Journal of Agriculture and Food Sciences
Volume 10 Number 2, October 2012 pp. 14-25

EVALUATION OF EFFECT OF *MORINGA OLEIFERA*-BASED AGRO-FORESTRY PRACTICES ON THE YIELDS OF *IPOMEA BATATA* IN NORTH CENTRAL NIGERIA

[1]**Polycarp Ozobia Anyaegbu,** [2]**Uzoma P. Iwuanyanwu** [1]**Barwa Abubakar** [1] Department Of Crop Science, University Of Abuja, Nigeria [2]Department Of Crop Production, Imo State Polytechnic, Umuagwo, Nigeria

ABSTRACT

The study evaluated the effect of Moringa oleifera based agro- forestry system on Sweet potato yields in North Central Nigeria.. The study was carried out in the Potato Multiplication Centre in Gikwoyi, Federal Capital Territory, Abuja. Randomized Complete Block Design with 3 replications was used. Data collected included, soil physico- chemical properties, aerial biomass weight, tuber yield, and weed biomass weight. Performance of Ipomea batata was significantly improved by Moringa oleifera based agro-forestry systems. Highest soil organic matter 0.76% (2010), 0.86% (2011) and soil pH 6.8 were obtained from Moringa+ Leucaena plots. Tuber yield of Ipomea batata peaked at 20.2 t ha^{-1} (2010) and 22.9 t ha^{-1} (2011) in Moringa + Leucaena plots. Although tuber yield of Ipomea batata that received N.P.K (20:10:10) was highest (18.6 t ha^{-1}) in the first year of planting, in subsequent years the yields in N.P.K fertilized plots decreased drastically. Poorest tuber yield (3.6 t ha^{-1}) was obtained from the control plots in the third year of planting. Weed infestation was drastically reduced (10.29 t ha^{-1} in Moringa + Leucaena plots compared to that in the N.P.K. fertilized plots; 21.61t ha^{-1} (2009), 29.10 t ha^{-1} (2010) and 27.63 t ha^{-1} in 2012 respectively.

Key words: *Moringa, Leucaena, Gliricidia,* Agro-forestry system ,*Ipomea batata,*

http://dx.doi.org/10.4314/jafs.v10i2.2

INTRODUCTION

Periodic enlightenment lectures on alley farming by the Federal Capital Territory (FCT) Agriculture Department for the local farmers have awakened interest of the farmers in agro-forestry practice. Farmers under the aegis of Potato Farmers Association of Nigeria have shown interest in the combination of the cultivation of the crop with forestry practice. In line with the interest of the farmers, this study evaluated the *Moringa oleifera* based alley-farming practice on sweet potato (*Ipomea batata*) yields in North Central Nigeria with a view to informing relevant stakeholders.

Potato Farmers Association of Nigeria, POFAN, with its a population of about 60,000 members across the country, has four Sweet Potato Multiplication Centers in the Guinea savannah zone of Nigeria namely Lokoja, in Kogi State, Lugbe, Gikwoyi in FCT, and Lafia in Nassarawa State, Nigeria. Since the formation of the POFAN whose aim is to enhance commercial production and marketing of sweet potato within and outside Nigeria, the production of the crop is highly being popularized, in Nigeria (Anyaegbu *et al*, 2011). Unlike other tuber crops, both the roots and leaves of sweet potato are good sources of pro-vitamins, A (B-carotene), B-group vitamins and vitamin C, calcium, iron, potassium and sodium, (Huaman 1997; Daris *et al* 1986; and Ewell and Mutura 1991)

The choice of *Moringa oleifera* based alley-farming arose from the fact that the plant is known to posses many valuable properties which are of great scientific interest: rapid growth, long taproots, minimal shade and large production of high protein biomass. The plant is a fast growing tree and has been found to grow to 6-7m in one year in areas receiving less than 400mm mean annual rainfall (Odee ,1998) .It has been reported that juice extracted from the leaves can be used to make foliar nutrient capable of increasing crop yield by up to 38%, (Rao *et al*, 1983). When cultivated intensively and then ploughed into the soil, *Moringa* can act as a natural fertilizer for other crops (Dutt *et al* ,1984).

Specifically, the study was designed to determine the effect of *Moringa oleifera* on the growth performance of sweet potato in alley cropping practice and also assessed whether the combination of *Moringa oleifera* with other leguminous fallow species improved its efficiency. Finally the study compared the efficiency of the leguminous follow species and that of *Moringa* in an alley farm setting.

