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COMPARATIVE ECONOMIC ASSESSMENT OF THE EFFECT OF SELECTED FALLOW SPECIES FOR SOIL AMENDMENT ON THE YIELD OF SWEETPOTATO *(IPOMOEA BATATAS*) ALLEY IN THE GUINEA SAVANNAH OF NIGERIA

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ABSTRACT

The study focused on the comparative economic assessment of the effect of selected fallow species for soil amendment on the yield of sweetpotato (Ipomea batatas) alley in the Guinea Savannah of Nigeria. As a result of the increasing cost and scarcity of inorganic fertilizers, sweetpotato production has been on the decline in recent times. Part of the intensive efforts being made by farmers to resuscitate the declining soil fertility so as to meet the challenge of providing food for the increasing population, is the use of cheap and available fallow species in a sweetpotato alley. Therefore, sweetpotato (Ipomea batata) vines (30cm long) of the variety, Ex- Igbariam were used in a three year alley cropping system using different combinations of the selected fallow species. These include; 100% Moringa alley, 50% Moringa + 50% Leucaena leucocephala alley, 50% Moringa + 50% Glaricidia septum alley, 100% Leucaena leucocephala alley, 100% Gliricidia alley, 50% Leucaena + 50 % Glaricidia alley, N.P.K. (15:15:15) fertilizer (200kg ha^{-1}) and Control. Mean yield of sweatpotato from plots treated with the different fallow species were separated using analysis of variance (ANOVA) to determine if statistical difference existed among the values. The economic analysis was done by simple gross margin analysis. The result showed that alley cropping with all the fallow species used in the trial, increased yield of sweetpotato progressively, with 50% Moringa + 50% Leucaena leucocephala alley, giving the highest average yield of 17.2 tons/ha and highest value of output ₦111,000 with a returns to investment of 1: 3.79. Also, the application of 100% Leucaena leucocephala alley and any other mixture of leuceana had yield advantage over the other fallow species used in the experiment. It was therefore concluded that alley cropping of sweetpotato with the selected fallow species, progressively increased yield and reduced cost of sweetpotato production in the Federal Capital Territory Abuja, Nigeria.

Keywords: Sweetpotato, Fallow, Species, Alley, Cropping, Economic, Yield.
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INTRODUCTION

Sweet potato (*Ipomoea batatas (L),* Lam) is a perennial crop belonging to the morning-glory family (*Convolvulaceae*) but cultivated annually. The crop originated from Central America and was spread rapidly to Asia and Africa during the 17th and 18th centuries respectively (Van An, 2004; Nwauzor and Afuape 2005). Sweet potato is an important crop in many areas of the world being cultivated over a range of environments (temperate, tropical and sub-tropical) in over 100 countries, and between latitudes 40^0N and 40^0S of the equator, as well as between the sea level and 2300m altitude. The crop is cultivated mainly for food, animal feed and industrial raw material. It is the only member of the genus *Ipomoea* whose roots are edible, and is one of the world's most important food crops due to its high yield and nutritive value (Data and Eronico, 1987). It is extensively cultivated in tropical and sub-tropical zones (Islam *et al*, 2002). As a crop that requires low inputs of land, labour and capital with less management in its production; it does well on marginal soils, giving more reasonable yield than most other crops (Islam *et al.*, 2002; Attaliru and Ilangantileke, 2007).

Sweetpotato ranks among the five most important food crops in the tropical areas where a high population of the world's poorest people live (Woolfe, 1992; Van An, 2004). However, it ranks fourth in terms of world most important food crops, after rice, wheat and corn (Babatunde *et al.,* 2007). Also, of the world's root and tuber crops, sweet potato ranked third after Irish potato and cassava (Ikeorgu, 2003). In Nigeria, sweet potato cultivation is still restricted to a few States and its production is mainly for local consumption. Tewe *et al.* (2003) reported that sweet potato is only a minor food crop in tropical Africa despite its potentials as indicated by its growth in terms of production. Sweetpotato is the only crop among the root and tuber crops that has a positive per capita annual rate of increase in production in Sub-Saharan Africa (Tewe *et al.,* 2003). It has a high yield potential that may be realized within a relatively short growing season (Tewe *et al.,* 2003) and is adaptable to a wide ecological conditions. It can be grown on poor soils but also performs well in a fertile environment, far exceeding yields of cereal crops (Attaliru and Ilangantileke, 2007). This root crop has become more important in this 21st century than it was in the 20th century, and is expected to be used in immense quantity as raw materials for biodegradable plastics and for fuel of automobiles as envisaged by Kozai *et al*., (1996). The cultivation and production of sweetpotato is on the increase in Nigeria (Afuape, 2006).

