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Factorial combination of manure rates and bunch pruning intensities influenced bunch physical traits of two plantain (*Musa* Spp. AAB) genotypes

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A b s t r a c t. The combined effects of three rates of poultry manure and three bunch pruning intensities on bunch physical traits of 'PITA 24' (a plantain hybrid) and 'Mbi-Egome' (a plantain landrace) were studied. Data were collected on bunch weight, number of hands per bunch, fruits per bunch, bunch-fill index, weights of hands 1- 6 (from the proximal end), fruit weight, girth and length, fruit edible proportion and pulp dry matter content. Results showed that 'PITA 24' produced significantly heavier bunches than 'Mbi-Egome'. Similar trend was observed in the number of hands and fruits per bunch, and fresh weights of the first four proximal hands. 'Mbi-Egome' however, had significantly higher values for individual fruit. Manured plants had a significant yield improvement over the control plants (no manure) however, there was a quantitative yield decline at 20 t application. The 20% pruned plants produced significantly heavier bunches and higher number of properly filled fruits. A significant increase in fruit size, bunch-fill index, fruit edible proportion, pulp dry matter content and weights of hands 1- 6 was observed as pruning intensity increased. It was concluded that harvest size of plantains could be improved through judicious use of poultry manure and bunch pruning management.

K e y w o r d s: plantains, bunch trimming, poultry manure, bunch yield, fruit physical traits

INTRODUCTION

Bananas and plantains (*Musa species* L.) are the most important tropical fruit crops (Ortiz *et al.*, 1998) and the fourth global food commodity after rice, wheat and maize, in terms of gross value of production (INIBAP, 1992). They are staple foods for rural and urban consumers, as well as, source of rural income in the humid tropics particularly in locations where small holders grow them in backyards (Chandler, 1995).

Many pests and diseases, especially black Sigatoka (caused by *Mycosphaerella fijiensis*) have significantly affected *Musa* cultivation over the years and have spurred genetic improvement programs (Persley and De Langhe, 1986). The use of resistant cultivars is considered the most appropriate component in efforts to control the diseases as improved genotypes could be readily adopted by farmers (Vuylsteke *et al.*, 1994).

'PITA 24', a secondary triploid plantain-derived hybrid, is among the *Musa* genotypes recently selected by the International Institute of Tropical Agriculture (IITA), for its biotic stress tolerance and good horticultural traits. This genotype produces a very large bunch of about 9-12 hands (nodal clusters) but only the first four proximal hands are properly filled to marketable fingers. Fruit metric traits [weight and size (length and girth)] are important commercial criteria for export bananas, as they influence the selling price in European market, same is true in Nigerian local markets particularly in cities where plantain and banana harvest is seldom sold as whole-bunch. This poor fruit-filling feature of 'PITA 24' hybrid could, therefore, have a negative impact on its adoption potential.

Fruit size is a function of the number of cells in the fruit and the size to which those cells grow (Jullien *et al.*, 2001; Luckwill, 1980). Many environmental factors interact to determine the final fruit size; these include adequate moisture, light and temperature, soil fertility management, cultivars, spacing, type of propagating material and the management of sucker succession (Dennis, 1982; Morton, 1987).

Bunch trimming *ie* decreasing sink size by removal of male bud and several distal hands from bunches soon after flowering, and judicious management of poultry manure could have the potential to increase the size, and hence grade and price of harvested fruits. Rodriguez *et al*. (1988) noted the beneficial effect of de-handing on fruit size and proposed that the distal hands, which do not reach commercial size,

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constitute a loss in respiration and represent a redistribution of dry matter which is of no commercial use. If such hands were to be removed, the expectations are that dry matter would be redistributed between the remaining hands in the bunch, and hence increase their size.

For optimum growth and fruit yield, bananas require high amounts of nutrients which are often supplied only in part by the soil (Lahav, 1995). Several inorganic fertilizer combinations have been recommended for optimum yield of plantain (Baiyeri, 2002; Ndubizu, 1981; Obiefuna, 1984a, 1984b) but inorganic fertilizers are rather too expensive for the subsistence farmers and often difficult to obtain (Brandjes *et al.*, 1989; Obatolu, 1995). Perennial production can be achieved with regular organic matter input (Swenen, 1990). The high productivity of plantains under a small-holder compound production system has always been attributed to continuous heavy applications of organic matter in the form of compound sweepings, livestock and kitchen wastes including miscellaneous waste water and wood ash thrown around the plantain and banana cultivation (Ndubizu, 1979; Nweke *et al.*, 1988; Robinson, 1996).

