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Effects of Weed Management System and Compost Manure on Plantain Yield in Agricultural Research Farm, AfahaNsit, AkwaIbom State, Nigeria

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ABSTRACT: Weed infestation and continuous decline in soil fertility tremendously reduced plantain bunch yield. Consequently, field experiments were conducted in 2016/2017 and 2017/2018 to examine weed management system and compost manure in plantain production in Agricultural Research Farm, AfahaNsit. Ten treatments were laid-out in randomized complete block design with three replicates. The treatments were sweet potato (10,000 plants/ha) plus three levels of compost manure (30, 35 and 40 t/ha); hand-slashing at two months interval plus the same three levels of compost manure; primextra (1.5kg ai/ha) plus *egusi*-melon (10,000 plants/ha) and sweet potato (integrated weed management) plus the same three levels of compost manure and control (weedy and no compost manure). Analysis of variance was carried out on data obtained on weed characteristics and plantain performance. Means were separated using Duncan Multiple Range Test at 5% probability level. The results showed that the treatment plot of primextra integrated withegusi-melon and sweet potato produced the least values in weed density, dry biomass and prolonged weed suppression followed by plot of sweet potato and hand-slashing at two months interval. The controlled treatment plot reduced plantain bunch yield (t/ha) by 93.3% in both planted and ratoon crops. The three levels of applied compost manure showed gradual increase in the growth, yield components and bunch yield of plantain in this order 40>35>30t/ha irrespective of the weed management system. The integrated weed management system, sweet potato and hand-slashing plus 40t/ha of compost manure are therefore recommended.

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Plantain (*Musa Paradisiaca* L. AAB) is among the major staples of the world with high potentials for increased production to combat hunger. It is one of the most preferred foods among urban and rural consumers of the humid forest zone of west and central Africa. In Nigeria, the consumption of plantain has risen tremendously in the last few years because of its use for the preparation of fast foods for the urban population. At the same time, there is a growing awareness in the profitability of plantain production; hence many plantations are springing up in the humid eco-region of the country (Akinyemi; Tijani- Eniola, 2001). Despite these potentials, plantain production in Nigeria has been hampered by a number of constraints, which have been identified to include soil fertility decline, diseases and weed competition. Proper weed management practices and maintenance of soil fertility are fundamentals for improving and conserving plantain production. Traditionally, the resource poor farmers who constitute the bulk of plantain growers in Nigeria deploy manual slashing in plantain production. This approach leads to huge crop losses through untimely weeding, increase cost of production and makes production of plantain a cumbersome venture (Nwagwu, 2004). Ibedu *et al. (*1993) obtained 27% greater net income from integrated use of chloramben and 'egusi'-melon at 20,000 plants for weed control in plantain than the traditional practice of three hand-weeding in the first year of plantation established in southeastern Nigeria.

Another serious problem in plantain production in the tropic is the maintenance of soil fertility. In the rainforest zone of Nigeria, a compound fertilizer (NPK 15:15:15) at the rate of 200- 400kg/ha is recommended for plantain production (Udo *et al.*, 2005). However, chemical fertilizer is currently very costly and sometimes not timely available and affordable in Nigeria. Chemical fertilizer causes problems not only to the soil but also to the human health and physical environment (Imran *et al.,* 2010). Efforts are being geared towards using alternative source of crop nutrients such as organic manure that could also improve the physicochemical properties of the soil within the framework of sustainable development. Ndukwe *et al.* (2012) reported that the fresh edible portion of plantain was highest when poultry manure was applied at 20t/ha at Onne in southeastern Nigeria and the lowest was obtained when no fertilizer was applied. Generally, the nutrient requirements of

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plantain in soils of southeastern Nigeria have been investigated mainly with inorganic fertilizers (Njoku, 1996).Therefore, this research was undertaken to assess the effects of weed management system and compost manure on plantain yield in agricultural research farm, AfahaNsit, AkwaIbom State, Nigeria

MATERIALS AND METHODS

Experimental Site: The study was conducted at Niger Delta Region (Afaha Nsit, Akwa Ibom State), Nigeria. The state lies between latitude 04°50[1]N and 05° 20[1]S and longitude 07°16[1] and 08°10[1]E. The mean annual rainfall of the experimental area is about 1800mm/ annum with a bimodal distribution; while mean daily temperature ranges from 24°c - 26°c.