The crop has moved up from the minor crop status it used to occupy (Agboola, 1979) to an enviable position of being the fourth most important root and tuber crop in Nigeria after cassava, yam and cocoyam. Its production has increased from 149,000 metric tones in 1961 to 106,197 million metric tons (FAO, 2007). Despite this increase, yield on farmers' fields have remained low at 6.8t/ha (Tewe *et al*., 2003). Sweetpotato is a highly recommended food security crop that can help low-income countries ride out of the turmoil created by food price increases (IYP, 2008). Sweetpotato (*Ipomea batatas* L) is a major crop that suffered serious neglect in the past but now occupies global position as a source of food and industrial raw material (Njoku, 2007). The high nutritive value and performance under resource-poor condition make it attractive to farmers and households.

China is the highest producer of sweetpotato in the world (75.80 million metric tons per annum). Nigeria ranks third in the world and second in Africa with a production figure of 2.43million metric tons per annum (FAO, 2009). It is interesting to note that unlike cereal crops (rice, wheat and maize) sweetpotato is not a globally traded commodity and its prices are usually determined by local supply and demand. Sweetpotato is an important staple food crop in Africa in general and Nigeria, in particular. It contains Vitamin A with sufficient quantities of a precursor known as beta-carotene. Vitamin A deficiency is a particular problem for children under five years and for pregnant and lactating women. Serious Vitamin A deficiency can lead to blindness; chronic deficiency reduces a child's capacity to fight other diseases with sufficient negative long-term effect on the health of human. Beta-carotene is produced in plants and Vitamin A is produced only in animals (including humans). The absorption of beta-carotene and it conversion to vitamin A in the body is controlled naturally, and because vitamin A does not exist in plants, there is little danger that over-ingestion of vitamin A beta-carotene from sources such as sweetpotato could lead to vitamin A toxicity. However, if excessive amounts of beta-carotene are ingested (which is very unlikely) simply reducing this intake will correct the situation with no lasting toxic effects. Kapinga (2001) opined that 100g of sweetpotato can provide enough beta-carotene to produce from 0 to 100% of the suggested daily vitamin A requirement (350ug) per day for infants and young children. Unlike other tuber crops, in some varieties of sweetpotato, both the roots and leaves are good sources of Pro-vitamins A (B-carotene), B-group vitamins and vitamin C, Calcium, iron, potassium and sodium, (Ewell and Mutura 1991)

The choice of *Moringa oleifera* as a fallow species arose from the fact that the plant has been discovered to posses many valuable properties which made it of great scientific interest with its 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,(Odee1998). 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). Cultivated intensively and then ploughed into the soil, *Moringa* can act as a natural fertilizer for other crops, (Dutt *et al* 1984). Moringa leaf extract is best used as plant growth enhancer (Phiri & Mbewe, 2010).

Shelton and Brewbaker (1994) reported that *Leucaena* can be used in cropping systems. Contour strips of *Leucaena* have been employed for many years in the Philippines and in Timor and Flores in Indonesia. The strips serve as erosion control on steep slopes and as a form of alley cropping in which *Leucaena* foliage is mulched into the soil to enhance yields of inter-row crops. *Leuceana leucocephala* has an aggressive taproot system which helps break up compacted subsoil layers, improving the penetration of moisture into the soil and decreasing surface runoff. It is used as a shade tree for cocoa, coffee and tea; it generally acts as a shelterbelt, providing shade and wind protection for a variety of crops, especially during early growth. *L. leucocephala* thrives on steep slopes and in marginal areas with extended dry seasons, making it a prime candidate for restoring forest cover, watersheds and grasslands. It has high nitrogen-fixing potential (100-300 kg N/ha a year), related to its abundant root nodulation and was one of the 1st species to be used for the production of green manure in alley-cropping systems. Leaves of *L. leucocephala,* even with moderate yields, contain more than enough nitrogen to sustain a maize crop. The finely divided leaves decompose quickly, providing a rapid, short-term influx of nutrients. The tree has the potential to renew soil fertility and could be particularly important in slash-and-burn cultivation, as it greatly reduces the fallow period between crops.