MATERIAL AND METHODS

The study was conducted at the Potato Multiplication Centre of the Potato Farmers Association of Nigeria in Gikwoyi, FCT, Abuja, Nigeria. The Federal Capital Territory (FCT) is located between latitude 8^0 251 and 9^0 251 North of the equator and Longitude 6^0 45^1 and 7^0 45^1 east of Greenwich Meridian. The Territory covers an area of 8,000 square kilometers and occupies about 0.87% of Nigeria. It is bordered by four states namely Niger to the West, and North West, Nassarawa to the East, Kogi to the South and Kaduna to the North of the territory. According to Balogun (2001), the climate of Federal Capital Territory (FCT) is the hot humid tropical type.

The FCT records its highest temperatures and greatest diurnal ranges during the dry season months, when the maximum temperature ranges between 30.41^0C and 35.1^0C. During the rainy season on the other hand, the maximum temperature ranges between 25.8^0C and 30.2^0C (Balogun, 2001).

The vegetation in the study area is dominated by herbaceous plants interspersed with shrubs and trees. A three year planting programme was carried out to actually determine the effect of the fallow species on the test crop namely 2009, 2010 and 2011. Prior to field planting , the seedlings of the fallow species ; *Moringa oleifera, Leucaena leucocephala and Gliriccdia septum* were raised in a temporary nursery for 12 weeks and were taken to the field for first year planting at average height of 131cm per plant with the number of leaves per plant for *Moringa*111, *Leucaena leucocephala* 102, and *Gliricidia septum*120.

In the first year, the experimental field was cleared, ploughed and harrowed and the experimental layout was set out appropriately. In the second and third years, clearing was done plot by plot. After clearing, the debris including the residues of the harvested crops and the prunes of the various fallow species were ploughed back into the soil in their various plots. Before planting, bulked soil samples were collected randomly from the experimental site using soil auger, from a depth of 0-15cm and 15-30cm respectively for soil physico-chemical analyses. The collected samples were air-dried and sieved using a 2mm mesh size sieve pan. The particles size fractions were determined by hydrometer method of Bouyocuos(1951), using sodium hexametaphosphate as a dispersant. *Ipomea batata* vines (30cm long) of the variety, *Ex- Igbariam* as recommended by Anyaegbu *et al* (2011), were used in the trial. The experimental treatments of whose effects were evaluated include; 100% *Moringa* alley, 50% *Moringa*+ 50% *Leucaena leucocephala* alley,50% *Moringa* + 50% *Gliricidia septum*, 100% *Leucaena leucocephala*, 100% *Gliricidia*, 50% *Leucaena* + 50 % *Glaricidia*, N.P.K. (15:15:15) fertilizer (200kg ha^{-1}) and control.

The experimental design used was a Randomized Complete Block Design (RCBD) with 3 replications. Each replicate (35.5m long) contained 8 plots giving a total of 24 plots in each trial. Each plot (4mx4m), was separated from each other within a replicate by 0.5m path way and between replicates by 1m alley. The seedlings of the fallow species were planted in the layout as determined by the treatment randomization scheme adopted. The planting spacing for the fallow species was 1m x 0.5m, giving a population of 20,000 stands/ ha. The seedlings of the fallow species were planted and allowed for 21 days in the field before the sweet potato vines were planted. The approach was to enable the seedlings to establish and stabilize in the field before the sweet potato vines were planted within their alleys. Planting spacing for the sweet potato vines was 1m x 0.4m, giving a population of 25,000 stands ha^{-1}. The treatment, N.P.K. (15:15:15) fertilizer was applied 3 weeks after planting. Each plot randomly assigned to the chemical fertilizer treatment (N.P.K.) received it at the rate of 0.32kg/plot (200 kg ha^{-1}) by band method of application. Weeding was done once, 3 weeks after planting (WAP).

Data collected included tuber yield of sweet potato and aerial biomass weight of sweet potato. During the harvesting of the sweet potato tubers, weed samples were collected from each plot using a 1mx1m wood quadrant which was thrown randomly into each plot .All the weeds within the quadrant were brushed, collected and wrapped in labeled paper bags which were oven-dried at 65^0 C for 24 hours.

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After harvesting the crop stands in each year, post- harvest soil physio -chemical data analyses were carried out to evaluate the current and residual effects of fallow species and the N.P.K. fertilizer on the soil nutrient status respectively.

