Journal of Animal & Plant Sciences, 2009. Vol. 3, Issue 2: 215 - 226.
Publication date: 15 June 2009, http://www.biosciences.elewa.org/JAPS; **ISSN 2071 - 7024**

Effects of poultry manure and bunch pruning management on fruit size, shelf life and pulp colour of 'PITA 24' and 'Mbi-Egome' plantains (*Musa* sp. AAB group)

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Key words
Plantains, de-handing, manuring, fruit size, shelf life, pulp colour.

1 SUMMARY

Fruit size is an important commercial characteristic for markets specializing in plantains. Bunch pruning and appropriate soil fertility management are measures adopted to improve the fruit size of *Musa* crops in many countries. This study investigated the combined effects of poultry manure and bunch pruning intensity on fruit metric traits, shelf life and pulp colour of 'PITA 24' (a plantain hybrid) and 'Mbi-Egome' (a plantain landrace). The effects of poultry manure applied at 0, 10 or 20 t/ha and bunch pruning at 0, 20 or 40 % intensity were studied on fruit metric traits (weight, length, girth, edible proportion), shelf life and pulp colour of 'PITA 24' and 'Mbi-Egome' plantains. Micro-propagated suckers were used in the study. Poultry manure was split-applied as half the calculated dose during planting (using a split combination of top-dressing with base placement), and the complement applied at the onset of flowering (i.e., 6 months after planting) as top-dressing. Bunch pruning, the removal of male bud with some two or more hands of fruits, was carried out at the distal portion of the bunch as soon as the last hand emerged. Pruning intensity denotes the proportion of the entire hands of fruits (borne on the infrutescence) that was severed during pruning. Compared to no-manure treatment, bunch yield and individual fruit size increased when manure was applied at 10t/ha. However, yield and fruit size decreased significantly ($P < 0.05$) when manure was applied at 20 t/ha, relative to the 10 t/ha rate, which could be related to mineral imbalances or excesses that occur when large amounts of poultry manure or compost are used. Shelf life decreased from 16 to 14 days, while pulp lightness (*L) increased significantly ($P < 0.05$) following manure application. In contrast, pulp yellowness (*b) and redness (*a) declined with increasing manure rate. A sequential improvement in fruit size, shelf life and pulp colour (*b and *a) was observed with increased pruning intensity. There was no significant weight difference between the non-pruned bunches and those pruned at 40% intensity. However, bunch weight was heaviest in the plants pruned at 20% intensity. In both clones, pulp lightness decreased with ripeness while *b and *a values were highest at senescence. 'Mbi-Egome' produced bigger fruits of deeper pulp yellowness and redness, whereas bunch weight was heavier in 'PITA 24'. This study revealed that bunch pruning improves the overall fruit quality of plantains, and that benefits

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of pruning management would be enhanced by combining bunch pruning with 10 t/ha of poultry manure per annum.

2 INTRODUCTION

Fruit size, weight, flesh firmness, colour and shape influence the consumer's choice (De Salvador *et al.*, 2006). These traits combined determine the fruit price in the export and Nigerian local markets, particularly in cities where plantain and banana harvest is seldom sold as whole bunch. Consumers often prefer larger fruits and associate high quality with bunches that have a few, but large fruits (10 – 20) per bunch as typified in horn plantains (Ferris *et al.*, 1996).

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

Internal limitations to fruit growth due to competition for photo-assimilates within the plant are well known (Dennis, 1982). In bananas, competition occurs between fruit development and male bud growth, and between every newly formed hand and its predecessor resulting in a progressive decrease in hand size from the proximal to the distal extremities of the infrutescence (Stover and Simmonds, 1987). The distal hands which do not reach commercial size, therefore, constitute a loss as they represent a redistribution of dry matter which is of no commercial use (Rodriguez *et al.*, 1988).

Bunch pruning entails the removal of male bud (de-budding) with one or more hands of fruit from the distal end of the bunch. When the relatively small fruits are severed, the remaining larger fruits not only have enough leaves to feed them, but also have a greater potential for growth (Krauss *et al.*, 1999). In many fruit trees, pruning or 'fruit thinning' improves fruit colour and organo-leptic or sensory qualities, reduces limb breakage and promotes general tree vigour, thus producing fruits of more alluring appearance at harvest (Relf, 1997).