Gliricidia sepium has also been used extensively outside its native range in places which include the Caribbean, the Philippines, India, Sri Lanka and West Africa. These landrace populations are largely remnants of colonial introductions used to shade plantation crops although more recently they have been integrated into indigenous farming practices being used for fuel wood, living fences, animal forage, green manure and soil stabilization. A less historic use of gliricidia but one that is increasing in occurrence is the use of leaves as a green manure; however, only isolated examples of mulching or incorporation of leaves into soil (e.g. El Gariton, Guatemala) are evident in the native range. Greater use of gliricidia as a green manure has been made outside the native range with reports as early as the 1930s in Malaysia and Sri Lanka on its benefits.

Leaf mulch of *G. sepium* increased the yield and reduced time to harvest of yam tubers in the Ivory Coast (Budelman 1989). Similarly, rice yields were boosted by up to 77% through the use of *G. sepium* mulch (Gonzal and Raros 1988). *Gliricidia* is lopped for mulch and green manure in agro forestry applications and regrows very rapidly given sufficient soil moisture and warm temperatures. *Gliricidia* is planted in contour hedgerows (alley cropping) on sloping lands susceptible to erosion. The hedgerows hold soil together and, when properly planned and managed, can slow erosive surface run-off. It has been intercropped in alley cropping systems with maize, cassava, taro, cucurbits, and other food crops. Intercropping maize with *Gliricidia*- a 'fertilizer tree'- produces more stable yields than applying inorganic fertilizer to mono-cropped maize (Spore 2013).

With the increasing population pressure in tropical Africa including Nigeria, shifting cultivation is no longer sustainable and the length of traditional bush fallow for maintaining the productivity of the soil is becoming shorter. Therefore continuous cultivation of crop like sweetpotato (*Ipomoea batatas* Lam) on the same land will lead to soil nutrient exhaustion and low yield. More so, sweetpotato like any other root tuber crops is a heavy feeder exploiting greater volume of soil for nutrient and water (Osundare, 2004, Agbede and Adekiya, 2011). Intensive and conscious efforts should therefore be made to resuscitate the declining soil fertility so as to meet the challenge of providing food for the increasing population. The use of inorganic fertilizer causes a drastic increase in the cost of sweetpotato production; especially now that fertilizers are scarce and expensive, in most times the farmers scarcely break even. This study was carried out against this background. Broadly, the study seeks to determine the economic returns to sweet potato using the selected fallow species as soil amendment technique in the guinea savannah agro ecology of Nigeria, to reduce cost of sweetpotato production. The specific objectives include:

i. identify the best combination and fallow species for optimal performance of sweetpotato in an alley cropping system; and

Journal of Agriculture and Food Sciences
Volume 14 Number2, October, 2016 pp. 1- 14 .

ii. estimate the cost and returns to sweetpotato production under the different combinations of the selected fallow species in an alley cropping system.

METHODOLOGY

The study was conducted at the Potato Multiplication Centre of the Potato Farmers Association of Nigeria in Gikwoyi, Federal Capital Territory (FCT) Abuja, Nigeria. The Federal Capital Territory (FCT) is in the guinea savannah Agro Ecology of Nigeria, lying between latitude 8.25 and 9.20 north of the equator and longitude 6.45 and 7.39 east of Greenwich Meridian. Abuja is geographically located in the center of the country. The FCT covers an area of 8,000 square kilometers and occupies about 0.87% of the land area 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 the Federal FCT is the hot, humid tropical type. The area records its highest temperatures and greatest diurnal ranges during the dry season months, when the maximum temperature ranges between 30.410^{0}C and 35.10^{0}C. During the rainy season on the other hand, the maximum temperature ranges between 25.80^{0}C and 30.20^{0}C (Balogun, 2001).The vegetation in the study area is dominated by herbaceous plants interspersed with shrubs and trees.

A three year alley cropping season was carried out to determine the economic effect of the fallow species on the test crop in 2009, 2010 and 2011. 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. *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 which economic evaluations were made include; 100% *Moringa alley*, 50% *Moringa* + 50% *Leucaena leucocephala alley*, 50% *Moringa* + 50% *Glaricidia septum alley*, 100% *Leucaena leucocephala alley,* 100% *Gliricidia alley,* 50% *Leucaena* + 50% *Glaricidia alley*, N.P.K. (15:15:15) fertilizer (200kg ha^{-1}) and Control.