Experimental Design and Layout: The experiment was laid out in randomized complete block design with three replicates each with ten treatments. The treatments were sweet potato (10,000 plants/ha) plus three levels of compost manure (30, 35 and 40 t/ha); hand-slashing plus the same three levels of compost manure; primextra (1.5kg ai/ha) plus *egusi*-melon (10,000 plants/ha) and sweet potato plus the same three levels of compost manure and control (weedy and no compost manure).

Land Preparation: The land area was measured 450m^2; while the net experimental plot was 300m^2. It was then cleared and tilled manually.

Planting and Cultural Operations: Plantain suckers and sweet potatoes vines (purple cultivar) were procured from seed multiplication centre of Akwa Ibom State Development project at Ikot Ekan, Etinan. Plantain suckers were planted 3m x 2m apart in holes dug 40cm x 40cm x 40cm. The plant population contained five stands per plot and only three were used for data collection. *Equsi*-melon (*Colocynthes citrullus*) seeds were sown three per hole and later thinned to one per stand. This gave 10,000 plants/ha while the vine of sweet potatoes (*Ipomeabatatas*) were planted 1m x 1m but three per hole and thinned to one per stand giving a population of 10,000 plants/ha. In plot p+m+sw*egusi*-melon and plantain were planted after primextra application while sweet potatoes were planted 15 weeks after the planting of *egusi*- melon in the same treatment plots. Slashing using matchet was carried out at 2, 4,6 and 8 months after planting of plantain as recommended by Nwagwu (2004). Compost manure was applied at the rate of 30, 35 and 40t/ha at planting. One follower-sucker was maintained after flowering as the ratoon crop. At every four weeks, desuckering was repeated. Bunch bearing plants were propped against wind damage. At maturity (15 months after planting) plantain bunches were harvested and the fresh weight recorded. However, only the representative samples of the fresh fruit were used for collection of data.

Composting of Weed Biomass: The fresh weed biomass was composted within two months and turned at two weeks interval to produce compost manure. The starter was mainly poultry droppings.

Soil Sampling and Analysis: The soil samples were taken at three meters interval and composited for routine soil analysis to determine the physicochemical properties of the soil.

Compost Manure and Soil Analyses: The compost manure was analyzed to determine the level of nutrients status.

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

Plantain Data: Data on agronomic characteristics were collected on Plantain at 2, 4, 6 and 8 Months after Planting

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

RESULTS AND DISCUSSION

Experimental soil and compost manure: Weeds and decline in soil fertility are serious threats to plantain production. This could be as a result of shallow rooted nature of the crop, wide spacing and the low growth rate in low soil fertility.

Table1: Pre-planting soil physical and chemical properties of the experimental site.

Soil Properties	Values
P^{H} 1:1 (H_2O)	5.1
Organic carbon (gkg^{-1})	26.0
Soil organic matter (gkg^{-1})	48.3
Total Nitrogen (gkg^{-1})	5.1
P (Mg kg^{-1})	28.6
Exchangeable cations	(cmol kg^{-1})
Ca	15.5
Mg	1.7
Na	0.9
K	0.5
Exchangeable acidity	0.2
Extractible micronutrients	Mg (kg^{-1})
Mn	180.2
Fe	17.5
Cu	0.9
Zn	11.2
Particle size	g (kg^{-1})
Sand	711.0
Silt	199.8
clay	89.2

Proper weed management practices and maintenance of soil fertility using organic manure are fundamentals

for improving the yield status of plantain (Emma-Okafor *et al.*, 2017). The experimental soil was moderate in soil fertility (Table 1). However, plantain is a heavy feeder and requires additional nutrients, hence the application of compost manure. This compost manure was relatively higher in exchangeable cations than their availability in the experimental soil (Table 2).

