International Journal of Agricultural Research and Food Production
ISSN: 2536-7331 (Print): 2536-734x (Online)
Volume 3, Number 1, March 2018
http://www.casirmediapublishing.com

Evaluation of Plant Populations of Velvet Bean (*Mucuna cochinchinensis*) for Soil Fertility Improvement in Yam (*Dioscorea rotundata*) Production at Makurdi, Southern Guinea Savanna, Nigeria

[1]Shave, P. A.; S. T. Wuese[2] & [1]Hiiorga, H. P.
[1] Department of Crop and Environmental Protection, University of Agriculture, Makurdi
[2]Department of Soil Science, University of Agriculture, Makurdi, Makurdi
Corresponding author: S. T. Wuese[2]
Email: *kumedula@gmail.com*

ABSTRACT

Field trials were conducted in 2013 and 2014 on a fallow field at the Teaching and Research Farm of the University of Agriculture, Makurdi (07⁰41¹N, 08⁰37¹E and 106m above mean sea level) using Velvet bean (Mucuna cochinchinensis) to improve soil fertility for yam production. Four Mucuna populations were used: 400 plants/ha, 800 plants/ha, 1600 plants/ha and 0 plants/ha (control). The experiment was set up using the Randomized Complete Block Design (RCBD). The physico-chemical properties of the soil before and after planting Mucuna as well as after yam harvest and number of earthworm cast were evaluated. Yam (Dioscorea rotundata) was planted the following year after Mucuna was ploughed-in into the heaps. The residual effect of Mucuna, yam germination percentage, number of leaves, leaf area index and yam yield were assessed. All the Mucuna populations influenced the physico-chemical properties of the soil. 1600 plants/ha had the highest number of earthworm cast while 800 plants/ha had the highest germination percentage, number of leaves, leaf area index and yam yield compared with the control (0.00 plants/ha). 800 plants/ha population decreased the pH by 4.09%, increased organic matter by 25.22%, Cation Exchange Capacity by 13.87%, Total Exchangeable Bases by 15.25% and Base saturation by 1.59% as compared with the control. Thus, it is recommended that planting Mucuna at 800 plants/ha will positively influence the soil properties and lead to higher yield of yam.

Keyword: *Evaluation, Populations, Velvet bean, Soil fertility and Guinea savanna*

INTRODUCTION

Origin and Production of Yam

Yam (*Dioscorea spp*) ranks third among the tubers in global production after cassava (*Manihot spp*), sweet potatoes (*Ipomea batatas*), and is a tropical plant, also grown in the Americas, the Caribbean, south pacific and Asia (FAO, 2010). Annual statistical data available from FAO (2014) shows that the area cultivated to yam in the world increased from 1.15 million (ha) in 1961 to 5.04 million (ha) in 2012. Yam yield (kg/ha) in the world has increased from 72.35 thousand metric tons in 1961 to 116.65 thousand metric tons in 2012. This increase in output is attributed more to the large area cultivated than increase in productivity. The overall world yam production in 2012 stood at about 58.8 million metric tons, out of which 92.2% was from West Africa (Nwosu *et al*., 2010).

Nigeria is the largest producer of yams in the world, the country accounts for over 65% (with 38 million metric tons) of the total world production valued at $7.75 billion and cultivated in about 2.9 million hectares of land in 2012. Average yield of yam ranges from 20-50 tons per hectare depending on the variety. During a bad season, yield could be as low as 10 tons per hectare (FAO, 1985).The major yam producing areas in Nigeria include the Middle Belt, (Benue, Nasarawa, Kwara, Kogi and Niger), Eastern parts of Nigeria (Imo and Anambra) and South Western parts(Ogun, Osun,Ondo) (Philip *et al.*, 2006).

Recent studies have revealed a sharp decline in soil fertility and crop productivity in the tropics in Nigeria and the Guinea Savanna ecological zone of Nigeria in particular due to low rates of fertilizer application by farmers, shortened fallow, continuous cropping, bush burning and infestation by noxious weeds such as *Imperata cylindrica* (Avav, 2008). Resource-poor farmers suffer more from the problem of soil fertility because they do not have sufficient resources to purchase inputs (fertilizers) to improve soil fertility (Avav, 2008). To improve soil fertility status, Green Manure Cover Crops (GMCC) are used. The benefits from the use of GMCC are well summarized by Vissoh *et al*. (l998). *Mucuna* has been the most researched green manure cover crop (GMCC) of the tropics (Buckles, 1995). It grows well in diverse environments usually producing the highest biomass among green manure cover crops (Lathwell, 1990; Lobo Burle *et al*., 1992; Carsky *et al*., 1998, 2001) and has a positive impact on main crops yield (Lathwell, 1990; Lobo Burle *et al*., 1992 Carsky *et al*., 1992, 2001; Buckles *et al*., 1998a, 1998b).