Mean yield of sweetpoato from the alley cropping with the different fallow species were separated using analysis of variance (ANOVA) to determine if statistical difference exists among the values. An economic analysis was carried out to determine the monetary benefit from using the various treatments. Total variable cost (TVC) was recorded for individual treatments. Total variable cost is defined as total expenses incurred during the production period which is obtained by multiplying the inputs used by unit prices. Total Revenue (TR) for individual treatments was obtained by multiplying units of output with current farm gate price levels in the study area. The difference between Total revenue and Total variable cost makes up the Gross margin (GM) per treatment. The model is specified as follows;

GM = TR – TVC ………. (1)

Where

GM = Gross margin
TR = Total Revenue
TVC = Total Variable Cost

RESULT AND DISCUSSIONS

Different combinations and fallow species for optimal performance of sweetpotato in an alley cropping system

The result of the study shows that inorganic fertilizer (N.P.K. (15:15:15) increases cost of production, not withstanding that it had an effect on the nutrient base of the soil since the yield from plots that received the inorganic fertilizer out yielded other treatments in 2009. This result is similar to the result obtained by Abdullahi *et al* (2014). Palada *et al* (1992) concurred with the findings that there is a significant increase in the yield of vegetables at the first season in the alley cropping system. Nunoo *et al.,* (2014) further confirmed that fertilizer helps in improving soil fertility in addition to increase in yield in cocoa production with cereals. However, as time progressed yield of sweetpotato continued to decrease rapidly with continuous application of NPK leading to loss of Naira invested per unit of output. Meanwhile, all the plots that were treated with organic manure from the fallow species, increased yield progressively with the third year recording the highest yield. Comparatively, Moringa + Leuceana mixture had the highest mean yield of 17.2 kg/ha. The combination of moringa and leuceana provided the essential nutrients needed by sweetpotato because both fallow species are reported to have positive and significant effect on soil organic matter, total soil N, low soil temperature fluctuation and high soil moisture, and soil moisture retention Kang *et al* (1990). Thus, the microclimate provided by the leucaena trees allowed burrowing organism to burrow into the soil and aid in degradation of fallen litters and also losing the soil structures which aids aeration and rooting of the crops (Imogie *et al.,* 2008).

From Table 1 above, Moringa + Leuceana mixture started exerting influence on the soil from the second year of the experiment. The yield from plots that received MLM increased from 8.5t on/ha to 20.2 tons / ha in the second year. The high yield expression of the treatment was consolidated in the third year with an increase to 22.9 tons / ha. This was followed by the plots that received LGM which had the highest yield of 20.6 tons/ha in the third year.

On the other hand, application of Leuceana alone showed superiority over the other single applications. This shows that among the three fallow species used in the experiment, *Leuceana leucocephala* have a better effect on the soil nutrient base as to influence the yield of sweetpotato in the study area. This is in line with the views of Dargo Kebede(2016) that leucaena in addition to its ability to fix N in the soil, through dead and decayed fallen leaves significantly added high quantities of N and organic matter to the soil.

On the percentage of total yield as influenced by the different fallow species, yields from plots that received leuceana either as a single treatment or combined treatment contributed more than others. As shown in the Table 2, plots treated with Moringa + Leuceana recorded the higher contribution in the 2nd year and highest in the 3rd than the rest (15.9% and 17.0% respectively). However, note that the use of the selected fallow species consistently increased percentage contributions to total yield. On the contrary, yields from NPK treated plots and the control, continued to decrease their contributions to total yield.

In the same vein, the economic analysis of the value of output as computed using the prevailing farm gate prices of sweetpotato in the study area showed similar trend with moringa + leuceana mixture recording the highest mean value of output (₦111,000.00), followed by leuceana alone (₦104,133.3) and leuceana + gliricidia (₦102,600.00). The values of production did not however differ significantly across the treatments except with the control.

On the economic analysis as shown in Table 4,all the treatments had a return on investment that is positive and greater than unity except that of the control which is also positive but less than unity. This means that the returns are higher than investment in the use of the selected fallow species in a sweetpotato alley enterprise. However, moringa + leuceana mixture gave the highest gross margin of ₦87,820.00 with a return to investment of 1: 3.79. This implies that for every unit of Naira invested in using moringa + leuceana mixture in sweetpotato alley, the expected return is 3.79 times the amount invested. Leuceana alone followed closely with a return to investment of 3.56. This result confirms the works of Dargo Kebede(2016) attributing it to the fact that leucaena in addition to its ability to fix N in the soil, through dead and decayed of fallen leaves significantly added high quantities of N and organic matter to the soil. The use of fallow species reduced the cost by removing the cost of fertilizer which imparts so much on the total variable cost thereby drawing down the returns from such enterprise.

From the table above, the combination of Moringa and Leuceana in a Sweetpotato alley cropping system gave the highest return to investment. This is an indication that the farmer is likely to make more money in Sweetpotato production if he practices alley cropping in the FCT Abuja using Moringa and Leuceana as fallow species.