Animal manures are valuable sources of crop nutrients and organic matter. A high level of organic matter in the soil is beneficial; it stimulates root development, improves soil drainage, and minimizes soil temperature fluctuations, and increases soil porosity and biological life. This study was therefore, carried out to investigate the combined effects of fruit pruning and manuring on the fruit-filling capacity and final harvest size of plantains using 'PITA 24' and 'Mbi-Egome' genotypes as test crops.

MATERIALS AND METHODS

The experiment was conducted at the High Rainfall Station of the International Institute of Tropical Agriculture (IITA), Onne (4° 43'N, 7°01'E, 10 m a.s.l.), in Southern Nigeria between November 2006 and April 2008. The station is located in a degraded rainforest swamp area, characterized by an ultisol derived from coastal sediments, and an annual unimodal rainfall of 2 400 mm (Ortiz *et al.*, 1997). Average daily temperature of about 27°C and solar radiation averaging 14 MJm^{-2} prevail.

The experiment was performed in a split-split-plot laid out in a randomized complete block design (RCBD). Experimental treatments comprised of three rates of poultry manure (0, 10 and 20 t ha^{-1}), three levels of fruit pruning regime (0, 20 and 40%) and two genotypes-'PITA 24' and 'Mbi Egome', thus, a total of 18 treatment combinations. Each treatment combination *ie* sub-subplot treatment was replicated four times, and each replicate consists of five plants, giving rise to 20 plants per treatment combination.

Poultry manure was split-applied as 50% at planting and the complement at the onset of flowering (six months after planting). Pruning was carried out on nodal clusters (hands) at the distal end of the bunch as soon as the last hand emerged. Male bud was also severed in all the treatments except the control (no-prune) plants.

Micro-propagated suckers were planted in holes measuring 40 x 40 x 40 cm in dimensions and spaced 3 m between rows and 2 m within row. Half the manure dose applied at planting was placed in the planting holes before planting and the complement applied top-dressed. Each plant received 15 g of Furadan 5G to control plantain weevil (*Cosmopolites sordidus* Germar) and root knot nematodes. A follower-sucker, as ratoon crop, was maintained after flowering. De-suckering was repeated routinely at every 4-6 weeks. Weeds were regularly control- led using a systematic herbicide 'Round-up' and bearing plants were propped against wind damage. Prior to field planting, the experimental site and poultry manure samples used were duly characterized following the analytical procedures described in AOAC (1990).

Data were collected on bunch weight (kg), number of hands per bunch, total fruit count per bunch and number of properly-filled fruits per bunch. Bunch fill index (%) was calculated as the ratio of properly-filled fruits to total fruit count per bunch multiplied by 100. Others were fresh weights (kg) of hands 1-6 (proximal hands), fruit weight (g), length and girth (cm) of the four middle fingers on each reference hand. Pulp fresh weight (g) of the fruits was determined after manual peeling. The pulp fraction was oven-dried at 65°C for 48 h to determine the dry matter content (%), which was calculated as the dry weight : fresh weight ratio multiplied by 100. Data were analyzed as factorial in randomized complete block design using GENSTAT 5.0 Release 4.23 DE (GENSTAT, 2003).

RESULTS

The soil was characterized as sand loam (Table 1). The site was acidic with moderate fertility. The NPK and organic matter contents were considered moderate.

Table 2 showed a significant ($P < 0.05$) clonal variability on most of the bunch and fruit traits studied at harvest. 'PITA 24' had a better value for bunch weight, number of hands and fingers per bunch, number of properly-filled fingers and the respective weights of the first four proximal hands. 'Mbi-Egome' however had correspondingly higher values for bunch fill index, fruit weight, girth, edible proportion and pulp dry matter content.

A significant ($P< 0.05$) clone-by-manure interaction effect was observed on most of the traits studied (Table 3). The 10 t application rate produced the best results in most cases. This was evident in bunch yield, the respective hand weights, fruit weight, girth, length, edible proportion and pulp dry matter content. In both clones, bunch and fruit traits improved with manure application but there was a quantitative decline at 20 t application.