According to Mureithi *et al*. (2000a) Mucuna is ranked the best green manure legume based on farmers' perception of its high biomass production, which is sufficient for incorporation into the soil. It has rapid establishment of ground cover for effective weeds and erosion control. Its alternative uses include as human food and livestock feeds. Legumes with soft stems are easily chopped prior to incorporation. Avav (2008) reported that, the chemical and physical properties of the soil before and after planting *Mucuna* showed marginal differences, the pH was reduced, while organic matter (OM), available phosporus and cation exchange capacity were higher in soils planted with *Mucuna*. The improved physico-chemical properties of the soils by incorporating *Mucuna* is attributed to greater microbial activity (e.g. earthworm abundance and microbial biomass) that are known to occur in organically managed soils than in conventionally managed soils (Mader *et al*., 2002). Nutrients in organic soils are less dissolved in the soil solution, and microbial transformation may have contributed to the phosphorus supply (Mader *et al*., 2002). High nitrogen replacement value of *Mucuna* was widely reported by Giller *et al*. (1987) and Carsky *et al*.(1998). Shave *et al.* (2008) attributed the changes in physico–chemical properties of organic soil to high biological activity associated with biodynamic soil systems. Asibuo and Osei-Bonsu (2002) reported that certain herbaceous organic legumes are able to utilize P from rock phosphate thereby enhancing the availability of P. The objective of this work was to determine the most appropriate plant population of *Mucuna* for improvement of soil physical and chemical properties (soil fertility) and its resultant influence on the growth and yield of yam.

MATERIALS AND METHODS

Experimental Site

The trials were conducted in 2013 and 2014 cropping seasons 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 with average rainfall of 1250-1400 mm. The temperature, rainfall, and relative humidity for the period of study were good for yam production.

Experiment 1: Evaluation of *Mucuna* Population Density for Soil Fertility Improvement

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 Seed Unit, Department of Crop and Environmental Protection, University of Agriculture, Makurdi.

The experimental design was Randomized Complete Block Design with a total of 16 plots and means were separated using Fisher's Least Significance Difference (F-LSD) at 5% level of probability. The individual plot size was 10 m x 10 m separated from each other by 2 m, while the total size of the study area was 46 m x 46 m. The *Mucuna* accession used was *M. cochinchinensis. Mucuna* seeds were planted in the first week of June 2013 when rain stabilized. Two *Mucuna* seeds were planted per hill and thinned down to one seedling. Weeding was carried out two weeks after planting to enable *Mucuna* to establish itself and no further weeding was done. A total of seven soil samples were taken at a depth of 0-30 cm using soil augar and bulked together before ploughing the field in 2013 and shortly before yam planting in 2014, for laboratory analyses. They were analyzed at the Soil Science Laboratory of the University of Agriculture, Makurdi, using standard laboratory procedures of IITA (1979) for physical and chemical properties. The evaluated laboratory results were interpreted based on analytical data guidelines as presented by FAO (2004).

Experiment 2: Evaluation of Residual Effects of *Mucuna* on Productivity of Yam

The 2014 trial was laid out with the same design (RCBD) and conducted on the same site on which *Mucuna* accessions were grown the previous year. Each plot was manually cultivated with 160 mounds using a big hole at the onset of rains in April. Yam cultivar "HEMBAM KWASE" was acquired from Zaki - Biam yam market and cut into sets weighing approximately 500g each thereafter treated with wood ash to prevent damage while in the soil. The sets were planted at a depth of 15-20 cm and covered with dry grasses as mulch. Weeding was manually done at 8 and 12 weeks after planting (WAP). Harvesting was done in the last week of December when all the vines had dried up by manually digging the tubers out using a small hole. Yam germination percentage was estimated by physically counting the number of germinated seedlings and relating it to the total number of planted seedlings using the relationship:

$$GP = \frac{GS}{PS} \times \frac{100}{1}$$

Where GP = Germination Percentage
GS = Germinated seedlings
PS = Planted seedlings

Leaf area index was determined by the leaf area

Yam leaf number was assessed at 6, 8 and 10 WAP yam by picking three yam stands at random in each plot and physically counting the number of leaves on each stand. The selected yam stands were then tagged for subsequent counting. The averages were taken for each treatment. Three tubers of yam were randomly taken from each treatment and weighed on a sensitive meter balance Model 1610 and the average weight per tuber was taken.