The hypothesis that early removal of distal fruits from a bunch could increase yield of first-grade fruits has been tested on bananas and plantains in the tropics and semi-tropics. Irizarry *et al.* (1991) reported that bunch trimming of 'Superplatano' plantain caused a gross yield decline which nullified the benefits from increased length and better grade of the remaining fruits. A similar result was found on 'Williams' banana by Daniells *et al.* (1994). However in a study on 'Dominica harton' and 'Africa' plantain cultivars, Quintero and Aristizabal (2003) reported that de-handing reduced the number of fingers from 50 to 40, but led to a substantial increase in the mean fruit weight and length of the pruned bunches over the non-pruned. Weerasinghe and Ruwanpathirana (2004) reported a similar result in 'Embul', 'Kolikuttu' and 'Ash' plantain cultivars. An increase in the weight and size of fruits resulting from the selective removal of hands was also reported for different cultivars of plantains by Prasannakumariamma *et al.* (1986). An extension in green-life of fruits due to bunch pruning has been reported in banana (Daniells & Foster, 2001; Weerasinghe & Ruwanpathirana, 2004).

Plant nutrition is another vital determinant of the quality of fruits at harvest (Rice *et al.*, 1994). For optimum growth and fruit yield, bananas require large amounts of nutrients which could be supplied through a judicious use of manure of poultry or other origin. Animal and green 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 & Tenkouano, 2007). Thus, a great proportion of plantain and banana crops benefits from the application of large doses of household refuse which is high in organic matter.

This experiment was designed to study the combined effects of poultry manure and bunch pruning management on fruit size, shelf life and pulp colour variability in 'PITA 24' and 'Mbi-Egome' plantains. Pulp colour is an important indicator of carotenoid content of the fruit. Carotene is a pre-cursor of pro-vitamin A, an important vitamin for proper sight development.

3 MATERIALS AND METHODS

3.1 Experimental site: The experiment was conducted at the High Rainfall Station of the International Institute of Tropical Agriculture, Onne (4^0 43'N, 7^0 01'E, 10 m a.s.l.), Rivers state, Nigeria. The station is located in a degraded rainforest swamp, soils are ultisol derived from coastal sediments, and receives an annual unimodal rainfall of 2400mm (Ortiz *et al.*, 1997); average daily temperature is about 27^0C and solar radiation averages 14 MJM^{-2} .

3.2 Design of experiment: The experiment was laid-out as a split-split-plot in a randomized complete block design (RCBD). Treatments comprised of three rates of poultry manure (0, 10 and 20 t/ha), three levels of fruit pruning regime (0, 20 and 40 % pruning of the nodal clusters) and two plantain genotypes-'PITA 24' and 'Mbi-Egome'. Each treatment combination (i.e., sub-subplot treatment) was replicated four times, and each replicate consisted of five plants, giving rise to 20 plants per treatment combination.

3.3 Treatment application: Three-month-old suckers produced *in-vitro* were used in the study. These were spaced 3m x 2m in planting holes measuring 40 x 40 x 40cm in dimensions. Poultry manure was split-applied as half the calculated dose during planting and the complement at the onset of flowering (6 months after planting) following the recommendations of Baiyeri and Tenkouano (2007). 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 severed in all the treatments except the control (no-prune) plants. Other necessary cultural practices as described in Swennen (1990) were duly observed. Prior to field planting, the soils at the experimental site and poultry manure samples were analyzed as described by the AOAC (1990).

3.4 Data collection and analysis: At harvest, data were collected on bunch weight (kg), fruit weight (g), length and girth (cm) of the four middle fingers on each hand. Pulp fresh weight (g) of the fruits was determined after manual peeling. The pulp weight: fruit weight ratio was calculated to estimate the edible proportion of the fruits. The pulp and peel fractions were oven-dried at 65 ^{0}C for 72 hrs to determine the fruit moisture content (%).

3.5 Pulp colour determination: The colour of the pulp was quantitatively determined with the aid of an electronic hand-held Colour Tec PCM/PSM™1 colour meter to estimate the β-carotene (pro-vitamin A) content in the second proximal hand of the bunch following the recommendations of Baiyeri and Ortiz (2000) and Adeniji *et al.* (2006 and 2008). During the measurement, the nosecone and sensor of the colour meter was placed at the middle of the cut transverse surface of the fruit just after a sharp cut (to prevent browning of the cut surface) and pressed down firmly and flatly against the surface to avoid the penetration of external light. On pressing the DO key, the meter generates a set of values: ***L** (degree of lightness), ***a** (degree of redness) and ***b** (degree of yellowness), the latter, being the most important as it relates to the β-carotene content of the pulp. The corresponding values of ***L**, ***a** and ***b**, which represent the reflectance of the sample viewed by the sensor (as displayed by the colour meter) were compared to Colour-Tec™CIE LAB Colour Chart to ascertain the pulp colour magnitude. Readings were respectively taken immediately after harvest (at green stage), at 50 percent ripeness (i.e., 50 % yellow stage), at full ripeness (100% yellow stage), and at senescence when the peel was completely black.