All data collected were assessed by analysis of variance (ANOVA) for a straight Randomized Complete Block Design. Treatment means were compared using Duncan's Multiple Range Test (DMRT). Coefficient of Variation for each ANOVA was estimated. Results of each parameter were presented in form of tables.

RESULTS AND DISCUSSION

The result of the preliminary analysis of the soil samples before planting were as follows; Soil pH(6.2), percent Nitrogen (0.34), P ppm (4.3), K (0.45),Ca (0.51), Mg (2.18), Na (1.33),OM(0.65), Clay (18.8), Silt(26.78 %), BD(1.44 %).

Generally, the emergence and survival of the fallow species was significant ($p>0.05$). Results showed that *Moringa oleifera* had 98% emergence and survival while *Leucaena leucocephela* was 86% , and *Gliricidia septum* gave 77% emergence and survival (Table 1) . Storage history of the *Moringa* seeds used in this trial showed that they were collected from the mother plant and planted 4 days after the harvest while the *Leucaena* and *Gliricidia* seeds had been under two months storage. The brilliant performance of *Moringa oleifera* in emergence and survival confirmed that *Moringa oleifera* has no dormancy problem. Perhaps, the above condition was responsible for the higher emergence of the *Moringa* seeds compared to others.

The higher performance of the species on the parameter assessed confirmed their suitability as fallow species; according to Anyaegbu (2005) ,a plant is considered suitable for alley farming if it has fast /high growth rate. Other qualities include, being a legume and high Biomass Index (B.I). *Leucaena leucocephela* and *Gliricidia septum* in addition to being legumes, have high Biomass Index. *Moringa*, though not a legume, has all the attributes of a legume (Ezeamuzie *et al*, 1996).

Tables 2, 3, and 4 showed the fertility status of the soil as influenced by the selected fallow species. The results showed that there was a general decline in soil fertility over time in control plots and areas that received chemical fertilizer. Conversely, the post harvest soil analyses showed that the use of the fallow species significantly ($P>0.05$) improved and sustained the soil fertility status throughout the period of the experiment. The above condition may be attributed to the ability of the trees in fixing nitrogen and other essential elements in the soil for component crops. *Leucaena leucocephala* and *Gliricidia septum* are legumes and *Leucaena*, according to Quivera and Liho (1976) fixes about 500 to 600 kg of nitrogen per hectare, per year and this is to the advantage of the companion crops. *Moringa oleifera* described as a fertility plant (Makkar and Beeker, 1996), is a fast growing plant and has been found to grow to 6-7 m in one year in areas receiving less than 400mm mean rainfall, (Odee 1998).

The sweet potato biomass weight as affected by the *Moringa* based systems is shown in Table 5. The biomass, in the first year, was generally poor except in plots that received N.P.K (20:10:10) fertilizer. Hence, the highest biomass weight (120kg ha^{-1}) was obtained from plots that received N.P.K fertilizer. The poor biomass weight recorded from the alley plots in the first year may be due to the fact that by one after planting, the fallow species were yet to establish properly to produce the desired biomass or to fix adequate nitrogen for improving the soil fertility. I n the second and third years of planting, the biomass weight of the stands in the alleys of the fallow species increased significantly, compared to those in control plots and those that received chemical fertilizer respectively, an indication that the fallow tree species had improved the soil fertility of the area.

Table 6 showed the tuber yield of sweet potato as influenced by the *Moringa* based agro-forestry systems. In the first year, the tuber yield of the potato stands that received N.P.K. Fertilizer was significantly (P> 0.05) high while in the second and third years, it decreased drastically. Continuous application of chemical fertilizer on the same piece of land over time without amelioration, destroys the soil fertility of the area, hence the soil pH would be automatically reduced as shown in Tables, 3 and 4

The poor performance of the sweet potato stands grown in the control plots was an indication that soil was originally poor in fertility as shown in the preliminary soil analysis. Generally, growing the crop in the alleys of the fallow species significantly (P>0.05) increased the tuber yield of *Ipomea batata*.

Ekeh- Okoro *et al* (1999) reported that the increased root yield of cassava grown in legume mixtures was due to the ability of the legumes to improve the nitrogen economy of the soil through nodulation. Although *Moringa* has all the attributes of a legume, it is not a legume (Makkar and Beeker 1998) and Shahina *et al* (2005). The plant has been reported as a “fertility plant”, one of the properties that made it a “Miraculous Plant” (Baker 1996). Machell (1997), reported that a *Moringa* concentration composed of 250ml of extract with 250 ml of water and 0.5ml detergent , with 25ml of the solution applied per plant every two weeks, led to increase of 94% in radish weight and 65% in number of beans compared to the control plots.