Data Analysis

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

RESULTS

Effects of *Mucuna cochinchinensis* on Physical and Chemical Properties of the Soil before and at the end of Cropping Season

Mucuna influenced the physical and chemical properties of the soil after incorporation and after harvesting yam (Table 1 & 2). The pH decreased by 7.18%, 7.68% and 4.09% and 3.62% in all treatments. There was a sharp increase in organic carbon (OC) in all the treatments, with 800 plants (plt)/ha having the highest (32.18%) and 0.00 plt/ha (control) being the lowest (14.14%). The organic matter content increased significantly with 800 plt/ha showing 25.22% increase, while 0.00 plt/ha (control) was the least with 16.34% (Table 2).

There was also a noticeable increase in N, P and K especially in 800 plt/ha (20.00%) while 0.00 plt/ha, 400 plt/ha and 1,600 plt/ha recorded 4.00%, 9.43% and 7.62%, respectively. There was positive percentage change in K too, where 800 plt/ha recorded the highest change and 1,600 plt/ha recorded the lowest change of 13.33% and 3.70%, respectively (Table 2).

Other micro nutrients like Na, Mg, Ca were also influenced, likewise, Total Exchangeable Base, Cation Exchange Capacity and Base Saturation.

Table 1: Physical and chemical properties of soil before and after sowing *Mucuna* in 2013 raining season at Makurdi

	Before sowing *Mucuna*	**After sowing *Mucuna***			
		***Mucuna*plant population/ha**			
Soil Property	**0.00**	**0.00**	**400**	**800**	**1600**
pH	6.87	6.41	6.38	6.60	6.63
Sand (%)	76.36	76.80	76.64	76.08	76.24
Clay (%)	13.63	12.36	13.06	13.64	13.92
Silt (%)	10.00	10.10	11.23	11.54	11.10
O.M (%)	3.38	4.04	4.31	4.52	4.17
P(Mg/L)	0.31	0.36	0.33	0.34	0.34
N (%)	0.048	0.050	0.053	0.060	0.052
K(Cmol/kg)	0.26	0.28	0.29	0.30	0.27
Na(Cmol/k)	0.23	0.24	0.26	0.27	0.25
Mg(Cmol/k)	0.28	3.00	3.20	3.40	3.10
Ca (Cmol/k)	3.10	3.30	3.40	3.60	3.40
EA(Cmol/k)	1.00	1.10	1.02	1.04	1.10
TEB(Cmol/k)	6.39	6.82	7.07	7.54	7.11
CEC(Cmol/k)	7.39	7.92	8.09	8.58	8.21
BS(%)	86.5	86.1	87.40	87.90	86.60

KEY

O.C	=	Organic Carbon
O.M	=	Organic Matter
P	=	Available Phosphorus (P)
N	=	Total Nitrogen, N
Na	=	Sodium
Ca	=	Calcium
EA	=	Exchangeable Acids
TEB	=	Total Exchangeable Bases

CEC = Cation Exchange Capacity
BS = Base Saturation.

Table 2: Percentage change in physical and chemical properties of the soil after sowing *Mucuna* 2013 raining season at Makurdi

	***Mucuna* (plt/ha)**			
Soil property	**0.00**	**400**	**800**	**1,600**
pH	-7.18	-7.68	-4.09	-3.62
Sand(%)	0.57	0.37	0.31	-0.37
Clay(%)	-10.36	-4.44	0.00	2.01
Silt(%)	0.99	10.95	13. 34	9.91
O.M(%)	16.34	21.58	25.22	18.94
P(Mg/L)	8.82	6.06	13.89	8.82
N(%)	4.00	9.42	20.00	8.82
K(Cmol/kg)	7.17	7.17	13.33	3.70
Na(Cmol/kg)	4.17	11.54	14.81	8.00
Mg(Cmol/kg)	6.67	12.50	17.65	9.68
Ca(Cmol/kg)	6.06	8.82	13.89	9.82
EA(Cmol/kg)	9.09	1.96	3.85	9.09
TEB(Cmol/kg)	6.30	9.62	15.25	10.13
CEC(Cmol/kg)	6.69	8.65	13.87	9.99
BS(%)	0.46	1.03	1.59	0.12

KEY

O.C = Organic Carbon
O.M = Organic Matter
P = Available Phosphorus (P)
N = Total Nitrogen, N
Na = Sodium
Ca = Calcium
EA = Exchangeable Acids
TEB = Total Exchangeable Bases
CEC = Cation Exchange Capacity
BS = Base saturation.

