
	Hyptis suaveolens Poit.	++
	Ipomea eriocarpa R. Br.	+
	Acanthospernum hisipidium DC	+
	Hetrotis rotundifolia (Sm) Jac-Fel	+
Sedges	*Cyperus haspan* Linn.	+++
	Cyperus iria Linn	+++

Key:
+ =Low Infestation (10-39% occurrence)
++ =Medium Infestation (40-59% occurrence)
+++ =High Infestation (60 - 90% occurrence).

Effects of *Mucuna cochinchinensis* on Weed Density at 3 WAS, 6 WAS and 9 WAS

At 3 weeks after sowing weed density ranges from 50.53 No/m^2 to 60.13 No/m^2 but did not differ significantly among the treatments, however 0.00 plants population had the highest weed density, 60.13 No/m2 whereas 800 plants population had the lowest weed density, 50.53 No/m^2 (Table 4).

At 6 weeks after sowing, there were significant differences among the treatments as the control (0.00plt/ha) recorded an increase in weed density of 85.50 No/m^2 while 800 plants population recorded the least density, 20.75 No/m^2 (Table 3).

Similarly at 9 weeks after sowing there were marked differences in weed density among the treatments. 800 plants population recorded the least weed density of 11.00 No/m^2 where as the control (0.00plt/ha) recorded the highest 87.75 No/m^2 (Table 4).

Table 3: Effect of *Mucuna cochinchinensis* on weed density (No/m^2) in 2013 raining season at Makurdi

Treatment	3WAP	6WAP	9WAP
0.00plt/ha)	60.13a	85.50a	87.75a
400plt/ha)	59.36a	35.75c	23.25c
800plt/ha)	50.53b	20.75d	11.00d
1600plt/ha)	58.05a	40.75b	30.00b
LSD	3.75	2.09	4.67

Means followed by the same letter(s) in a column of any set of treatments are not significantly different at 5% level of probability using LSD.

Effects of *Mucuna cochinchinensis* on Weed Composition 3 WAS, 6 WAS and 9 WAS

The composition of broadleaves at 3 weeks after sowing differed significantly ($P \leq 0.05$) with 800plt/ha, had the least percentage 3.74% and 1,600plt/ha, had the high percentage 28.87%. The composition of grasses did not differ among 0.00plt/ha, 400plt/ha and 800plt/ha but differs with 1,600plt/ha, 71.13% lower than 800 plants population which had a higher percentage, 95.99%. Weed composition for sedges differ among the treatments, 400 plants population had a high percentage 0.27 and 0.00, 1,600 plant population had no (Table 4).

At 6 weeks after sowing, the composition of broadleaves differ significantly (P0.05) among the treatments,1600 plants population had the highest percentage 43% and 0.00 plants population had the lowest percentage,10.40%. There were marked differences for composition of grasses where the control has the highest composition of 74.00% and 800plt/ha has the least, 45.00%. The composition of sedges for 800plt/ha, 15% was higher compared to 400 plants population which had 8.00% (Table 5).

At 9 weeks after sowing, the composition of broad leaves differ significantly (P0.05),1600 plants population had the higher percentage 41.00% while 0.00 plant population had the lower percentage, 20.00%. The composition of grasses shows a higher percentage, 65.00% in 0.00 plants population whereas 1,600 plants population had a lower percentage, 47.00%. The composition of sedges differ significantly (P0.05), however 400 plants population had a higher percentage, 20% while 1,600 plants population had a lower percentage, 12.00% (Table 6).

Table 4: Effects of *Mucuna cochinchinensis* on weed composition at 3 week after sowing in 2013 raining season at Makurdi

Treatment	Broadleaves (%)	Grasses (%)	Sedges (%)
0.00plt/ha	10.40b	89.60a	0.00b
400plt/ha	11.38b	88.37a	0.25a
800plt/ha	3.74c	95.99a	0.27a
1600plt/ha)	28.87a	71.13b	0.00b
LSD	2.86	8.71	0.06

Means followed by the same letter(s) in a column of any set of treatments are not significantly different at 5% level of probability using LSD.

Table 5: Effects of *Mucuna cochinchinensis* on weed composition at 6 weeks after sowing in 2013 raining season at Makurdi

Treatment	Broadleaves (%)	Grasses (%)	Sedges (%)
0.00plt/ha	16.00c	74.00a	10.00b
400plt/ha	30.00b	62.00b	8.00b
800plt/ha	40.00a	45.00c	15.00a
1600plt/ha)	43.00a	47.00c	10.00b
LSD	5.29	5.47	2.71

Means followed by the same letter(s) in a column of any set of treatments are not significantly different at 5% level of probability using LSD.