T a b l e 1. Physical and chemical properties of the experimental site and poultry manure sample utilized for the study

Properties	Substrate		
	Top soil (0-15 cm)	Subsoil (15-30 cm)	Poultry manure
Granulometric distribution			
Sand (%)	69	67	–
Silt (%)	7	7	–
Clay (%)	24	26	–
Chemical properties			
pH in water	4.5	5.5	6.5
Organic C (%)	1.72	1.28	35.40
Organic matter (%)	2.97	2.21	61.02
Total N (%)	0.17	0.13	1.56
Total P (%)	0.01	0.01	1.40
Zinc (mg kg^{-1})	6.15	10.72	11.36
Iron (mg kg^{-1})	298	266	313.2
Copper (mg kg^{-1})	1.65	0.85	–
Manganese (mg kg^{-1})	43	34	–
Exchangeable cations ($cmol^{+}$ kg^{-1})			
Potassium	0.34	0.30	–
Calcium	5.14	3.72	–
Magnesium	0.34	0.26	–
Sodium	0.43	0.43	–
Acidity	0.17	0.42	–
ECEC	6.42	5.13	–

There was a non-significant clone-by-prune interaction effect on most of the traits studied (Table 4). As expected, number of hands and fingers per bunch significantly ($P< 0.05$) decreased with increasing pruning intensity. The 20% pruned plants produced the heaviest bunch in both clones. In ‘Mbi-Egome’, the 20% prune-derived bunches and the control were significantly ($P< 0.05$) heavier than that of the 40 percent pruned, but in ‘PITA 24’ the bunch weights of the pruned plants were heavier than the control (no-prune). The number of properly-filled fingers and bunch fill index significantly ($P< 0.05$) increased with increasing prune intensity in ‘PITA 24’, however properly-filled fruits decreased in ‘Mbi-Egome’ as the pruning intensity increased. In both clones, the respective hand weights, fruit weight, girth, length, edible proportion and pulp dry matter all improved with increasing pruning intensity, and were superior in the 40% pruned bunches.

Table 5 showed a non-significant manure-by-prune interaction on most of the traits studied. Except in bunch fill index for which the control (no manure) plants that were 40% pruned had the highest value (91.9 %), the best bunches came from 10 t plants that were either 20 or 40% pruned. This was evident in the bunch weight, number of properly- filled fingers and the respective hand weights. A combination of 10 t manure application rate and 40% bunch pruning regime produced the best quality fruits. The poorest fruits came from the intact (no-prune) plants that received 20 t of poultry manure.

DISCUSSION

Variability in efficiency of resource conversion into dry matter has been observed in *Musa* species, and may be related to differences in genomes (Baiyeri and Tenkouano, 2008; Robinson, 1996; Stover and Simmonds, 1987). The

Table 2. Main effect of clone on plantain bunch and fruit quality traits

Clone	Bchwt (kg)	After prune nHds (#)	After prune nFgs (#)	PFF (#)	BFI (%)	Hand weight (kg) Hd1	Hd2	Hd3	Hd4	Hd5	Hd6	Whole-bunch mean values FW (g)	FG (cm)	FL (cm)	FEP (%)	PDMC (%)
PITA 24	16.4	8.4	150.0	84.7	59.6	3.1	2.9	2.5	2.0	1.6	1.2	115.1	10.5	22.3	49.5	25.9
Mbi-Egome	12.4	5.6	70.9	69.8	98.8	2.8	2.6	2.3	1.9	1.6	1.5	157.3	12.2	22.5	59.6	36.8
$LSD_{(0.05)}$	0.6	0.1	2.3	6.2	4.3	0.2	0.2	0.2	ns	ns	0.1	10.5	0.3	ns	1.7	0.6

Bchwt – bunch weight, nHds – number of hands per bunch, nFgs – number of fingers per bunch, PFF – number of properly filled fruits, BFI – bunch fill index, Hd – Hand, # – number, FW – fruit weight, FG – fruit girth, FL – fruit length, FEP – fruit edible proportion, PDMC – pulp dry matter content, $LSD_{(0.05)}$ – least significant difference at 5% probability level, ns – not significant.