Effect of *Mucuna cochinchinensis* on Earthworm Cast

Mucuna plant population significantly influenced the number of earthworm cast per m² on the field (Table 3). Planting of 800 plants /ha of *Mucuna* resulted in significantly higher number of earthworm casts per m² than 400 plants/ha and the control (0.00 plant population).

Table 3: Effects of *Mucuna cochinchinensis* on earthworm cast (No/m²) in 2013 raining season at Makurdi

Treatment	Earthworm Cast
0.00 plants/ha	23.00c
400 plants/ha	63.00b
800plants/ha	85.00a
1,600plants/ha	41.00c
LSD	18.31

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 Yam weekly Germination Percentage

Germination percentage ranged from 56.56 % in 800 plants population to 72.74% in 0.00 plants population at 6 weeks after sowing. The highest germination percentage was observed in 0.00 plants population while the lowest germination percentage was observed in 800 plants population (Table 4). At 8 weeks after planting, 800 plants population had 69.08% and 1,600 plants population with 63.26% did not significantly differ just as 400 plants population and 800 plants population .The control, 0.00plt/ha produced the highest germination index of 80.04%. (Table 4).

Effects of *Mucuna cochinchinensis* on Leaf Area

The leaf Area at 6 weeks after sowing ranged from 84.12 cm² (800plt/ha) to 62.36 cm² (0.00plt/ha). However 800 plants population produced the best result of 84.12 cm² whereas the control, 0.00 plants population produced the least leaf area of 62.36 cm² (Table 4). At 8 weeks after sowing, leaf area ranged from 99.20 cm² in 400 plants population to 69.90 cm² in 0.00plt/ha with no significant difference between 0.00plt/ha and 400plt/ha. The highest leaf area was observed at 1,600 plant population whereas the lowest leaf area was observed in the control plot, 0.00 plants population.

Table 4: Effects of *Mucuna cochinchinensis* on Yam Weekly Germination Percentage and Leaf Area at 6 & 8 Weeks after Sowing in 2014 cropping season at Makurdi

	Weekly Germination Percentage (%)		Leaf Area (cm²)	
Treatment	**6WAS**	**8WAS**	**6WAS**	**8WAS**
0.00plt/ha	72.74a	80.04a	62.36c	69.90c
400plt/ha	68.30b	78.94a	72.89b	70.23c
800plt/ha	56.56c	69.08b	84.12a	79.14b
1,600plt/ha	64.76b	63.26b	66.67c	99.20a
F-LSD	4.72	6.66	5.43	5.49

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 Yam Leaf Number per Plant

At 6 weeks after planting, 800plt/ha showed a significant difference in yam leaf number of 74.00 leaves/plt higher than the control (0.00plt/ha) with 39.00 leaves/plt while 400 plants population and 1,600 plants population did not show significant difference with 51.00 leaves/plt and 55.00 leaves/plt respectively (Table 5).

Similarly at 8weeks after sowing, all treatments differed significantly, with 800 plants population producing the highest number of leaves (113.00) followed by 1,600 plants population with 89.00 leaves; 400 plants population with 81.00 leaves and 0.00 plants population with the least number of leaves (70.00). In the like manner at 10 weeks after sowing 800 plants population produced 134.00 leaves /plt as the highest leaf number, while 0.00 plants population (control) produced the least number of leaves (90.00).

Table 5: The effect of *Mucuna cochinchinensis* on yam leaf number (YLN) at 6, 8 and 10 WAS (No/plant) in 2014 cropping season at Makurdi

Treatment	6WAS	8WAS	10WAS
0.00plt/ ha	39.00c	70.00d	90.00d
400plt/ha	51.00b	81.00c	102.00c
800plt/ha	74.00a	113.00a	134.00a
1,600plt/ha	55.00b	89.00b	108.00b
F-LSD	5.65	7.68	5.92

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 Yam Yield

Yam yield in 400 plants population (86.25 t/ha) and 0.00 plant population (90.00 t/ha) did not significantly differ but differed between 800 plant population (135.65 t/ha) and 1,600 plants population (102.50 t/ha). The results showed that 800 plant population produced the highest yield of 135.65 t/ha while the control (0.00 plant population) produced the lowest yield of 90.00 t/ha.

Table 6: Effects *of Mucuna cochinchinensis* on yam yield in 2014 cropping season at Makurdi

Treatment	Yam Yield (t/ha)
0.00plt/ha	90.00c
400plt/ha	86.25c
800plt/ha	135.65a
1,600plt/ha	102.50b
F-LSD	9.25

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.