Conclusion

The use of the selected fallow species to improve the yield of sweetpotato in an alley cropping system in the study area is cost effective, encourages indigenous technology and has the prospect of generating additional income to sweetpotato farmers. The fallow species are in abundance; they not only increase soil fertility but can also serve other purposes that are important to the farmer, such as their use as fungicides etc. All the treatments involving fallow species used in this study, show more than double the return on investment. The use of fallow species especially Leuceana, Moringa and Gliricinda is therefore recommended for use in an alley cropping system in the Guinea Savanna of Nigeria. This will reduce

Journal of Agriculture and Food Sciences
Volume 14 Number2, October, 2016 pp. 1- 14 .

overdependence on the use of inorganic fertilizers and give better financial returns to the farmers.

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Journal of Agriculture and Food Sciences
Volume 14 Number2, October, 2016 pp. 1- 14 .

APPENDIX

Table 1: Yield of Sweetpotato as influenced by different fallow species and NPK (15:15:15) fertilizer in the study area.

	Yield (tons/Ha)							
Years	**MA**	**LA**	**GA**	**MLM**	**MGM**	**LGM**	**N.P.K. (20:10:10)**	**Control**
2009	7.6	10.6	7.6	8.5	7.9	8.8	18.6	7.6
2010	16.8	18.6	16.2	20.2	15.3	18.6	16.7	4.8
2011	18.8	19.6	18.9	22.9	19.4	20.6	10.7	3.6
Mean	14.4^{ab}	16.27^{a}	14.23^{ab}	17.2^{a}	14.2^{ab}	16.0^{a}	15.33^{a}	5.33^{b}
LSD	**9.6468**							

Source: Field Survey, 2009-2011

MA= moringa alone, LA= *leuceana leucocephala* alone, GA= Gliricidia septum alone, MLM= Moringa + Leuceana Mixture, MGM= Moringa + Gliricidia Mixture, LGM= Leuceana + Gliricindia Mixture

Table 2: percentage of total yield as influenced by treatments

		% of total Yield							
Years	**Total yield(kg)**	**MA**	**LA**	**GA**	**MLM**	**MGM**	**LGM**	**N.P.K. (20:10:10)**	**Control**
2009	77.2	9.8	13.7	9.8	11.0	10.2	11.4	24.1	9.8
2010	127.2	13.2	14.6	12.7	15.9	12.0	14.6	13.1	3.8
2011	134.5	14.8	14.6	14.1	17.0	14.4	15.3	8.0	2.7

Source: Field Survey, 2009-2011

Table 3: Value of Sweetpotato yield as influenced by different fallow species and NPK (15:15:15) fertilizer in the study area.

				Value of Production	(₦)			
Yrs	**MA**	**LA**	**GA**	**LGM**	**MGM**		**N.P.K. (20:10:10)**	**Control**
2009	45,600	63,600	45,600	51,500	47,000	52,000	111,600	45,600
2010	100,800	111,600	97,200	121,200	91,800	111,600	100,200	28,800
2011	131,600	137,200	132,300	160,300	135,800	144,200	74,900	25,200
Mean	92,667^{ab}	104,133.3^{a}	91,700^{ab}	111,000^{a}	91,533.3^{ab}	102,600^{ab}	95,566.7^{ab}	33,200^{b}
LSD	**69,406**							

Source: Field Survey, 2009-2011

MA= moringa alone, LA= *leuceana leucocephala* alone, GA= Gliricidia septum alone, MLM= Moringa + Leuceana Mixture, MGM= Moringa + Gliricidia Mixture, LGM= Leuceana + Gliricindia Mixture

Table 4: Economic analysis of Sweeetpotato yield in an alley cropping system using different fallow species and NPK (15:15:15) fertilizer in the study area.

Treatments	**Av. Yield (t/ha)**	**TVP (₦)**	**TVC (₦)**	**GM (₦)**	**RI**
Moringa Alone	14.40	92,667.00	23,146.00	69,521.00	3.00
Leuceana Alone	16.27	104,113.30	22,840.00	81,293.30	3.56
Gliricinda Alone	14.23	91,700.00	24,080.00	67,620.00	2.81
Moringa + Leuceana	17.20	111,000.00	23,180.00	87,820.00	**3.79**
Moringa + Gliricinda	14.20	91,553.30	29,430.00	62,103.30	2.11
Leuceana + Gliricnda	16.00	102,600.00	31,480.30	71,119.70	2.26
NPK (15:15:15)	15.33	95,566.70	47,355.00	48,211.00	1.02
Control	5.33	33,200.00	20,800.00	12,400.00	0.60