Table 3. Combined effects of clone and varying manure application rates on plantain bunch and fruit quality traits

Clone	Manure (kg)	Bchwt (kg)	After prune nHds (#)	After prune nFgs (#)	PFF (#)	BFI (%)	Hand weight (kg) Hd1	Hd2	Hd3	Hd4	Hd5	Hd6	Whole-bunch mean values FW (g)	FG (cm)	FL (cm)	FEP (%)	PDMC (%)
	0	16.5	8.2	140.9	87.4	65.2	3.1	2.8	2.5	2.0	1.6	1.3	116.4	10.5	22.5	49.7	26.7
PITA 24	10	17.4	8.6	155.0	85.3	57.5	3.3	3.2	2.7	2.2	1.7	1.3	127.6	11.0	23.2	52.1	26.9
	20	15.3	8.5	154.0	81.5	56.2	3.0	2.8	2.4	1.8	1.4	1.1	101.4	10.1	21.3	46.7	24.1
	0	11.4	5.4	65.5	65.0	99.4	2.5	2.3	2.0	1.7	1.5	1.4	150.3	12.0	22.5	58.5	36.6
Mbi-Egome	10	13.1	5.6	71.8	70.9	99.0	3.0	2.7	2.4	2.1	1.7	1.6	164.8	12.5	22.6	61.1	36.8
	20	12.9	5.7	75.4	73.6	98.1	2.9	2.8	2.4	2.0	1.7	1.6	156.8	12.1	22.5	59.7	37.1
$LSD_{(0.05)}$		1.0	ns	ns	6.6	4.2	ns	0.2	0.2	0.2	0.2	0.2	10.5	0.4	0.8	2.2	ns

Explanations as in Table 2.

T a b l e 4. Combined effects of clone and fruit pruning on plantain bunch and fruit quality traits

Clone	Pruning regime (%)	Bchwt (kg)	After prune		PFF (#)	BFI (%)	Hand weight (kg)						Whole-bunch mean values				
			nHds (#)	nFgs (#)			Hd1	Hd2	Hd3	Hd4	Hd5	Hd6	FW (g)	FG (cm)	FL (cm)	FEP (%)	PDMC (%)
	0	15.7	10.8	182.5	71.9	40.9	2.9	2.7	2.2	1.7	1.3	1.0	98.2	10.2	21.0	47.4	24.5
PITA 24	20	17.3	8.5	152.7	91.5	60.5	3.2	3.0	2.6	2.1	1.6	1.3	119.8	10.6	22.7	49.8	26.5
	40	16.3	6.6	118.8	90.9	77.5	3.4	3.1	2.8	2.2	1.8	1.4	127.5	10.8	23.3	51.2	26.7
	0	12.9	7.0	85.5	82.0	96.9	2.5	2.3	2.0	1.7	1.5	1.4	137.8	11.7	21.6	58.9	36.8
Mbi-Egome	20	13.0	5.8	74.4	74.2	99.8	2.9	2.6	2.3	1.9	1.7	1.5	151.4	12.1	22.2	59.1	36.6
	40	11.4	4.2	53.6	53.4	99.8	3.0	2.8	2.5	2.1	1.7	1.7	182.8	12.7	23.8	61.3	36.9
$LSD_{(0.05)}$		1.0	0.2	5.6	5.6	4.2	ns	ns	ns	ns	ns	ns	10.1	ns	0.7	ns	ns

Explanations as in Table 2.

T a b l e 5. Combined effects of manure and fruit pruning on plantain bunch and fruit quality traits