The highest (P>0.05) tuber yield of *Ipomea batata* was obtained from the mixed *Moringa+ Leucaena* alleys in both the second and third year of planting. This impressive performance of the stands in *Moringa+ Leucaena* alleys is an indication that the neighborhood effect between the two fallow species was complementary.

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In the first year of the trial, weed biomass was high, especially in the plots that received N.P.K fertilizer (P>O.O5) and the control plots. The fallow species at the early stage were yet to establish to control weed growth but in the second and third years of planting, weed weight in the alleys of the fallow species was significantly reduced. Prunes from the weed that were spread on the soil surface in each plot, acted as carpet against weed growth. Zuofa *et al* (1992) reported a 13% reduction in weed growth in cassava intercropped with legumes. The least weed biomass was obtained from alleys of *Moringa*. *Moringa oleifera* has been reported to have inhibitive effects on weed growth.

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Table 1. Percent Emergence and Survival of the Tree Species used in the study

Tree Species	Percent Emergence
Moringa oleifera	98
Leucaena leucocephala	86
Gliricidia septum	77

Table 2. Soil physico-chemical properties as affected by the selected fallow species in FCT

First year (2009) Parameters

% ← (Cmol/kg) -- >

TREATMENTS	pH	N	P(ppm)	K	Ca	Mg	Na	OM	Clay	Silt	BD
Moringa	6.2	0 .38	4.8	0.45	0.50	2.84	1.31	0.68	18.8	26.83	1.45
Leucaena	6.4	0.37	4.7	0.48	0.48	2.61	1.36	0.68	18.6	26.34	1.43
Gliricidia	6.2	0.38	4.8	0.43	0.46	2.31	1.36	0.64	18.5	26.81	1.44
Moringa+Leucae.	6.3	0.37	4.5	0.47	0.47	3.56	1.35	0.67	18.4	26.84	1.40
Moringa+Giricidia	6.3	0.37	5.8	0.45	0.47	2.63	1.34	0.63	18.2	26.51	1.42
Leucaena+Gliricid.	6.4	0.37	5.8	0.45	0.47	2.63	1.34	0.63	18.2	26.52	1.42
N.P.K (20:10:10)	6.1	0.35	4.7	0.45	0.46	2.41	1.37	0.52	17.8	26.90	1.43
Control	6.2	0.35	4.5	0.45	0.45	2.38	1.38	0.52	17.8	26.7	1.41
$\bar{X} \pm S$	6.3 ±0.11	.35±.01	4.8±.42	.46±.12	.47±.02	2.67±.40	1.35 ±.02	.62 ±.07	18.3 ±.39	26.7±.20	.43±.02

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Table 3. Soil physico-chemical properties as affected by the selected fallow species in FCT

Second year of planting (2010) Parameters

TREATMENTS	pH	N ,%	P(ppm)	K ← (Cmol/kg) -- >	Ca	Mg	Na	OM	Clay	Silt	BD
Moringa	6.6	0 .49	6.9	0.75	0.64	3.85	0.81	0.76	18.8	26.83	1.45
Leucaena	6.7	0.48	5 .8	0.53	0.53	3.62	0.84	0.74	18.6	26.34	1.43
Gliricidia	6.6	0.44	5.3	0.48	0.50	3.33	0.84	0.66	18.5	26.81	1.44
Moringa+Leucae.	6.6	0.47	6.3	0.72	0.62	3.56	0.78	0.76	18.4	26.84	1.40
Moringa+Giricidia	6.6	0.45	6.2	0.68	0.51	3.82	0.70	0.70	18.2	26.51	1.42
Leucaena+Gliricid.	6.6	0.44	6.0	0.50	0.51	3.65	0.81	0.66	18.2	26.52	1.42
N.P.K (20:10:10)	5.5	0.42	5.2	0.48	0.40	2.38	1.39	0.48	17.8	26.90	1.43
Control	5.7	0.26	2.6	0.31	0.38	1.32	1.38	0.45	17.8	26.7	1.47
$\bar{X} \pm S$	6.3 ±0.1	1.35±.01	4.8±.42	.46±.12	.51±.09	3.19±..9	.94±.2	.65±.1	18.3±.4	26.7±.20	1.43±0.02

Table 4. Soil physico-chemical properties as affected by the selected fallow species in FCT