Table 2: Chemical properties of compost manure

pH	7.80
Ec(u/m)	569.0
Organic carbon%	28.49
Total N	2.63
C/N	10.00
Ca	16000.00
Mg	4000.00
K	2145.00
Na	1045.50
P	583.28

Weed Studies: In this study the percentage ground cover of *egusi*-melon increased from 25.6% at 4WAP to 100% at 12WAP thereafter declined (Table 3).This cover crop is a fast growing crop and within two months reached its peak growth and thereby smothered weeds and deprived the weed seeds of sunlight and moisture necessary for germination as reported by Ekpo *et al.* (2010 a). However, sweet potato suppressed weeds better than *egusi*-melon and at the same time has more longevity (100% ground coverage at 24WAP) thus provided relatively prolong seasonal weed control (Table 3).This could be attributed to having large leafy material and extricated light more than those with less leafy material Teasdale (1996) apart from relatively longer life-span due to the ability to produce high biomass, and regenerate vegetative through the succulent vine. Eneji *et al.* (1995) reported relatively low weed density and dry weight with sweet potato (10,000plants/ha) and similar results were obtained in this study.

Table 3: Percentage ground cover of egusi-melon, egusi-melon/ sweet potato and sweet potato in plantain plot

	4	8	12	16	20	24	28	32
2016/2017: **Planted crop;** Weeks after planting (WAP)								
M	25.6a	89.7a	100.0a	56.5b	27.9c	0.0	0.0	0.0
Sw	22.7a	69.16	90.0a	100.0a	100.0a	100.0a	88.3b	75.5b
	M		m+sw		sw			
M+Sw	26.0a	90.1a	100.0a	57.7b	55.3b	65.1b	100.0a	100a
2017/2018: **Ratoon crop;** Weeks after planting (WAP)								
	4	8	12	16	20	24	28	32
M	24.2a	89.7a	100.0a	56.5b	27.9c	0.0	0.0	0.0
Sw	22.7a	69.16	92.0a	100.0a	100.0a	100.0a	88.3b	75.5b
		M		m+sw		sw		
M+Sw	26.0a	90.1a	100.0a	57.7b	55.3b	65.1b	100.0a	100a

Means in a column followed by the same letter(s) are not significantly different by DMRT at 5% probability level.
Sw_1 = sweet potato (10,000 plants/ha), M = egusi-melon (10,000pantsIha), Sw_1 = sweet potato (10,000 plants/ha) + M = egusi-melon (10,000pantsIha)

Table 4: Weed density (number m^{-2} on plantain treatment plots

Treatments	**2**	**4**	**6**	**8**
2016/2017 Planted crop: Months after planting (MAP)				
Sw + C_1	16.2b	4.0c	8.1bc	14.9bc
Sw + C_2	15.9b	3.8c	7.2bc	15.2bc
Sw + C_3	16.0b	4.1c	9.0bc	15.0bc
S + C_1	49.1a	30.8b	17.0b	28.0b
S + C_2	50.9a	31.0b	16.9b	27.0b
S + C_3	52.8a	30.6b	16.6b	26.9b
P+m+sw_2+ C_1	3.8c	2.0c	10.2bc	9.0c
P+m+sw_2+ C_2	4.1c	2.1c	9.8bc	9.1c
P+m+sw_2+ C_3	3.6c	2.2c	10.1bc	8.2c
Wo+ Co	54.8a	79.8a	68.3a	60.2a
2017/2018 Ratoon crop; Months after planting				
Treatments	**2**	**4**	**6**	**8**
Sw + C_1	14.8b	5.1c	6.5bc	12.0bc
Sw + C_2	14.6b	4.8c	7.0bc	11.8bc
Sw + C_3	15.0b	5.0c	6.8bc	12.1bc
S + C_1	50.8a	28.2b	17.7b	30.2b
S + C_2	51.0a	28.0b	18.0b	29.8b
S + C_3	50.6a	27.9b	17.5b	30.5b
P+m+sw + C_1	2.7c	4.5c	8.8bc	8.9c
P+m+sw + C_2	3.0c	4.7c	9.1bc	8.7c
P+m+sw + C_3	2.8c	4.3c	8.5bc	9.1c
Wo+ Co	50.5a	82.1a	71.5a	62.8a

Means in a column followed by the same letter(s) are not significantly different by DMRT at 5% probability level. P = Primextra (1.5kg ai//ha), Sw = sweet potato (10,000 plants/ha), S =slashing at 2months interval, M = Egusi-melon (10,000 plants/ha), Sw =sweet potato (10,000 plants/ha) but planted at 16WAP (senescence of egusi – melon, C_1 = Compost manure (30t/ha), C_2 = Compost manure (35t/ha) and C_3 = compost manure (40t/ha), Wo + Co = weedy and no compost manure (control)