3.6 Determination of fruit shelf life: Shelf life of the fruits on the second proximal hand was studied at room temperature (25 ^{0}C). Data were collected on the number of days to 50% ripeness, number of days to full ripeness and days to complete senescence. The fruits were examined on daily basis to ascertain the least number of days it took any of the fruits on the reference hand to attain the respective stages of ripeness. All data were analyzed as factorials in randomized complete block design using GENSTAT 5.0 Release 4.23 DE (GENSTAT, 2003).

Table 1: Physicochemical properties of the experimental site and poultry manure sample used in the study.

PROPERTIES	Substrate	
	Soil	Poultry manure
Particle size		
Sand (%)	68	-
Silt (%)	7	-
Clay (%)	25	-
Textural class	**Sandy loam**	
Chemical properties		
pH in water	5.0	6.5
Organic matter (%)	2.59	61.02
Total Nitrogen (%)	0.15	1.56
Total Phosphorus (%)	0.01	1.40
Potassium (%)	0.96	1.69
Zinc (ppm)	8.44	11.36
Iron (ppm)	282	313.2
Copper (ppm)	1.25	-
Manganese (ppm)	38.5	-
ECEC ($cmol^+/kg$)	5.78	-

4 RESULTS

The experimental site was an acidic sandy loam with moderate fertility (Table 1). The NPK and organic matter contents were considered moderate. Data (table 2) shows a significant ($P < 0.05$) clonal variability in most of the fruit quality traits studied. Fruit size (fresh weight, girth and length) as well as the edible proportion were higher in 'Mbi-Egome'.

This clone also had significantly ($P < 0.05$) less moisture in the fruits, suggesting a higher dry matter content. 'PITA 24', however produced a higher bunch weight.

For all levels of poultry manure, fruit traits improved substantially with increasing pruning intensity (Fig. 1). A decline in bunch weight and fruit metric traits was observed on further application of poultry manure beyond 10 t/ha. The best quality fruits (in terms of size, weight and edible proportion) were obtained from a combined application of 10 tonnes of manure and 40 percent pruning of the nodal clusters. Bunch weight was

heaviest when 10 t/ha of poultry manure was applied in combination with 20 percent pruning (Fig. 1). Fruit moisture content increased progressively with manure application, but reduced substantially with pruning across the manure rates.

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Publication date: 15 June 2009, http://www.biosciences.elewa.org/JAPS; **ISSN 2071 - 7024**

Table 2: Clonal variability in plantain fruit characteristics†

Clone	Bch wt (kg)	FW (g)	FG (cm)	FL (cm)	EP (%)	MC (%)
PITA 24	16.4	115.1	10.5	22.4	49.5	82.4
Mbi-Egome	12.4	157.3	12.2	22.6	59.7	73.4
$LSD_{(0.05)}$	0.6	10.5	0.3	ns	1.7	0.7

Bch wt = Bunch weight; FW = Fruit fresh weight; FG = Fruit girth; FL = Fruit length; EP =Fruit edible proportion; MC = Fruit moisture content; $LSD_{(0.05)}$ = Least significant difference at 5% probability level; ns = Non-significant. Fruit traits data were presented as whole-bunch mean values.

Table 3: Clonal variability in shelf life and pulp colour of plantain fruits at different physiological stages of ripeness.

Clone	DR_{50}	DFR	SL	Green stage *L	Green stage *a	Green stage *b	50 % Yellow stage *L	50 % Yellow stage *a	50 % Yellow stage *b
PITA 24	4.2	6.0	14.5	80.3	- 1.4	32.4	78.6	- 0.5	35.8
Mbi-Egome	4.5	6.6	16.0	78.7	5.8	37.6	77.3	6.1	40.5
$LSD_{(005)}$	ns	0.4	0.7	0.7	0.4	1.4	0.8	0.4	1.4

Clone	100 % yellow stage *L	100 % yellow stage *a	100 % yellow stage *b	Senescence stage *L	Senescence stage *a	Senescence stage *b	Mean values across ripening stages *L	Mean values across ripening stages *a	Mean values across ripening stages *b
PITA 24	76.6	- 0.3	38.3	69.3	- 0.4	40.7	76.2	-0.6	36.8
Mbi-Egome	75.0	6.5	43.5	66.4	7.5	46.0	74.4	6.5	41.9
$LSD_{(005)}$	1.1	0.4	0.2	1.6	0.3	0.2	0.6	0.3	0.7

A significant ($P < 0.05$) genotypic variability in shelf life and pulp colour rating at different stages of fruit ripeness was observe (table 3). The number of days to 50% ripeness was similar in both clones. 'PITA 24' ripened earlier and had a shorter shelf life than 'Mbi-Egome'. The higher values of ***L** in 'PITA 24' at the different stages of ripeness indicated a lighter pulp. 'Mbi-Egome' however, had higher values for pulp redness (***a**) and yellowness (***b**) at all stages of ripeness.