Effect of Yam Harvest on Soil Physical and Chemical properties

After yam was harvested in the 2014 cropping season, the results of the laboratory analysis showed that there was a decline in some of the soil constituents in all plant populations as seen in the negative values. 0.00 plant population and 400 plant population had the highest decline in sand content while 800 plant populations had the lowest decline of 0.87% (Table 6). The composition of clay increased in 0.00 plants population and 400 plants population. However, 0.00 plants population had the highest increase in clay content, 6.36% whereas 400 plants population had the least increase in clay content, 2.25%. There was also a decline in clay content in 800 plants population and 1,600 plants population, nevertheless 1,600 plants population had the higher decline, 0.96% than 800 plants population had 0.87%. The silt content in all plants population declined after yam harvest, however 1,600 plants population had the highest decline, 9.90% while 0.00 plants population had the lowest decline, 2.02%. Similarly the N, P and K contents declined in all plants population with 800 plants population having the highest decline of 30.43% while 400 plants population had the lowest decline of 20.45%. The decline in P content was highest in 0.00 plants population (12.50%) and lowest in 800 plant population (3.03%). Also the decline in K content was highest in 400 plants population (26.07%) whereas 800 plants population had the lowest decline (11.11%).

Table 7: Physical and chemical properties of the soil after harvesting yam in 2014 cropping season at Makurdi

Soil Property	*Mucuna* plant/ha)			
	0.00	400	800	1,600
pH	6.72	6.89	6.78	6.62
Sand(%)	75.80	75.64	75.80	75.36
Clay(%)	13.20	13.36	13.20	13.64
Silt(%)	9.90	10.30	10.84	10.10
O.M(%)	3.79	4.04	4.10	4.00
P(Mg/L)	0.32	0.32	0.33	0.31
N(%)	0.041	0.044	0.46	0.042
K(Cmol/kg)	0.24	0.23	0.27	0.24
Na(Cmol/kg)	0.22	0.23	0.24	0.22
Mg(Cmol/kg)	2.70	3.00	3.10	2.80
Ca(Cmol/kg)	3.10	3.20	3.30	3.10
EA(Cmol/kg)	1.00	1.00	1.00	1.00
TEB(Cmol/kg)	6.26	6.56	6.86	6.51
CEC(Cmol/kg)	7.26	7.26	7.96	7.51
BS(%)	86.20	86.70	86.80	86.20

O.C = Organic Carbon
O.M = Organic Matter
P = Available Phosphorus (P)
N = Total Nitrogen, N
Na = Sodium
Ca = Calcium
EA = Exchangeable Acids
TEB = Total Exchangeable Bases
CEC = Cation Exchange Capacity
BS = Base Saturation.

Table 8: Percentage change in physical and chemical properties of the soil after harvesting yam in 2014 cropping season at Makurdi

	***Mucuna* (plt/ha)**			
Soil Property	**0.00**	**400**	**800**	**1600**
pH	4.61	7.40	2.65	-0.15
Sand(%)	-1.32	-1.32	-0.87	-0.96
Clay(%)	6.36	2.25	-3.33	-2.05
Silt(%)	-2.02	-9.03	-6.46	-9.90
OM(%)	-1.76	-6.68	-10.24	-4.25
P(Mg/L)	-12.5	-3.13	-3.03	-9.68
N(%)	-21.95	-20.45	-30.43	-23.81
K(Cmol/kg)	-16.67	-26.07	-11.11	-12.50
Na(Cmol/kg)	-9.09	-13.04	-12.50	-13.64
Mg(Cmol/kg)	-11.11	-6.67	-9.68	-10.71
Ca(Cmol/kg)	-6.45	-6.25	-9.09	-9.68
EA(Cmol/kg)	-10.00	-2.00	-5.45	-10.00
TEB(Cmol/kg)	-8.95	-7.77	-9.91	-9.22
CEC(Cmol/kg)	-9.09	-7.01	-7.79	-9.32
BS(%)	-0.12	-0.81	-1.27	-0.46

O.C = Organic Carbon
O.M = Organic Matter
P = Available Phosphorus (P)
N = Total Nitrogen, N
Na = Sodium
Ca = Calcium
EA = Exchangeable Acids
TEB = Total Exchangeable Bases
CEC = Cation Exchange Capacity
BS = Base Saturation.