Manure ($t\ ha^{-1}$)	Pruning regime (%)	Bchwt (kg)	After prune		PFF (#)	BFI (%)	Hand weight (kg)						Whole-bunch mean values				
			nHds (#)	nFgs (#)			Hd1	Hd2	Hd3	Hd4	Hd5	Hd6	FW (g)	FG (cm)	FL (cm)	FEP (%)	PDMC (%)
	0	14.2	8.5	123.9	76.6	71.6	2.6	2.4	2.0	1.6	1.4	1.1	122.5	11.3	21.7	54.4	31.3
0	20	14.8	6.9	105.6	81.4	83.4	3.0	2.7	2.3	1.9	1.6	1.3	141.0	11.5	23.0	55.4	31.1
	40	12.9	5.2	80.2	70.6	91.9	2.9	2.6	2.3	1.9	1.6	1.5	153.5	11.7	23.8	56.0	32.5
	0	14.9	8.7	131.9	76.0	69.1	2.8	2.6	2.2	1.8	1.4	1.2	122.0	11.0	21.4	54.2	31.1
10	20	15.6	7.2	115.9	83.8	79.6	3.1	2.9	2.5	2.1	1.7	1.5	136.4	11.4	22.4	55.1	32.0
	40	15.3	5.6	92.3	74.6	89.1	3.5	3.1	3.3	2.4	2.0	1.6	163.5	12.0	23.8	56.9	32.4
	0	13.9	9.2	139.0	78.1	66.1	2.7	2.5	2.1	1.6	1.4	1.2	109.6	10.5	20.6	50.9	29.6
20	20	15.0	7.3	119.1	83.3	77.5	3.1	2.8	2.5	2.0	1.6	1.3	129.3	11.1	22.0	52.9	31.5
	40	13.4	5.3	86.0	71.2	87.9	3.1	3.1	2.6	2.1	1.7	1.6	148.5	11.6	23.1	55.9	30.6
$LSD_{(0.05)}$		ns	ns	ns	ns	ns	ns	ns	0.2	ns	ns	ns	ns	ns	ns	ns	ns

Explanations as in Table 2.

larger bunch yield found in 'PITA 24' may be a function of its genetic make-up and could be attributed to a stronger competitive sink as seen in the greater fruit number per bunch. A high significant positive correlation between bunch weight and number of fruits per bunch has been established (Baiyeri and Ortiz, 1995; Baiyeri and Tenkuoano, 2008); meaning that genotypes like 'PITA 24' that produce a great number of fruits are likely to produce heavy bunches.

The significant effect of the applied manure on the bunch and fruit traits is attributable to the better plant nutrition provided by the manure application. Animal manure is a valuable source of crop nutrients and organic matter, which can improve soil biophysical conditions thereby making the soil more productive and sustainable for food production (Baiyeri and Tenkouano, 2007). The quantitative decline in bunch and fruit yield observed at 20 t manure application suggests that adequate quantities of nutrient elements were supplied by the 10 t application rate. A similar yield decline was observed in muskmelon (Ijoyah, 2007) on application of decomposed poultry manure above 30 t ha^{-1}.

The yield decline observed in the present study is probably nutritional and could be due to changes in soil reaction and the consequent nutrient solubility or fixation. Soil pH increases progressively with the application and subsequent decomposition of poultry manure (Amanullah, 2007). In any case, very high pH values (7.5-8.5) will adversely affect the availability of phosphorus (Mugwira, 1979) and that of most cationic micronutrients which are more available at low pH values. Tisdale and Nelson (1975) also noted the accumulation of copper in the soil as one of the problems of excessive use of poultry manure.

Organic amendments such as poultry manure are often applied to supplement soil N.

Application of N-fertilizer to crops promotes vegetative growth, in some cases to the disadvantage of harvestable product (Baiyeri, 2002). This author found a similar depression in yield and harvest index of plantains above 448 kg N ha^{-1}.

The improvement in bunch and fruit yield observed with pruning could be attributed to the reduction in sink size, thereby concentrating assimilates in a smaller sink volume. In other words, pruning assured that assimilates were not wasted on the non-essential portions of the bunch, but channelled for the optimum growth of the remaining fruits. An inverse relationship seems to exist between the fruit number and the overall fruit quality (Ferris *et al.*, 1995). This could be affirmed by the better fruit quality (weight, size, pulp dry matter and edible proportion) found in 'Mbi-Egome' and the pruned bunches that had fewer number of fingers per bunch.

CONCLUSIONS

1. The harvest size and the overall fruit physical traits of plantains could be improved through judicious use of poultry manure and bunch pruning management.

2. 'PITA 24' had a better bunch yield than the landrace 'Mbi-Egome', but the landrace produced superior fruits in terms of fruit size, edible proportion and pulp dry matter content.

3. The 10 t poultry manure application rate produced the best quality fruits. There was a quantitative yield decline at 20 t application.

4. A combination of 10 t ha^{-1} of poultry manure yearly with 20% pruning of the nodal clusters gave the best bunch traits, but to produce extra large fruits, 40% pruning could be applied without a significant economic loss to the farmer.

5. These practices are therefore, recommended for plantain growers particularly on the highly weathered Oxisols of the humid tropics, not only for improved harvest but also for soil fertility maintenance, yield sustainability and a greater potential for suckering *ie* on-farm multiplication.

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