The effect of manure on fruit shelf life and pulp colour traits is shown on Table 4. The numbers of days to 50% ripeness were fairly similar for the three manure rates. Fruits from the manured plots ripened and senesced faster than the control. Manured plants produced fruits of lighter pulp colour at all the stages of ripeness. The mean values across the four stages of ripeness indicate that manure significantly ($P < 0.05$) influenced the pulp colour. The degree of pulp lightness (***L**) increased with increasing manure rate while pulp redness and yellowness decreased.

A non-significant pruning effect was observed in most of the shelf life and pulp colour traits studied (Table 5). Days to 50% ripeness and number of days to complete ripeness were similar across the pruning regimes. Shelf life however, slightly increased with pruning. There was a significant ($P < 0.05$) increase in the pulp yellowness (as observed from the mean values) as the intensity of pruning increased. The degree of pulp redness also slightly increased as the pruning intensity increased at the different stages of ripening.

Figure 2 shows the increase in pulp lightness observed with manuring, showing a slight depression at 40 percent pruning. Pulp redness and yellowness rather improved with pruning, and were higher at lower doses of manure. Results (Table 6) showed a significant ($P < 0.05$) effect of ripeness on pulp colour variables. In both clones, the degree of pulp lightness decreased sequentially with increasing

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ripeness while redness and yellowness increased as the fruit ripens and were highest at the senescent stage.

Table 4: The main effect of manure on shelf life and pulp colour of plantain fruits at different physiological stages of ripeness

Manure (t/ha)	DR_{50}	DFR	SL	Green stage *L	Green stage *a	Green stage *b	50 % Yellow stage *L	50 % Yellow stage *a	50 % Yellow stage *b
0	4.3	6.5	16.2	79.1	2.3	34.8	77.8	3.1	38.3
10	4.3	6.0	14.9	79.0	2.4	35.0	77.9	2.9	38.0
20	4.5	6.3	14.6	80.3	2.0	35.1	78.1	2.6	38.2
$LSD_{(005)}$	ns	0.4	ns	1.1	ns	ns	ns	0.2	ns

Manure (t/ha)	100 % yellow stage *L	100 % yellow stage *a	100 % yellow stage *b	Senescence stage *L	Senescence stage *a	Senescence stage *b	Mean values across ripening stages *L	Mean values across ripening stages *a	Mean values across ripening stages *b
0	75.0	3.1	41.2	66.5	3.8	43.7	74.6	3.1	39.5
10	76.5	3.2	40.7	67.5	3.6	43.3	75.2	3.0	39.3
20	76.0	3.0	40.8	69.6	3.2	43.1	76.0	2.7	39.3
$LSD_{(005)}$	1.1	ns	ns	1.3	0.4	0.4	0.8	0.2	ns

DR_{50} = Number of days to 50 % ripeness (50 % yellow stage) ; DFR= Number of days to full ripeness (100 % yellow stage); SL= Shelf life; *L= Degree of pulp lightness; *a= Degree of pulp redness; *b= Degree of pulp yellowness; $LSD_{(0.05)}$= Least significant difference at 5% probability level; ns= Non-significant.

5 DISCUSSION

The marked differences observed in fruit size, pulp colour and other fruit traits between the two clones were largely due to differences in some loci. 'PITA 24' is a maternal grand-offspring of 'Mbi-Egome', but the introgression of some genes via the paternal parent, though led to increased bunch weight, but reduced its fruit quality (in terms of fruit size, weight, pulp fraction and pulp colour). Similar opinion was earlier reported (Adeniji *et al.*, 2007).

The use of colour meter is a cheap and quick method of ranking *Musa* varieties by colour assessment as a proxy for total carotenoids (Lusty *et al.*, 2006). The colour variation observed between the clones confirmed the genotypic differences that exist and influence pigment composition or pulp browning potential in *Musa* fruits (Tourjee *et al.*, 1998; Adeniji *et al.*, 2006 & 2008). A close relationship exists between pulp colour and β-carotene content — which increases with fruit yellowness (Lusty *et al.*, 2006).

