ECONOMIC OF PLANTAIN PRODUCTION UNDER WEED MANAGEMENT STRATEGIES INTEGRATED WITH ORGANIC MATTER AT AFAHA NSIT, AKWA IBOM STATE, NIGERIA

BY

TIMOTHY UDOUDO EKPO, *Ph.D*

AND

NSE TIMOTHY EKPO, *Ph.D*
DEPARTMENT OF AGRICULTURAL EDUCATION
COLLEGE OF EDUCATION
AFAHA NSIT, AKWA IBOM STATE
NIGERIA

ABSTRACT

Plantain production in Nigeria may result in unprofitable enterprise due to weed infestation and soil fertility decline. Therefore, field experiments were conducted to examine the economic production of plantain under weed management strategies integrated with organic matter at Afaha-Nsit, Akwa Ibom State, Nigeria. Seven treatments were replicated three times. These were sweet potato (20,000 plants/ha) plus organic matter (poultry manure (20t/ha)) or sawdust (40t/ha); egusi-melon (20,000 plants/ha) plus hand-slashing (3months interval) plus organic matter, cover crops (sweet potato plus egusi-melon) plus organic matter and weedy plus no organic matter (control). The experiments were laid out in randomized complete block design. Analysis of variance was carried out on data obtained on weed studies and plantain performance. Means were separated using Duncan Multiple Range Test (DMRT) at 5% probability level. Partial budget analysis was carried out to assess the net profit of each weed management strategy integrated with either sawdust or poultry manure. The results showed that the treatments of sweet-potato plus sawdust; egusi-melon plus sweet-potato plus sawdust; egusi- melon plus hand-slashing plus sawdust and the control reduced the percentage net profit by average of 42.3, 43.1, 66.6 and 95.8% respectively. The highest net profit (N 745,600) and marginal rate of return (4.4) were obtained from the treatment of egusi-melon plus sweet potato integrated with poultry manure; hence it is recommended.

KEYWORDS: plantain, cover crops, hand-slashing, organic matter and profit.

INTRODUCTION

Plantain production has potential to generate revenue and sustain many households in humid region of Nigeria. The crop is prolific, has low growing risk and low capital investment once it is established (Nwagwu, 2004); the crop has a longer window of harvest and storage potential if processed (IGPR, 2002). Currently, plantain provides food security and income for small scale farmers who represent the majority of producers (CGIAR, 2014). It pays vital roles in the feeding systems of both human and farm animals and in addition has a very high nutritional value including carbohydrates, vitamins and minerals (Kainga and Seiyabo, 2012).

Demand for plantain within Nigeria is high with supply struggling to meet demand (Akinyemi et al., 2010). However global plantain production has increased by nearly 60% over the last 30years to 37million metric tons although about 85% production is consumed in domiciling areas (CGIAR, 2014).

Factors affecting profitability of plantain production in Nigeria have been identified to include land, cultural practices, labour, pests, diseases, post-harvest handling and storage (Akinyemi et al. ,2010). In another report, Kainga and Seiyabo (2012) listed farm size, labour, planting material and capital investment while Bomanaziba (2014) added other factors to include education of the farmers, household size and de-suckering technology.

However, the critical plantain production constraints in the rainforest zone, Nigeria are weed infestation and nutrients decline (Akinyemi and Tijani-Eniola, 2001). The crop is a heavy feeder and also requires wider spacing hence necessitates intensive maintenance in terms of fertilizer supply and efficient weed management (Ekpo and Ekpo, 2019). Weed control among plantain growers is identified as hand-slashing and this is cost intensive, requires repeated operations and sometimes the labour is scare (Nwagwu, 2004). The alternative measure for weed control is the use of cover crops as suitable and profit-oriented compared to hand-slashing in any cropping system (Lawal et al., 2019).

On the other hand, soil fertility decline can be improved using inorganic fertilizer, but it is always costly and sometimes not available and affordable by the small scale farmers who formed the majority of the plantain growers (Ndukwe et al., 2012). Alternatively, organic matter has been reported to greatly improve water holding capacity, enhances cations exchange capacity (CEC), and improves microbial activities in addition to nutrient retention and cations ability (Bolan et al., 2010). Utilization of organic manure in crop production is a current trend in sustainable agriculture (Scotti et al., 2015). There are many sources of organic manure but poultry manure and sawdust are easily available and affordable (Danmaigoro, 2019); and their potency to promote crop production has been reported in Nigeria (Ayeni et al., 2008).