Table 6: Effects of *Mucuna cochinchinensis* on weed composition at 9 weeks after sowing in 2013 raining season at Makurdi

Treatment	Broadleaves (%)	Grasses (%)	Sedges (%)
0.00plt/ha	16.00c	74.00a	10.00b
400plt/ha	30.00b	62.00b	8.00b
800plt/ha	40.00a	45.00c	15.00a
1600plt/ha)	43.00a	47.00c	10.00b
LSD	5.29	5.47	2.71

Means followed by the same letter(s) in a set of treatments group are not significantly different at 5% level of probability.

Persistent Weeds at the end of 2013 Cropping Season

The density *of Andropogon gayanus*, *Vernonia ambigua*, *Commelina benghalensis*, *Cyperus haspan* Linn, *Agerantum Conyzoides*, *Roettboellia cochinchinensis*, *Hyptis suaveolens*, *Tehrosia bracteolata* and *Paspalum obiculare* were higher in 0.00 plants population which differ significantly with rest of the treatment. However, weeds including *Commelina benghalensis*, *Agerantum conyzoides*, *Hyptis suaveolens* and *Tephrosia bracteolata* were not seen in 800 plants population (Table 7).

Table 7: Persistent weeds (No/plot) at the end of 2013 cropping season at Makurdi

Treatment	*Andropogon gayanus*	*Vernonia ambigua*	*Commelina benghalensis*	*Cyperus haspan* Linn	*Agerantum conyzoides*	*Roettboellia cochinchinensis*	*Hyptis suaveolens*	*Tephrosia bracteolate*	*Paspalum obiculare*
0.00plt/ha	40.00a	25.00a	45.00a	80.00a	22.00a	44.00a	24.00a	32.00a	65.00a
400plt/ha	4.00b	6.00b	2.00bc	9.00b	3.00b	5.00bc	3.00c	9.00b	20.00d
800plt/ha	1.00b	3.00c	0.00c	4.00b	0.00c	1.00c	0.00d	0.00d	4.00b
1600plt/ha	2.00b	8.00b	3.00b	8.00b	4.00b	8.00b	6.00b	5.00c	11.00c
F-LSD	2.26	2.99	2.35	5.28	2.99	4.04	2.94	2.29	3.59

Means followed by the same letter(s) in a column of any set of treatments group are not significantly different at 5% level of probability using LSD.

Number of Nodules of *Mucuna cochinchinensis* per plant

The effect of *Mucuna* plant population significantly influenced the number of nodules per plant of *Mucuna* (Table 8). At 4 and 8 WAS, 800plt/ha significantly produced higher number of nodules of 8, 11 and 15 but was statistically at par with 400plt/ha at 4 and 6 WAS. The highest plant population of 1,600plt/ha and 0.00plt/ha significantly gave the least number of nodules per plant at 6 and 8WAS

Table 8: *Mucuna cochinchinensis* number of nodules at 4, 6 and 8 WAS in 2013 raining season at Makurdi

Treatment	No/plt		
	4 WAS	6 WAS	8 WAS
0.00 plants/ha	0.00c	0.00c	0.00c
400.00 plants/ha	6.00ab	9.00a	12.00b
800.00 plants/ha	8.00a	11.00a	15.00a
1600.00 plants/ha	4.00b	6.00b	9.00c
CV (%)	3.14	5.77	4.33

Means followed by the same letter(s) in a column of any set of treatments group are not significantly different at 5% level of probability using LSD.

The Effect of *Mucuna cochinchinensis* on Percentage Weed Control (%)

At 3 weeks after sowing, percentage weed control was higher in 1,600 plants population compared to 0.00 plants population which had no weed control and 400 plants population which had the least control, 1.28% (Table 10).

At 6 weeks after sowing, percentage weed control was highest in 800 plants, representing 75.73% whereas lowest weed control was recorded in 0.00 plants population and lower in 1,600 plants population with 52.34% (Table 10).

At 9 weeks after sowing, percentage weed control was highest in 1,600 plants population compared to 0.00 plants population which had no weed control effect and 800 plants population with the lowest percentage weed control, 65.81% (Table 10).

Table 9: Effect of *Mucuna cochinchinensis* on percentage weed control (%) in 2013 raining season at Makurdi

Treatment	3WAS	6WAS	9WAS
0.00plt/ha	0.00	0.00	0.00
400plt/ha	1.28	58.16	73.50
800plt/ha	3.46	75.73	65.81
1,600plt/ha	15.96	52.34	87.46

Note: percentage weed control is the difference between weed control percentage in 2013 cropping season and 2014 cropping season.