The improvement in bunch and fruit size observed in this study as a result of manure application was made possible by nutrients released by the poultry manure. Poultry manure, the richest of the animal manures, is a valuable source of nutrients and organic matter, particularly nitrogen and potassium (Ani & Baiyeri, 2008), which are crucial elements in the nutrition of *Musa* crops (Lahav, 1995).

The decline in bunch weight and the poor quality of fruits obtained at 20 tonnes/ha manure application, suggest that adequate quantities of nutrient elements were supplied by the 10 tonnes rate. Optimum nutrient supply results in the production of high quality and better nutritious plants (Rice *et al.*, 1994).

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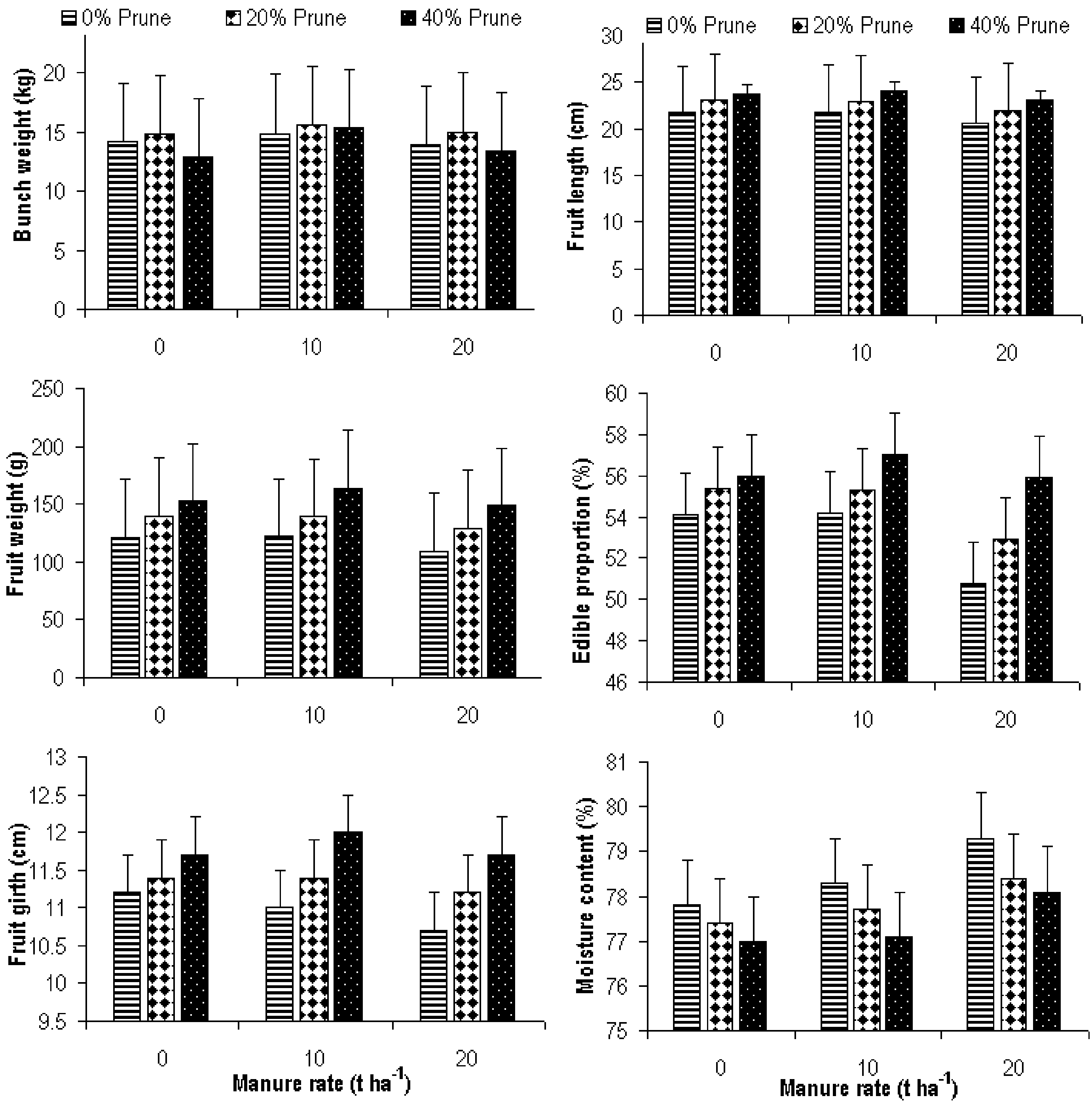

Figure 1: Bunch weight and individual fruit characteristics as influenced by bunch pruning management at varying manure rates.