DISCUSSION

Effects of *Mucuna cochinchinensis* on physico –chemical Properties of the Soil

The physical and chemical properties of the soil at the end of the cropping season revealed that *Mucuna* had a positive impact on physico-chemical properties, especially when planted at 800plt/ha. In 2013, sand and silt were improved by 0.13, 3.34%, respectively while the pH was lowered by 4.09%. However there was no percentage change in the composition of sand. This could be due to the thick canopy by *Mucuna* which makes sand not to be easily moved during erosion as compared to the smaller particle sizes of clay and silt. Similarly organic carbon, organic matter, available P, total N, available K and CEC were improved by 32.18, 25.22, 13.89, 20.00,13.33 and 13,87%, respectively.

Other chemical properties such as Na, Mg, Ca, exchangeable acids, total exchangeable bases and base saturation were greatly improved when *Mucuna* was planted at 800plt/ha as compared to the control. The improved physical and chemical properties of the soils by incorporating *Mucuna* at 800plt/ha might be attributed to greater microbial activity (e.g. earthworm abundance and microbial biomass) that are known to occur in organically managed soils than in conventionally managed soils (Mader *et al*., 2002). The greater microbial activity observed in 800 plants population can be attributed to the high nodulation produced by 800 plants population at 4, 6 and 8 WAS. High nitrogen replacement value of *Mucuna* has been widely reported (Giller *et al*.1987; Carsky *et al*.1998; Shave *et al*. 2008). These results collaborates Shave, *et al*.(2008), who attributes the changes in physical and chemical properties of organic soil to high biological activity associated with biodynamic soil systems. Asibuo and Osei – Bonsu (1999) reported that, certain herbaceous organic legumes are able to utilize P from rock phosphate due to rhizosphere process thereby enhancing the availability of P.

Effect of *Mucuna cochinchinensis* on Earthworm Casting

The result of earthworm casting also showed that *Mucuna* population of 800plt/ha recorded the highest number of earthworm casts of 85 No/plot. Biological activities in the soil also positively influenced the plant mineral nutrition and soil aggregate stability (Avav *et al*. 2008). The improved physico-chemical properties of the soils by incorporating *Mucuna* at 800plt/ha might be attributed to greater microbial activity (e.g. earthworm abundance and microbial biomass) that are known to occur in organically managed soils than in conventionally managed soils (Mader *et al*. 2002). In this study, the mechanisms of weed suppression by *Mucuna* were not investigated. However other researchers have reported that shading and allelopathy are the main ways by which crops smother weeds (Fuji *et al*. 1991; Macdiken *et al*., 1997). Nancy *et al*. (1996) also indicated that the possible mechanism by which cover crops modify weed seed germination is through altering the seed environment and other interference methods such as allelopathy.

Effect of *Mucuna cochinchinensis* on Yam Weekly Germination Percentage

The result also showed that at 6 WAP all the treatments recorded over 50% germination. Germination was however higher in 0.00plt/ha (72.74%) and lowest in 800plt/ha at 6 WAS .The same trend was observed in at 8 weeks after sowing. The yam weekly germination percentage was higher in 0.00 plants population however, it recorded lower performance in other parameters which ultimately will lead to lower yields.

Effect of *Mucuna cochinchinensis* on Yam Leaf Area

Yam Leaf Area was higher in 800plt/ha (84.12sq/cm) and lowest in 0.00plt/ha (62.36sq/cm) at 6 WAS. This could be attributed to high performance in the growth characteristics of 800plt/ha (canopy duration, ground cover, nodulation), biomass and microbial activity year which resulted to improvement in the physical and chemical properties of the soil (Shave *et al*., 2008)

Effect of *Mucuna cochinchinensis* on Yam Leaf Number

The result showed that at 6 weeks after sowing, all the treatments recorded over 50 leaves /stand except 0.00plt/ha .This could be attributed to lower soil fertility in the control plot compared to *Mucuna* incorporated plots. However 800plt/ha produced the highest number of leaves per stand at 6, 8 and 10 WAP corresponding to 74.00, 113.00 and 134.00 leaves, respectively.

Effect of *Mucuna cochinchinensis* on Yam Yield

The results obtained from harvest in 2014 showed that yield differ significantly among the treatments. Treatment 800plt/ha produced the highest yield of 135.65ton/ha compared to the control which produced 90.00ton/ha, while 1,600plt/ha produced the lowest yield of 86.25ton/ha. This result does not collaborate with Aflakpui and Bolfrey-Arku (2007) who recorded higher yield of 13.22 ton/ha at 10 months after planting yam but with different cultivars. This could be attributed to genetic differences and inherent varietal characteristics of yam genotypes (Angus *et al*. 2012).

These findings agreed with the findings of FAO (2000), that different varieties of crop differ in their nutrient requirements and response to treatments like fertilizer and that a local crop variety will not respond so well compared to improved variety.