Effect of Plant Population on Mucuna cochinchinensis Canopy Development

The Mucuna populations differ in canopy establishment (Fig 1) and canopy duration (Fig 2).All the populations except 400 plants population covered up to 50% of the ground at 7 weeks after sowing and all attained 100% ground cover at 13weeks after sowing. Indeed 1,600 plants population attained 100% cover earlier at 10 weeks after sowing and persisted longer compared to other treatments. The treatment 400 plants population covered the ground at 100% till 16 weeks after sowing and diminishes thereafter. (Fig 1)

The canopy of 1,600 plants population lasted longer on the field unlike the canopy of 400 plants population had the least duration on the field (Fig 2).

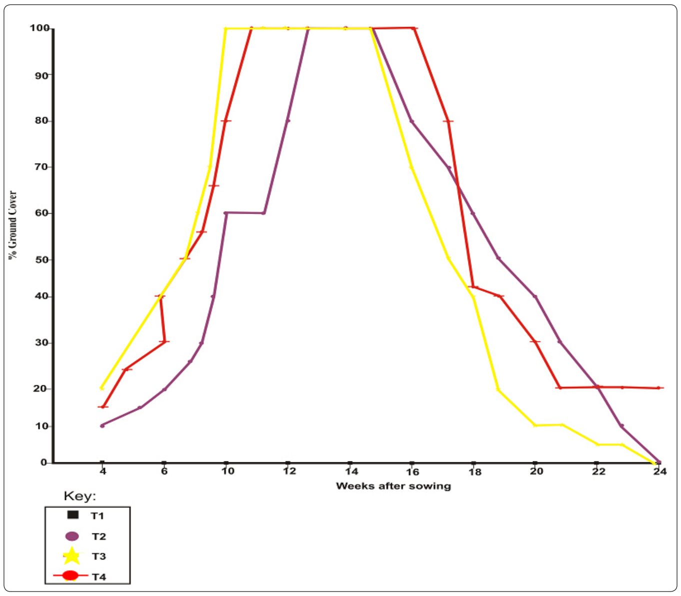

Figure 1: Canopy development for four Mucuna populations in 2013 raining season at Makurdi
(T_1 = 0.00plt/ha, T_2 = 400plt/ha, T_3 = 800plt/ha, T_4 = 1600plt/ha)

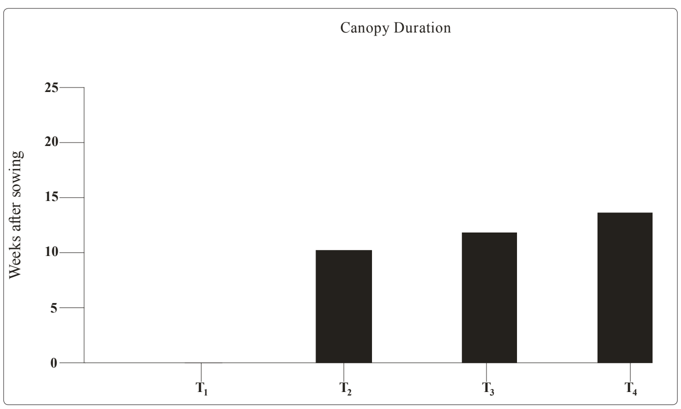

Figure 2: Canopy duration of Mucuna cochinchinensis in 2013 raining season at Makurdi
(T_1 = 0.00plt/ha, T_2 = 400plt/ha, T_3 = 800plt/ha, T_4 = 1600plt/h

Discussion

Common Weeds at the Experimental Site before Treatment Application in 2013

The study revealed that the trial field was dominated by grasses with majority of the grasses highly infested. Out of the seventeen identified grasses seven (*Andropogon gayanus* which is found mostly on land under fallow, *Imperata cylindrica, Echinochloa colona, Agerantum conyzoides, Hydrolea palustris,Ludwigia abyssinica* and *Ludwigia hyssopifolia*) showed high infestation [24]. Nine species showed medium infestation while one *Seteria pumila* showed low infestation.

The result showed moderate infestation of broadleaves weeds and highly infestation of sedges. These results corroborate that of Avav et al. (2008); Tunku et al. (2014); Adeyemi et al. (2013) who reported that the above mentioned weeds are found in uncultivated fields [4,25,26].