The yield decline observed in the present study could be related to mineral imbalances or excesses which can occur when large amounts of poultry manure or compost are used (Patriquin *et al.*, 1995). Soil pH increases progressively with the application and subsequent decomposition of poultry manure (Amanulla, 2007). Very high pH values (7.5 - 8.5) will adversely affect the availability of phosphorus (Mugwira, 1979) and most cationic micronutrients which are more available at low soil pH. Weil and

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Kroontje (1979) found the application of poultry manure at rates below 20 t ha^{-1} very useful in boosting crop yields, but at higher rates (above 20 t ha^{-1}) phytotoxic quantities of ammonium nitrate and salt are released.

The progressive improvement in fruit size, pulp colour and other fruit quality traits observed with pruning could be attributed to the reduction in available sink size; thereby concentrating assimilates in a smaller sink volume. Pruning assured that assimilates were not wasted on the non-essential portions of the bunch, but channeled for the optimum growth of the remaining fruits.

Table 5: Effect of varying bunch pruning regimes on shelf life and pulp colour of plantain fruits at different physiological stages of ripeness

				Green stage			50 % Yellow stage		
Prune (%)	DR_{50}	DFR	SL	*L	*a	*b	*L	*a	*b
0	4.5	6.2	14.9	79.9	2.1	34.7	77.7	2.9	38.0
20	4.2	6.5	15.1	79.6	2.1	34.3	78.0	2.7	37.8
40	4.3	6.2	15.7	78.9	2.6	35.9	78.1	2.9	38.6
$LSD_{(005)}$	ns	ns	ns	ns	0.4	1.0	ns	ns	0.7

	100 % yellow stage			Senescence stage			Mean values across ripening stages		
	*L	*a	*b	*L	*a	*b	*L	*a	*b
0	75.4	3.1	40.9	67.6	3.5	43.3	75.1	2.9	39.2
20	75.9	3.1	40.7	68.2	3.5	43.4	75.4	2.8	39.1
40	76.1	3.1	41.1	67.8	3.6	43.3	75.2	3.1	39.7
$LSD_{(005)}$	ns	ns	ns	ns	ns	ns	ns	ns	0.6

DR_{50} = Number of days to 50 % ripeness (50 % yellow stage) ; DFR= Number of days to full ripeness (100 % yellow stage); SL= Shelf life; *L= Degree of pulp lightness; *a= Degree of pulp redness; *b= Degree of pulp yellowness; $LSD_{(0.05)}$= Least significant difference at 5% probability level; ns= Non-significant.

An increase in the weight and size of *Musa* fruits resulting from the selective removal of hands has been reported by several authors (Prasannakumariamma *et al.*, 1986; Irizarry *et al.*, 1991; Daniells *et al.*, 1994; Quintero & Aristizabal, 2003; Weerasinghe & Ruwanpathirana, 2004). An extension in green life / shelf life of fruit due to bunch pruning, similar to the result obtained in the present study, had earlier been reported in bananas (Daniells & Foster, 2001; Weerasinghe & Ruwanpathirana, 2004). This could be due to the higher food reserves accumulated in the larger fruits which may take a longer time to breakdown by the catalytic action of endogenous enzymes during respiration.

The genotypic response to ripeness and shelf life suggested variability in climacteric initiation related to morphological and physiological traits (Ferris *et al.*, 1996). The smaller fruits of 'PITA 24' hybrid ripened and senesced faster than the larger 'Mbi-Egome' fruits. The hybrid also had a higher fruit moisture content which may further predispose

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it to growth of fungi and other moulds that could accelerate senescence.

Table 6: Combined effects of clone and fruit ripening stage on pulp color indices of plantains.