Despite plantain production challenges, economic return is still feasible. Nwai et al. (2012) reported that a net farm income/ha of plantain production was N148,346 with marginal rate of return (N1.12) in Abia State. Kainga and seiyabo (2012) reported that plantain farming is profitable in Yenagoa Local Government Area, Balyelsa State. Similarly, Fakayode et al. (2011) also reported viable and profitable plantain production in Rivers State.

However, neither the assessment of different weed management systems nor the type of fertilizer deployed in the production of plantain was specifically assessed to determine the net benefit which to a large extent hinges on the input-output relationships.

Therefore, this research was conducted to assess the economics of plantain production under weed management strategies integrated with organic matter at Afaha Nsit, Akwa Ibom State, Nigeria.

Materials and Methods

Experimental site: Agricultural Education Research Farm, College of Education, Afaha Nsit.

Method of soil and sawdust analyses: Prior to planting 30 core samples were collected from experimental site with auger at 0-15cm depth. These were bulked together, air dried and later ground. Routine soil analysis was carried out to determine the physicochemical properties of the soil. The sawdust was also air dried and later ground before it was analyzed to determine its physicochemical properties.

Experimental design and layout: The seven treatments were laid out in randomized complete block design with three replicates. The treatments namely: sweet potato (20,000plants/ha) plus poultry manure 20t/ha (sw+p), sweet potato (20,000plants/ha) plus sawdust (40t/ha) (sw+sa), hand-slashing at three months interval plus poultry manure (20t/ha) sl+p, hand-slashing at three months

interval plus sawdust (40t/ha) sl+sa, sweet potato (20,000plants/ha) plus *egusi*-melon (20,000plants/ha) plus poultry manure 20t/ha (sw+m+p), sweet potato (20,000plants/ha) plus *egusi*-melon 20,000plants/ha plus sawdust 40t/ha (sw+m+sa), weedy + no organic manure (wo+mo).

Land preparation: In the planting season usually March, the land was cleared, the biomass and the stumped removed. Thereafter, the soil was manually tilled in April, 2017. The experimental area was demarcated according to treatments and replicates. Each treatment plot measured 420m2 and the net plot measured 270m2.

Planting and cultural operations: The plantain suckers and sweet potato vines were procured from seed multiplication centre, Etinan, Akwalbom State. Plantain suckers were planted 3x2m apart in holes dug 40cmx40cmx40cm in May 2017. The plantain population (1667/ha) contained five stands per treatment plot and only three located within the centre were used for data collection. The seeds of *egusi*-melon were sown three per hole and spaced one metre apart. It was thinned to two per hole to maintain a population of 20,000plants/ha. The potato vines were planted three per stand and later thinned to two to maintain a density of 20,000 plants/ha. In the plot of sweet potato and *egusi*-melon (sw+m), *egusi*-melon was integrated in the plot of sweet potato in early September during the 'August' break. Hand-slashing was repeated at three months' interval.

Application of organic manure: Sawdust was treated with ultracide solution to prevent termites attack. Sawdust and poultry manure were applied 40t/ha and 20t/ha respectively at planting of plantain using ring application method. The control plot was weedy and no manure was applied throughout the study.

Weed studies: Weed data were collected at 2, 4, 6, 8, and 10months after planting. The weed studies included weed density and dry weed biomass.

Data collection on plantain: Data collection on plantain was undertaken at 2, 4, 6 and 8months after planting. The growth parameters including the plant height stem girth, number of functional leaves, leaf area and leaf area index. The leaf area (LA) was calculated using the linear equation: Leaf Area (LA) = 0.8 (LxW) L = length of the leaf, W = width of the leaf at the widest portion while 0.8 remains constant.

The leaf area index (LAI) was determined as:

$$LAI = \frac{\text{Total leaf area}}{\text{Land area occupied by the plant}}$$

The yield components were number of hands and fingers per bunch, the girth and length of each finger. The yield was measured in tonnes/ha.

Data analyses: Analysis of variance was used while the means were separated by Duncan multiple range test.

Partial budget analysis

This budget is termed partial due to the fact that renting of farmland and payment to the personnel (Researchers) was not included as the production cost. The partial budget aimed at assessing the net profit of the enterprise. This is obtained as:

GM= ($\sum$Tr - $\sum$Tvc) ,GM= Gross Margin ,TR= Total revenue (unit price of output x quantity produced). TVC= Total variable cost (unit price of each variable input x quantity used). Therefore, Net benefit (profit) = GM-TVC. Marginal Rate of Returns (MRR) sometimes called Rate of Return on Investment (ROI). This is the ratio of net profit to total cost of production.

$$MRR = \frac{Net\ benefit}{Total\ cost\ of\ Production}$$

This implies the return derived from every one-naira investment in the enterprise.