Effects of Mucuna cochinchinmensis on Weed Density

The results obtained in 2013 showed that there was a reduction in weed density in all *Mucuna* populations planted compared to the control. However *Mucuna* planted at 800plt/ha at 3, 6 and 9 WAS showed lesser weed density of 50.53, 20.75 and 11.00No/m2, respectively compared with the control which showed the highest weed density of 60.13, 85.50 and 87.75 No/m2 at 3, 6 and 9 WAS, respectively. According to Adeniran et al. (2004), *Mucuna* has a trailing/spreading ability which can ensure a good cover in two to three months [27]. This result corroborates the report of Shave, (2012) that *Mucuna* reduced weed density by 52% and 16% when introduced at 6 and 9 WAS, respectively.

The low weed density recorded in 800 plants population is due to the moderate *Mucuna* density which is devoid of overpopulation unlike 1,600 plants population that witnessed intra specific competition and 400 plants population that was sparsely populated.

Effects of *Mucuna cochinchinmensis* on Weed Composition

The results obtained showed that all *Mucuna* populations exerted control on all the classes of weed in the study area. However 800 plants population showed a high reduction in the composition of grasses from 95.99% to 49.00% at 3 and 9 weeks WAS but exerted less control on broad leaves at 3 and 9 WAS. This can be attributed to the rapid establishment and canopy development of this *Mucuna* population.

Persistent Weeds at the End of Cropping Season in 2013

The result showed that there were persistent weeds in all *Mucuna* populations used; the numbers of weeds significantly lower compared to the control *Cyperus haspan* (80 No/plot), *Paspalum orbiculare* (65No/plot), *Commelina benghalensis* (45No/plot) and *Roettboellia cochinchinensis* (45No/plot) were dominant persistent weeds in the control. Weeds like *Commelina benghalensis, Agerantun conzoides, Hyptis suaveolens, Tephrosia bracteolata* were 100% controlled in population 800plt /ha. This is because the real success of weeds depends on their ability to invade and colonize or dominate and persist an area.

Mucuna Nodulation

Nodulation ranged from 0.00 nodules/plant to 8.00 nodules/plant, 0.00 to 11 nodules/plant and 0.00 to 15.00 nodules /plant at 4, 6 and 8 WAS, respectively. The results showed that 800 plants population produced the highest number of nodules at all stages of *Mucuna* growth evaluated. Avav et al. (2008) also reported that *Mucuna* at 6 WAS produced 10.00 nodules/plant [4]. However, Shave et al. (2008) reported high Mucuna nodulation of 33 nodules/plant at 8WAS [28]. These differences could be attributed to lack of nutrients which may restrict the development of a population of free living rhizobia in the rhizosphere, limit the growth of the host plant, restrict nodulation itself, and cause impaired nodule function [29].

Effect of *Mucuna cochinchinensis* on Weed Control Percentage

The results obtained at the end of 2013 cropping season showed that all *Mucuna* populations exerted control on weeds. However 800plt/ha showed the highest weed control at 3, 6 and 9 weeks after planting, representing 15.96, 75.73 and 87.46%, respectively. The lowest weed control (1.28%) was recorded by 400plt/ha at 3weeks after sowing while highest weed control (87.46%) was recorded by 800plt/ha at 9 weeks after planting. This result corroborates with Avav et al. (2008), who reported that *Mucuna* reduced weed by

79.7%, Shave et al. (2012) that *Mucuna* intercropped with maize at 6 and 9WAP reduced weeds by 52% and 16%, respectively [4]. However, Danielle et al. (2011) reported weed control by *Mucuna* at 4 and 20 WAS to be 20% and 55%, respectively [30].

Effect of *Mucuna cochinchinensis* on Ground Cover Duration and Canopy Development

All the *Mucuna* population except 400plt/ha covered up to 50% of the ground at 7WAS, and all attained 100% ground cover at 13WAS. The canopy of 1,600plt/ha decreased in ground cover from 17WAS and persisted longer with a canopy duration of about 13 weeks. *Mucuna* has the spreading/trailing growth ability which can ensure a good cover in 2 or 3 months [27]. Similar results were obtained by Shave et al. (2008) who reported that *Mucuna* covered 50% of ground at 6WAS and attained 100% ground cover at 12 WAS; Avav et al. (2008) who reported *Mucuna* ground cover duration of 15 weeks and 50% canopy development at 8 WAS [4,28,31].

Conclusion

Based on the results obtained from the study, it can be concluded that yam farmers at Makurdi can adopt a *Mucuna* population of 800 plts/ha since it resulted in better suppression of weeds

Recommendations

The problems of weeds can be reduced by planting *Mucuna* at a population of 800plt/ha in fallow to control or suppress weeds.

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