		Pulp colour indices		
Clone	Stage of Ripeness	Lightness	Redness	Yellowness
PITA 24	Green stage	80.3	-1.4	32.4
	50 % yellow stage	78.6	-0.5	35.8
	100 % yellow stage	76.6	-0.3	38.3
	Senescence	69.3	-0.4	40.7
LSD $_{(0.05)}$ (Within clone comparison)		0.1	0.3	0.7
Mbi-Egome	Green stage	78.7	5.8	37.6
	50 % yellow stage	77.3	6.1	40.5
	100 % yellow stage	75.1	6.5	43.5
	Senescence	66.4	7.5	46.0
LSD $_{(0.05)}$ (Within clone comparison)		0.9	0.3	0.5
LSD $_{(0.05)}$ (Between clone comparison)		0.9	0.2	ns

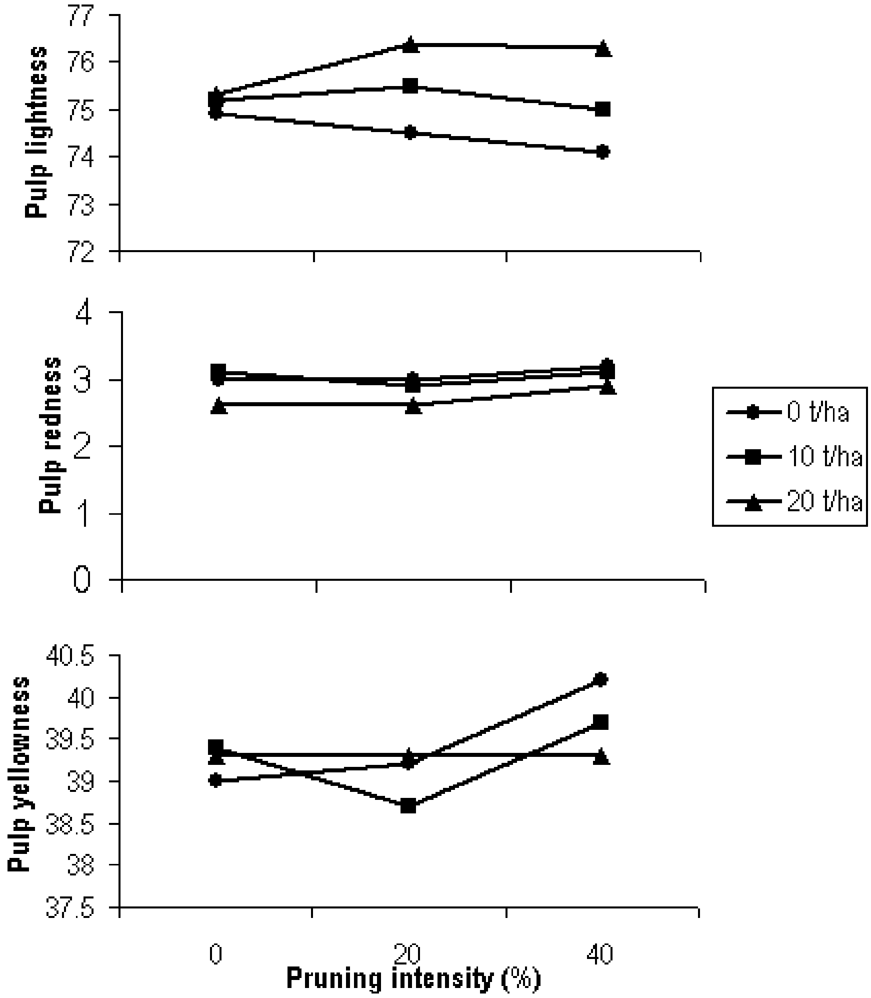

Figure 2: Pulp colour indices as influenced by manuring and bunch pruning management.

The improvement in pulp colour (***a**- and ***b** values) observed as the fruits ripen may not necessarily mean a progressive accumulation of β-carotene as ripening progresses. Rodriguez-Amaya (1997) suggested that the yellowing of the fruit pulp during ripening is caused by the breakdown of chlorophyll pigments; a process which reveals the carotenoids rather than by carotenoid biosynthesis, as occurs in apricot, mango and paw-paw fruits. Research has shown that carotenoid content in plantain fruits could decline as much as 50 – 75 percent during ripening (Giami and Alu, 1994; Ngoh Newilah, 2005). In any case, over-ripe fruits or fruits with senesced peel are still of economic importance in some localities. In western Nigeria, the pulp of such fruits is ground with maize or guinea corn and boiled as pottage (Baiyeri & Unadike 2001). The utilization of over-ripe fruits in wine production has also been documented (Adeniji, 1995).

This study revealed a progressive improvement in the overall fruit quality of plantains with bunch pruning; however, bunch pruning management should be combined with 10 t ha^{-1} of poultry manure per annum for optimum result.

6 REFERENCES

Adeniji, T. A.: 1995. Recipe for plantain / banana wine. MusaAfrica 8: 23-24.

Adeniji, T. A., Sanni, L. O., Barimalaa, I. S. & Hart A. D.: 2006. Determination of micronutrients and colour variability among new plantain and banana hybrids flour. World Journal of Chemistry 1 (1): 23-27.