The initial integration of primextra (1.5kgai/ha) contributed tremendously in the initial establishment of the crop as the plot produced the lowest values of weed density (Table 4) and dry biomass (Table 5). Primextra has been the most popular used pre-emergence herbicide in the humid-rainforest zone and its effectiveness was reported by Ekpo *et al.* (2010b). The plot treated with primextra integrated with egusi-melon and sweet potato effected prolonged and effective weed suppression.This could be attributed to the early weed suppression by the herbicide followed by smothering of the weeds by egusi-melon and thereafter by sweet potato. Effectiveness and benefits of integrated weed management has been reported by Njoku (1996); Ademiluyi (2013).The hand-slashing at two months interval was also effective in weed control. This method of weed control is very common among plantain growers in Nigeria because it requires little skill and sometimes the labour is available in some rural areas in Nigeria. Timely initiation of hand-slashing at two months interval effectively suppressed the first flush of weeds and enhanced the competitive ability of plantain over subsequent weeds that emerged thus resulting in better vegetative performance and yield of plantain as reported by Nwagwu (2004).

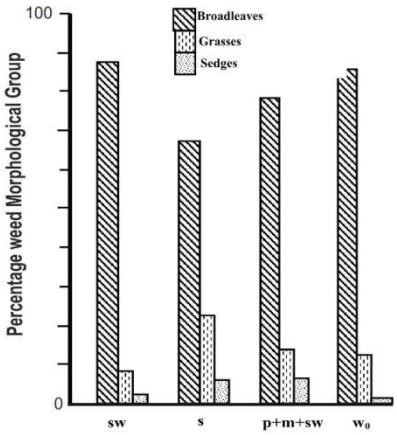

Fig. 1*:* Weed Morphological Group

Broadleaf weeds (*Calapogonium mucunoides* and *Alternantherabezzickiana*) generally dominated the experimental plots including the control for both the plant and ratoon crops of plantain. However the weed management techniques affected the morphological weed group. The dominance of broadleaves (82-86%) (Figure 1) in cover crop plots was associated with their reproductive, adaptive and survival mechanisms to tolerate shade as reported by Teasdale (1996) while the emergence of grasses in slashed plots (Figure 1) was relatively high probably the approach exposed the plot to direct sunlight which might favour grass emergence.The least weed flora across the experimental plots was the sedges this could be linked with insignificant number of the seeds or propagules in the soil seed bank of this ecosystem. In addition, changes in weed morphological groups due to weed management strategies were observed by Ekpo *et al.* (2010 a; b).

Table 5: Weed management strategies on dry weed biomass (kg/ha) in the plots of plantain production.

2016/2017 Planted crop Months after planting (MAP)				
Treatments	**2**	**4**	**6**	**8**
Sw + C_1	118b	211b	82c	59c
Sw + C_2	120b	209b	81c	59c
Sw + C_3	119b	211b	81c	58c
S + C_1	170a	163bc	155b	149b
S + C_2	173a	165bc	158b	148b
S + C_3	171a	162bc	156b	150b
P+m+sw+ C_1	70c	143c	70d	51cd
P+m+sw+ C_2	72c	140c	71d	50cd
P+m+sw+ C_3	69c	141c	70d	49cd
W_0+ Co	170a	1200a	310a	510a
2017/2018 Ratoon crop Months after planting				
Treatments	**2**	**4**	**6**	**8**
Sw + C_1	107.0b	199.3b	68.2c	55.5c
Sw + C_2	106.5b	200.0b	68.0c	56.0c
Sw + C_3	107.1b	198.7b	66.8c	55.7c
S + C_1	170.8a	154.8bc	134.8b	121.8b
S + C_2	171.0a	155.0bc	136.0b	122.0b
S + C_3	170.6a	154.6bc	136.1b	121.2b
P+m+sw + C_1	67.8c	139.0c	65.4c	48.8cd
P+m+sw + C_2	67.6c	137.8c	66.8c	49.0cd
P+m+sw + C_3	70.0c	137.6c	65.0c	49.2cd
W_0+ Co	168.8a	1188a	279.a	410a