Effect of Yam Harvest on Soil Physical and Chemical properties

The results of soil laboratory analysis after yam was harvested in 2014 showed that yam utilized both the physical and chemical constituents of the soil that were improved by the incorporation of *Mucuna*. The O.M in 800 plants population got depleted by 10.24%, N by 30.43%, P by 3.03% and

K by 11.11% which suggests the higher yield recorded in this treatment. This deletion explained the fact that these nutrients deposited in the soil through the incorporation of *Mucuna* were used by yam and their depletion calls for another fallow period to replenish them back.

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 plants/ha since it resulted in a better suppression of weeds, growth, yield of yam as well as physical and chemical properties of the soil for improved yam production. The same population also gave a better utilization of P which was locked up in pockets in the soil and was released as free P that was made available to the yam plants for use during growth cycle of the crop.

RECOMMENDATIONS

The problem of poor soil fertility can be reduced by planting Mucuna at a population of 800 plants/ha to improve the physical and chemical properties of the soil for improved yam yield in the study area.

REFERENCES

Aflakpui, G.S.K. and Grace E. K. Bolfrey-Arku (2007). Suppression of *Imperata cylindrica* (spear grass) and changes in cassava fields. *Nigerian Journal of Plant Sciences*.**2**:25-34.

Avav, T.,Shave P.A and Hilakaan, P.H (2008). Growth of *Mucuna* accessions under fallow and their influence on soil and weeds in a sub humid savanna environment. *Journal of Applied Biosciences (2008),Vol.10:442-448. ISSN 1997 5902:www.biosciences.elewa.org*

Buckles.,D, Triomphe.,B and Sain,G. (1998b). Cover crops in hillside agriculture. Farmer innovation with *Mucuna*. IDRC and CIMMYT, Ottawa, Canada, 222p.

Buckles, D. (1995). Velvetbean: A "New" Plant with a History. *Economic Botany* 49(1): 13-25.

Carsky, R. F., Tarawali,S.A., Becker,M., Chikoye,I., Tian,G and Sangiga,N (1998). *Mucuna* an herbaceous cover legume with potential for multiple uses. Resource and Crop Management Monograph No 25.IITA, Ibadan, Nigeria. 98pp.

Carsky, R. J, Hayashi, and Tian, G. (1992). Benefits of mulching in the sub humid savannah zone research needs and technology targeting, resource and crop management research monograph NO. 26, IITA, Ibadan, Nigeria.

Carsky, R.J., Asiedu. R and Cernet. D. (2001). Review of soil fertility management for yam based systems in West Africa. *African Journal of Root and Tuber Crops* 8(2):1-17.

FAO (2000). The State of Food Security in the World, FAO Rome, pp 31

FAO (2014) FAOSTAT database online. Available at: http://faostat.fao.org/Accessed : 10th August 2014.

FAO (2010) FAO Databases Results http://apps.fao.org.

Fujii, Y., Shibuga, T and Usanii, Y. (1991). Allelopalhic effects of *Mucuna pruriens* on the appearance of weeds. *Weed Research* (Tokyo) **36**. 43-49.

Giller, K.E., Sakal.W.D and Mafongoya. P.L. (1987). Building Soil Nitrogen Capital in Africa. In: Buresh, R.J. (ed) Replenishing Soil Fertility in Africa. SSA, ASA, Madison W.L: 151-192.

IITA (1987). Annual Report of 1987 International Institute of Tropical Agriculture, Ibadan ,Nigeria.p.37.

IITA (1979). Selected Methods for Soil and Plant Analysis. International Institute for Tropical Agriculture, Ibadan, Nigeria. Manual series No. 1.

Lathwell, D.J. (1990). Legume green manure: Principles for management based on recent research. Trop. Soils Technical Bulletin. Soil Management collaborative research support programme. Raleigh, North Carolina. pp 90-91.

Lobo Burle, M., Suhet,A.R., Pereira, J., Reseek, D.V.S., Peres, R..R., Cravo, M.S., Bowen,W., Bouldin, D.R. and Lathwell, D.J. (1992). Legume green manures:their dry season survival and the effect on succeeding maize crop. *Soil Management CRSP Bulletin*.Soil Management collaborative research support programme, Raleigh, North Carolina.pp 92-94.

Macdiken, K.G. Hairiah, K.L., Otsano. A.M Onguma B. and Majid, N.M. (1997). Shade Based Control of Imperata Cylindrical: Tree fallows and cover crops. *Agrofor. Syst*. 36: 131-149.