Results and Discussion

The soil analysis in Table 1 shows that potassium, calcium, phosphorus, and some trace nutrients were insufficient for the growth and development of plantain being a heavy feeder. The analyses of organic manure namely sawdust and poultry droppings showed that sawdust contained inadequate exchangeable cations while poultry dropping was nutritionally superior to sawdust (Table 2). Both materials are used as organic manure in crop production (Mbah & Mbagwu, 2003)

Table 1: Soil physical and chemical properties of the experimental site

Soil Properties	Values
pH /:/ (H2O)	5.1
Organic carbon gkg^{-1}	26.0
Soil organic matter gkg^{-1}	48.3
Total Nitrogen gkg^{-1}	5.1
P ($mgkg^{-1}$)	28.6
Exchangeable	**($cmolkg^{-1}$)**
Ca	15.5
Mg	1.7
Na	0.9
K	0.5
Exchangeable acidity	0.2
Extractible micro nutrient	**($Mgkg^{-1}$)**
Mn	180.2
Fe	17.5
Cu	0.9
Zn	11.2
Particle size	**(kgk^{-1})**
Sand	711.0
Silt	199.8
Clay	89.2

Table 2: Sources and chemical properties of organic manure

	Poultry Manure	Sawdust
pH	8.80	7.80
E c(u/m)	1921.00	388.0
Organic carbon %	31.3	50.01
Total N	2.39	0.49
C/N	13.40	98.06
Mg/Kg	←	→
Ca	13800.00	3121.00
Mg	3559.00	1771.00
K	4200.00	2811.20
Na	2152.50	556.10
P	722.15	162.10

Weed management Strategies

In an attempt to curb weed interference in plantain production; sweet potato, sweet potato integrated with *egusi*-melon; *egusi*-melon and hand-slashing integrated in the same treatment plot were used as weed management strategies. *Egusi*-melon was efficient to control the early flush of weeds within 3-4 months (Table 3).

This could be attributed to its rapid growth rate and 100% ground cover and thereafter declined. The efficiency in weed suppression by *egusi*-melon was reported by Ekpo, et al. (2011a). The early utilization of *egusi*-melon for weed suppression favoured the growth of plantain as reported by Ekpo & Ekpo (2019). However, sweet potato has the potential for longer and sustainable weed control than *egusi*-melon; this is due to the short-lived of melon while sweet potato maintained weed suppression up to 6-7 months.

The effectiveness of sweet potato in weed suppression was reported by Njoku et al. (2007) and attributed this to persistent ground cover attained by the crop. The integration of sweet potato plus *egusi*-melon was an indication to further strengthen the prolonged weed suppression than either sweet potato or *egusi*-melon alone. This was favoured by the bi-modal rainfall regime by favouring two periods of planting in a year (March-April) and (August-September). The integration of weed management strategies usually provides the best and sustainable weed management as reported by Ibedu, et al. (1993). Generally, the weed management strategies used in this study enhanced the early development of plantain due to their ability to curb early weed interference. The early development of plantain uninterrupted by weed interference probably indicated its superiority over later effect of weed provided adequate and quality nutrients were available.

Plantain growth and yield

The weed management strategies that suppressed weeds in the treatment plot fertilized with sawdust produced insignificant low growth parameters, yield components and bunch yield compared with poultry manure. This could be attributed to relatively low exchangeable cations present in the sawdust as reported by Idem & Udo (2017). The application of sawdust (40t/ha) plus hand-slashing at three months' interval reduced plantain bunch yield /ha by 48.5% (2016/2017) and 42.4% (2017/2018) compared with yield from the plot treated with poultry manure in planted and ratoon crops respectively. Sweet potato+sawdust reduced 50% flowering time by 7.6 and 6.8 % while, slashing + sawdust reduced flowering time by 2.52 and 1.71% in planted and ratoon crops respectively; whereas sweet potato plus poultry manure reduced 50% flowering time by 24.4 and 21.4% in the planted and ratoon crops respectively (Table 4). This indicated that sawdust also produced relatively low essential plant nutrients compared with poultry manure (Table 2). Okonkwo, et al. (2012) reported that physical and chemical properties are richer in sawmill dumpsite than soil from non-dumpsite; hence the soil treated with sawdust produced plantain growth parameters and bunch yield than the unfertilized weedy plot (control). The weedy and unfertilized treatment plot reduced plantain bunch average yield (t/ha) by 89.3% and 90.5% in planted and ratoon plantain crops respectively. This is ascribed to low soil fertility, weed competition for nutrients, light, water and space (Table 2).