Means in a column followed by the same letter(s) are not significantly different by DMRT at 5% probability level.P = Primextra (1.5kg ai//ha), Sw = sweet potato (10,000 plants/ha), S =slashing at 2months interval, M = Egusi-melon (10,000 plants/ha), Sw =sweet potato (10,000 plants/ha) but planted at 16WAP (senescence of egusi – melon. C_1 = Compost manure (30t/ha), C_2 = Compost manure (35t/ha) and C_3 = compost manure (40t/ha). Sw = sweet potato (10,000plants/ha), C_1 = compost manure (30t/ha), C_2 = compost manure (35t)ha), C_1 = compost manure (40t/ha), S=slashing at 2months interval, p = primextra (1.5kg)ha), M = egusi-melon (10,000pantsIha), Wo + Co = weedy and no compost manure (control)

Table 6: Weed management strategies and compost manure on 50% flowering of plantain

Treatments	**2016/2017: Plant crop**	**2017/2018: Ratoon crop**
Sw + C_1	10.6b	10.5b
Sw + C_2	10.4b	10.0b
Sw + C_3	9.2c	9.0c
S + C_1	10.5b	10.4b
S + C_2	10.5b	10.3b
S + C_3	9.3c	9.2c
P+m+sw + C_1	10.5b	10.4b
P+m+sw + C_2	10.2b	10.1b
P+m+sw + C_3	9.0c	8.9c
W_0+ Co	12.7a	12.5a

Means in a column followed by the same letter(s) are not significantly different by DMRT at 5% probability level.P = Primextra (1.5kg ai//ha), Sw = sweet potato (10,000 plants/ha), S =slashing at 2months interval, M = Egusi-melon (10,000 plants/ha), Sw =sweet potato (10,000 plants/ha) but planted at 16WAP (senescence of egusi – melon. C_1 = Compost manure (30t/ha), C_2 = Compost manure (35t/ha) and C_3 = compost manure (40t/ha). Sw = sweet potato (10,000plants/ha), C_1 = compost manure (30t/ha), C_2 = compost manure (35t)ha), C_1 = compost manure (40t/ha), S=slashing at 2months interval, p = primextra (1.5kg)ha), M = egusi-melon (10,000pantsIha), Wo + Co = weedy and no compost manure (control)

Plantain Agronomic Studies: The application of 40t/ha of compost manure and associated with suitable weed management system accelerated the time for flowering significantly for both plant and ratoon crops, hence reduced the flowering time by 27.6% and 27.2% for plant and ratoon crops of plantain respectively compared with the values obtained from the control (Table 6).This is attributed to favourable growth environment that enhanced flowering development due to the improvement of the soil physicochemical properties as supported by Emma-Okafor*et al.* (2017).

Plantain Yield: The high quantity of compost manure (40t/ha) in an uninterrupted weed environment might influence the agronomic characters due to release of available exchangeable cations; thereby influence the agronomic characters and produced the highest yield components and bunch yield than the lower levels (Table7).

Table 7: The weed management strategies and compost manure on plantain bunch yield components at 15MAP

Treatments	Number of fingers bunch^{-1}	Finger length (cm)	Finger girth (cm)	Number hands bu
Sw+c$_1$	24.6b	22.5b	9.5b	5.9b
Sw+c$_2$	28.8ab	24.6ab	10.9ab	6.3ab
Sw+c$_3$	34.3a	25.0a	11.7a	6.8a
S+c$_1$	24.8b	22.7b	9.4b	6.0b
S+c$_2$	29.0ab	24.5ab	10.9ab	6.2ab
S+c$_3$	34.3a	25.2a	11.9a	6.7a
P+m+sw+c$_1$	25.0b	22.4b	9.5b	6.0b
P+m+sw+c$_2$	29.1ab	24.6ab	11.0ab	6.3ab
P+m+sw+c$_3$	34.5a	25.3a	11.8a	6.8a
Wo+co (control)	10.3c	6.8c	5.7c	5.1c
2017/2018 Ratoon crop: Months after planting				
Treatment	**14**		**16**	**18**
Sw + C$_1$	28.8b	23.7b	10.1b	6.2b
Sw + C$_2$	31.7ab	24.7ab	10.8ab	6.8ab
Sw + C$_3$	33.8a	26.8a	12.0a	7.6a
S + C$_1$	29.0b	24.0b	9.8b	6.4b
S + C$_2$	32.0ab	25.0ab	11.0ab	7.1ab
S + C$_3$	33.6a	26.5a	11.9a	7.7a
P+m+sw + C$_1$	28.8b	23.8b	10.0b	6.4b
P+m+sw + C$_2$	32.0ab	24.0ab	10.9ab	7.0ab
P+m+sw + C$_3$	34.0a	26.8a	12.1a	7.9a
Wo+ Co	9.8c	6.5c	6.3c	5.5c