Madar, P.A., Fliebech. A., Dubois. D., Gunst. L., Fried. P. and Niggli. U. (2002). Soil Fertility and Biodiversity in Organic Farming. *Science*, 296:1694-1697.

Mureithi, J.G.,Mwaura,P. and Nekesa,C. (2000). The role of green manure legumes in small holders' farmers in Gatanga, Central Kenya. *Proceedings of 2nd Scientific Conference of Soil Management and Legume Research Network Projects*.26th-30th June 2000. Kenya Agricultural Research Institute.Pp153-164.

Nancy, G.C. Bennett. M.A., Stinner B.R. Cardina, J. and Reginier E.E. (1996). Mechanism of weed suppression in cover crop-based production systems. *Hort Science*, 31:410-413.

Nwosu, C.S and V. B.N. Okoli (2010). Economic Analysis of Resource use by Wase yam

Farmers in Owerri Agricultural zone of Imo State, Nigeria in proceedings of 44th Annual Conference of Agricultural Society of Nigeria held Ladoke Akintola University 18-22 October, 2010.

Philip, O., Adefiloye, K.,Okeleye,A and Ganiyu,O.O. (2006).Principles and practices of crop production ideals and innovations publications,a division of BUM(Nigeria) Ltd.P198.

Shave P.A., Avav T., Kalu B.A., Ekefan E,J. (2008). Potential for organic system of maize production using *Mucuna*-maize rotation sequence in Sub Humid savanna of Nigeria. Department of crop and Environmental Protection, University of Agriculture, Makurdi.

Vissoh, P.V., Manyon, V.M., Carsky, R.J., Osei-Bonsu, P. and Galiba, M. (1998). Green manure cover crops systems in West Africa. Experiences with *Mucuna* in cover crops in West Africa. Contributing to sustainable Agriculture. (Buckles,D., Eteka.,Osimane,O.,Galiba,M.and Gallano,eds),Pp 132.Int.Dev. Res.Cent.Ottawa,Canada

Plate 1: *Mucuna* at 6 Weeks after Planting

Appendix 1: Meteorological Data for Makurdi during the study (2013-2014) **Appendix 1: Meteorological Data for Makurdi during the study (2013-2014)**

	2013					2014					2015				
Month	Total rainfall (mm)	Temperature		Mean Relative Humidity (%)		Total rainfall (mm)	Temperature		Mean Relative Humidity (%)		Total Rainfall (mm)	Temperature		Mean Relative Humidity (%)	
		Max ^{0}C	Min ^{0}C	High	Low		Max ^{O}C	Min ^{0}C	High	Low		Max ^{O}C	Min ^{0}C	High	Low
Jan	0.00	35.30	17.90	48.00	30.00	4.00	35.50	18.30	55.00	27.00	0.00	33.80	17.90	40.00	23.00
Feb	0.00	36.70	20.90	57.00	35.00	4.00	37.00	21.20	51.00	26.00	111.80	36.30	23.70	71.00	41.00
March	44.20	37.70	23.30	66.00	42.00	33.70	36.20	24230	69.00	44.00	3.90	35.80	24.20	70.00	43.00
April	122.90	34.40	21.50	75.00	55.00	56.40	35.20	23.10	72.00	52.00	17.70	36.90	24.00	65.00	39.00
May	183.40	32.20	20.40	81.00	66.00	160.50	33.10	22.30	78.00	61.00	37.20	35.00	24.40	72.00	53.00
June	141.80	31.00	20.50	82.00	68.00	165.00	31.60	21.60	81.00	65.00	123.60	32.70	23.60	76.00	60.00
July	243.60	30.00	22.60	85.00	71.00	129.30	30.60	21.50	83.00	70.00	139.70	30.90	23.00	82.00	68.00
Aug	131.00	29.50	22.70	85.00	72.00	274.60	29.40	22.00	86.00	74.00	339.10	30.90	23.50	85.00	68.00
Sept	285.30	30.30	22.40	84.00	73.00	306.90	30.20	22.80	86.00	73.00	127.30	30.90	23.30	85.00	68.00
Oct	125.50	31.90	23.00	85.00	72.00	100.60	31.50	21.80	81.00	65.00	82.90	32.40	23.80	79.00	66.00
Nov	0.00	34.30	23.00	75.00	47.00	26.40	33.30	21.30	77.00	51.00	16.80	34.00	20.10	69.00	43.00
Dec	10.10	34.60	19.50	58.00	32.00	4.70	33.70	17.90	56.00	30.00	0.00	33.30	17.50	27.00	19.00

Source: Nigerian Meteorological Agency (Tactical Air Command), Makurdi