Similar findings were reported by Emma-Okafor, et al. (2017) in unfertilized plantain-cassava mixture. Poultry manure was superior in both years to sawdust in terms of plantain growth parameters particularly in cover crop treatment plots (Table 5, 6 and 7), yield components (Table 8) and bunch yield (Table 9) under the same weed management strategies.

Table 3: The effect of weed management strategies on dry weed biomass g (m-1)

Planted crop (2016/2017) Months after planting (MAP)

Treatments	2	4	6	8	10
Sw+p	0.34b	0.11c	0.24cd	1.8c	5.55b
Sw+sa	0.36b	0.13c	0.22cd	1.6c	5.49b
M+sl+p	6.81a	3.80b	12.07b	10.72b	4.31bcd
M+sl+sa	6.79a	3.90b	12.02b	10.93b	4.10bcd
Sw+m+p	0.32b	0.13c	0.13cde	0.26d	2.79e
Sw+m+sa	0.32b	0.11c	0.14cde	0.23d	2.81e
Wo+mo	6.72a	11.31a	22.81a	29.5a	32.7a
Ratoon crop					
Sw+p	0.42b	0.20c	1.29cd	5.12c	8.2b
Sw+sa	0.40b	0.18c	1.3cd	5.10c	8.1b
M+sl+p	5.38a	3.15b	13.2b	8.92b	6.3cd
M+sl+sa	5.40a	3.10b	13.1b	8.89b	6.5cd
Sw+m+p	0.41b	0.17c	0.16cde	0.92d	4.1e
Sw+m+sa	0.38b	0.14c	0.13cde	0.94d	4.2e
Wo+mo	5.30a	10.9a	24.83a	27.5a	39.3a

Means in the same column followed by the same letters are not significantly different at p = .05 (DMRT). sw+p = sweet potato 20,000 plants/ha + poultry manure (20t/ha). Sw +sa = sweet potato 20,000 plants/ha + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + poultry manure (20t/ha), Sw+m+p = sweet potato 20,000plants/ha + egusi-melon 20,000plants/ha + poultry manure (20t/ha), wo+mo = weedy and no manure.

Table 4: Weed management strategies and organic manure on 50% flowering of plantain.

Treatments	2016/2017 Planted crop	2017/2018 Ratoon crop
Sw+p	9.0c	9.2c
Sw+sa	11.0b	10.9b
M+sl+p	10.2bc	10.0bc
M+sl+sa	11.6d	11.5d
Sw+m+p	9.0c	9.0c
Sw+m+sa	11.3b	11.1b
Wo+mo	11.9a	11.7a

Means in the same column followed by the same letters are not significantly different at p = .05 (DMRT). sw+p = sweet potato 20,000 plants/ha + poultry manure (20t/ha). Sw + sa = sweet potato 20,000 plants/ha + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + poultry manure (20t/ha), Sw+m+p = sweet potato 20,000plants/ha + egusi-melon 20,000plants/ha + poultry manure (20t/ha), wo+mo = weedy and no manure.

Table 5: The weed management strategies and organic manure on plantain bunch yield components at 15 MAP.

Treatments	Number of fingers bunch^{-1}	Finger length (cm)	Finger girth (cm)	Number of hands bunch^{-1}
Sw+p	37.8a	22.3a	12.0a	6.2a
Sw+sa	22.8c	18.0c	7.9b	5.3b
M+sl+p	31.9b	20.5b	10.8ab	5.7ab
M+sl+sa	22.7c	18.9c	8.0b	4.9b
Sw+m+p	38.0a	22.5a	11.9a	6.3a
Sw+m+sa	23.0c	18.1c	7.8b	5.2b
Wo+mo	13.5d	10.4d	6.0c	4.7c
Ratoon crop				
Sw+p	38.0a	25.1a	11.7a	5.8a
Sw+sa	20.7c	20.8c	9.0c	4.8b
M+sl+p	33.0b	22.5b	10.1ab	5.0ab
M+sl+sa	20.5c	21.0c	8.9c	4.8b
Sw+m+p	38.2a	25.2a	11.7a	6.0a
Sw+m+sa	20.7c	21.1c	8.9c	5.0b
Wo+mo	12.8d	11.0d	6.3d	4.2d

Means in the same column followed by the same letters are not significantly different at p = .05 (DMRT). sw+p = sweet potato 20,000 plants/ha + poultry manure (20t/ha). Sw +sa = sweet potato 20,000 plants/ha + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + poultry manure (20t/ha), Sw+m+p = sweet potato 20,000plants/ha + egusi-melon 20,000plants/ha + poultry manure (20t/ha), wo+mo = weedy and no manure.