Third year of planting (2011)
Parameters

TREATMENTS	pH	N ,%	P(ppm)	K ← (Cmol/kg) -- >	Ca	Mg	Na	OM	Clay	Silt	BD
Moringa	6.8	0 .76	7.3	0.81	1.01	3.65	0.41	0.81	18.8	25.83	1.45
Leucaena	6.7	0.69	8 .5	0.80	0.98	3.60	0.44	0.78	18.7	26.34	1.43
Gliricidia	6.5	0.57	6.3	0.53	0.76	3.13	0.44	0.71	18.6	26.81	1.44
Moringa+Leucae.	6.7	0.65	8.3	0.91	1.14	3.57	0.38	0.86	18.7	26.84	1.40
Moringa+Giricidia	6.6	0.58	7.0	0.71	0.84	3.62	0.20	0.75	18.5	26.71	1.47
Leucaena+Gliricid.	6.4	0.54	6.2	0.61	0.68	3.66	0.31	0.80	18.2	26.52	1.42
N.P.K (20:10:10)	5.4	0.51	6.4	0.53	0.20	0.83	1.40	0.32	17.8	26.80	1.44
Control	5.1	0.17	1.2	0.11	0.21	0.80	1.39	0.40	7.8	26.7	1.48

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$\bar{X}$ ± S 6.3 ±0.11.35±.01 4 .8±.42 .46±.12 .6±.41 2.86±1.3.62±.48 .94±.28 0.7±.12 18.3±.36 26.7±..20 1.43±.02

Table 5: Sweet Potato Aerial Biomass as influenced by the selected Fallow Species

Treatment	Sweet potato Biomass (t ha^{-1})			
	First year	Second year	Third year	mean
Moringa alone	1.08 d	2.14 c	2.24 c	1.82
Leuceana leucocephala alone	1.08 d	2.18 b	2.25 c	1.84
Gliricidia septum alone	1.06 d	1.76 e	2.16 d	1.66
Moringa + Leuceana mixture	1.14 b	2.86 a	3.55 a	2.52
Moringa + Gliricidia mixture	1.10 c	2.11 d	2.29 a	1.83
Leuceana + Gliricidia mixture	1.08 d	2.14 d	3.11 b	2.11
N.P.K. (20:10:10)	1.26 a	1.20 f	1.17 d	1.21
Control	0.98e	0.84g	0.78e	0.87
DMRT (P>0.05)	*	*	*	

Means in the same column with the same letter(s) are not significantly different at P>0.05.
Key; * = significant difference

Table 6. Tuber Yield of *Ipomea batata* as influenced by the Selected fallow species

Treatment	Tuber Yield (t ha-1)			
	First year	Second year	Third year	mean
Moringa alone	7.6 d	16.8 c	18.8b	14.4
Leuceana leucocephala alone	10.6 b	18.6 b	19.6c	16.3
Gliricidia septum alone	7.6 d	16.2 c	18.9b	14.2
Moringa + Leuceana mixture	8.5 c	20.2 a	22.9a	17.2
Moringa + Gliricidia mixture	7.9 d	15.3 d	19.4c	14.2
Leuceana + Gliricidia mixture	8.8 c	18.6 b	20.6b	16
N.P.K. (20:10:10)	18.6a	16.7 c	10.7c	15.3
Control	7.6 d	4.8 e	3.6d	5.3
DMRT (P>0.05)	*	*	*	

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Means in the same column with the same letter(s) are not significantly different at P>0.05.
Key; * = significant difference

Table 7. Weed biomass as influenced by *Moringa* based Agro-forestry practice

Treatment	Weed Biomass (t ha^{-1})			
	First year	Second year	Third year	mean
Moringa alone	21.36 b	17.63 d	13.25 e	17.41
Leuceana leucocephala alone	21.38 b	20.17 c	20.14 d	20.56
Gliricidia septum alone	21.16 b	21.65 c	21.13 c	21.31
Moringa + *Leuceana* mixture	21.46 b	12.44 e	12.14 g	15.35
Moringa + *Gliricidia* mixture	21.41 b	13.02 f	10.29 e	14.91
Leuceana + *Gliricidia* mixture	21.50 b	13.12 f	12.81 g	15.81
N.P.K. (20:10:10)	22.61 a	29.10 a	27.63 a	26.45
Control	21.61 b	26.81 b	22.15 b	23.52
DMRT (P>0.05)	*	*	*	

Means in the same column with the same letter(s) are not significantly different at P>0.05.

Key; * = significant difference