Means in a column followed by the same letter(s) are not significantly different by DMRT at 5% probability level.P = Primextra (1.5kg ai//ha), Sw = sweet potato (10,000 plants/ha), S =slashing at 2months interval, M = Egusi-melon (10,000 plants/ha), Sw =sweet potato (10,000 plants/ha) but planted at 16WAP (senescence of egusi – melon, C_1 = Compost manure (30t/ha), C_2 = Compost manure (35t/ha) and C_3 = compost manure (40t/ha); Sw = sweet potato (10,000plants/ha), C_1 = compost manure (30t/ha), C_2 = compost manure (35t)ha), C_1 = compost manure (40t/ha), S=slashing at 2months interval, p = primextra (1.5kg)ha), M = egusi-melon (10,000pantsIha), Wo + Co = weedy and no compost manure (control)

Similar result of high yield of plantain bunch was obtained from the application of 20t/ha of poultry droppings by Ndukwe *et al.* (2012). Organic manure is an agent of soil climate regulation and conservation thus contributing to crop productivity. The agronomic characters and bunch yield of plantain obtained with 30t/ha of compost manure in cover crop and hand-slashed treatments plot were significantly lower than the values obtained from the plot fertilized with 40t/ha (Table 8). This is attributed to the limited exchangeable cations available for the crop since it is a heavy feeder and competes for environmental nutrients per unit area as noted by Emma-Okafor*et al.* (2017). The probability of sustainable high productivity of plantain is only with adequate organic manure (Nwajiuba and Akinsanmi, 2002). Similarly, 35t/ha of compost manure was medium quantity hence the agronomic characters, yield components and bunch yield were intermediate between the values obtained from the high (40t/ha) and low (30t/ha) quantities of compost manure. The controlled treatment plot reduced an average plantain bunch yield (t/ha) by 93.3% in plant and ratoon crops (Table 8).

Table 8: Weed management strategies and compost manure on Plantain bunch yield (t/ha)

Treatments	Planted crops (2016/ 2017)	Ratoon crops 2017/2018
Sw + C$_1$	5.8b	6.3b
Sw + C$_2$	7.9ab	8.8ab
Sw + C$_3$	9.1a	10.3a
S + C$_1$	5.7b	6.4b
S + C$_2$	8.0ab	9.1ab
S + C$_3$	9.0ab	10.4a
P+m+sw + C$_1$	6.0b	6.5a
P+m+sw + C$_2$	8.8ab	9.0ab
P+m+sw + C$_3$	9.2a	10.6a
Wo+ Co	0.61c	0.70c

Means in a column followed by the same letter(s) are not significantly different by DMRT at 5% probability level.P = Primextra (1.5kg ai//ha), Sw = sweet potato (10,000 plants/ha), S =slashing at 2months interval, M = Egusi-melon (10,000 plants/ha), Sw =sweet potato (10,000 plants/ha) but planted at 16WAP (senescence of egusi – melonC_1 = Compost manure (30t/ha), C_2 = Compost manure (35t/ha) and C_3 = compost manure (40t/ha), Wo + Co = weedy and no compost manure (control)

The low yield is attributed to the low soil fertility and weed infestation. Similarly, Ekpo *et al.* (2010a) reported 85.6% reduction in yield of cassava. Generally, low organic matter, low reserves of essential plant nutrients and high soil acidity constitutes the main agricultural lands of south-eastern Nigeria (Udo*et al*., 2005) and has necessitated the regular application of fertilizers especially organic (Law-Ogbomo; Remison, 2008).

Conclusion: The best and sustainable weed management was the integrated weed management approach (primextra, sweet potato and *egusi*-melon). The treatments: primextra plus *egusi*-melon integrated with sweet potato; hand-slashing at two months interval; sweet potato 10,000 plants/ha;plus compost manure (40t/ha) enhanced plantain growth parameters, yield components and bunch yield.

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