Table 6: Effect of weed management strategies and organic manure on plantain bunch yield(cm)

	Plantain Bunch Yield		
Treatments	Planted	Ratoon	Average
sw+p	8.0	7.8	7.90
sw+sa	4.3	4.7	4.50
sl+p	6.8	6.6	6.70
sl+sa	3.5	3.8	3.65
sw+m+p	8.1	8.2	8.15
sw+m+sa	4.5	4.7	4.20
wo+mo	0.85	0.78	0.82

Means in the same column followed by the same letters are not significantly different at p = .05 (DMRT). sw+p = sweet potato 20,000 plants/ha + poultry manure (20t/ha). Sw +sa = sweet potato 20,000 plants/ha + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + poultry manure (20t/ha), Sw+m+p = sweet potato 20,000plants/ha + egusi-melon 20,000plants/ha + poultry manure (20t/ha), wo+mo = weedy and no manure.

Partial budget analysis

The highest total variable cost/ha was obtained from the treatment involving hand slashing (Table 7). Generally, the high cost of labour involved in hand-slashing in weed management tends to

increase the total cost of production due to scarcity of labour (Ekpo et al. 2010) and (Udosen et al. 2017).

The highest total gross return/ha (N917,000) and net benefit (N745,600) were obtained from the weed management using cover crops and poultry-manure for soil fertility restoration (Table 7). This was attributed to the highest income from plantain bunch yield/ha and the income derived from the edible cover crops (sweet potato and *egusi*-melon). Similar findings of high net benefit associated with integrated weed management using edible cover crops have been reported (Nwagwu, 2004) and (Ekpo et al. 2011).

In addition, the high quality of poultry manure is incomparable with sawdust. The treatments involving sawdust reduced crop yield and net benefit significantly. The treatments of sweet potato plus sawdust; sweet potato plus *egusi*-melon plus hand-slashing plus sawdust; and *egusi*-melon plus hand-slashing plus sawdust reduced average net benefit/ha by 42.3, 43.1, and 66.6% respectively. The superiority of poultry manure to sawdust in terms of enhancing crop yield and income were reported by Idem and Udo (2017) and Emma-Okafor et al. (2017).

The weedy and unfertilized treatment plot produced N18,700 as average total gross returns/ha resulting in unprofitable enterprise by incurring a loss of N31,500 (Table 7). Similarly, Nwagwu (2004) reported zero bunch yield and income from the weedy treatment plot of plantain in Laoso, Ibadan.

Table 7: Summary of partial budget analysis of plantain, ration crop and component crops/ha (2016/2017 and 2017/2018).

	Average Gross Returns						
Treatments	Average total variable cost/ha (N 000)	Planted plantain and ration crop (N 000/ha)	Sweet potato (N 000/ha)	Egusi-melon (N 000/ha)	Average total gross returns (N 000/ha) (Total Revenue)	Net benefit (profit) (N 000/ha)	Marginal rate of returns
sw+b	161.3	646.0	204.0	-	850.0	688.7	4.3
sw+b	150.0	382.5	198.0	-	580.5	430.5	2.9
m+sl+p	209.0	569.0	-	47.08	616.08	407.08	1.9
m+sl+sa	195.7	399.5	-	44.5	444	249.0	1.3
sw+m+p	171.4	680.0	200.0	37.0	917.0	745.6	4.4
sw+m+sa	160.0	391.0	156.0	37.4	584.4	424.4	2.6
wo+mo	50.2	18.7	-	-	18.7	-31.5	-0.63

Means in the same column followed by the same letters are not significantly different at p = .05 (DMRT). sw+p = sweet potato 20,000 plants/ha + poultry manure (20t/ha). Sw +sa = sweet potato 20,000 plants/ha + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + sawdust (40t/ha). M+sl+p = hand-slashing at 3months interval + poultry manure (20t/ha), Sw+m+p = sweet potato 20,000plants/ha + *egusi*-melon 20,000plants/ha + poultry manure (20t/ha), wo+mo = weedy and no manure.

Conclusions and Recommendations

Sawdust is not as efficient as poultry manure in soil fertility restoration. Cover crop serves as low input cost compared to hand-slashing in weed suppression. Weed management strategies using *egusi*-melon integrated with sweet potato plus poultry manure (20t/ha) produced the highest gross returns, net profit and marginal rate of return; hence it is recommended.

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