Adeniji, T. A., Sanni, L. O., Barimalaa, I. S. & Hart, A. D.: 2007. Nutritional composition of five new Nigerian *Musa* hybrid cultivars: implications for adoption in human nutrition. Fruits 62(3): 135-142.

Adeniji, T. A. & Tenkouano, A.: 2008. Effect of processing and storage on the colour of plantain and banana products. Agro-Science 7(2): 88-92.

Amanullah, M. M.: 2007. Nutrient release pattern during composting poultry manure. Research Journal of Agriculture and Biological Sciences 3 (4): 306 – 308.

Ani, J. U. & Baiyeri, K. P.: 2008. Impact of poultry manure and harvest season on juice quality of yellow passion fruit (*Passiflora edulis* var. Flavicarpa Deg.) in the sub-humid zone of Nigeria. Fruits 63: 239-247.

AOAC.: 1990. Official methods of analysis of the Association of Official Analytical Chemists, 5th ed., AOAC, Arlington, Virginia, USA.

Baiyeri, K. P. & Ortiz, R.: 2000. Agronomic evaluation of plantain and other triploid *Musa.* In: Proceedings of the 1st International Conference of Banana and Plantain in Africa, Kampala, Uganda, 12 – 18th October, 1996. [Craenen, K., Ortiz, R., Karamura, E. B. & Vuylsteke, D. R., eds.], International Society for Horticultural Sciences, Acta Horticulturae 540: 125-135.

Baiyeri, K. P. & Unadike, G. O: 2001. Ripening stages and days after harvest influenced some biochemical properties of two Nigerian plantains (*Musa* species AAB) cultivars. Plant Product Research Journal 6: 11 – 19.

Baiyeri, K. P. & Tenkouano, A.: 2007. Manure placement influenced growth and dry matter yield of a plantain hybrid. African Crop Science Conference Proceedings 8: 385-390.

Baiyeri, K. P. & Tenkouano, A.: 2008. Fruit characteristics and ripening pattern of ten *Musa* genotypes in a sub-humid environment in Nigeria. Fruits 63 (1): 3-9.

Daniells, J. W. & Foster, S.: 2001. Is the number of hands relative to leaf number important? Queensland Department of Primary Industries, Banana Topics 31: 16–19.

Daniells, J. W., Lisle, A. T. & Bryde, A.: 1994. Effect of bunch trimming and leaf removal at flowering on maturity, bronzing, yield and other aspects of fruit quality of bananas in north Queensland. Australian Journal of Experimental Agriculture 34: 259-265.

Dennis, F. G.: 1982. Fruit Development. In: Physiological basis of crop growth and development. American Society of Agronomy, USA , 265-289.

De Salvador, F. R., Fisichella, M. & Fontanari, M.: 2006. Correlations between fruit size and fruit quality in apple trees with high and standard crop load levels. Journal of Fruit and Ornamental Plant Research 14 (2): 113-122.

Ferris, R. S. B., Adeniji, T., Chukwu, U., Akalumhe, Y. O., Vuylsteke, D. & Ortiz, R.: 1996. Post harvest quality of plantains and cooking bananas. In: Plantain and Banana – production and research in West and Central Africa [Ortiz, R. & Akoroda, M. O., eds.]. Proceedings of a regional workshop, held at High Rainfall Station, Onne, Rivers state, Nigeria 23-27th September, 1995. Published by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, 15-22.

GENSTAT: 2003. GENSTAT 5.0 Release 4.23DE, Discovery Edition 1, Lawes Agricultural Trust, Rothamsted Experimental Station.

Miami, S. Y. & Alu, D. A.: 1994. Changes in the composition and certain functional properties of ripening plantain (*Musa* spp. AAB group) pulp. Food Chemistry 50: 137-140.

Mugwira, L. M.: 1979. Residual effect of dairy cattle manure on millet and rye forage and soil properties. Journal of Environmental Quality 2: 251-255.

Irizarry, H., Rivera, E., Krikorian, A. D. & Rodriguez, J. A.: 1991. Proper bunch management of the French type ‘Superplantain’ (*Musa* AAB) in Puerto Rico. Journal of Agriculture of the University of Puerto Rico, 75: 163-171.

Jullien, A., Munier-Jolian, N. G., Malezieux, E., Chillet, M. & Ney, E. : 2001. Effect of pulp cell number and assimilate availability on dry matter accumulation rate in a banana fruit [*Musa* sp. AAA group ‘Grande Naine (Cavendish subgroup)]. Annals of Botany 88: 321 – 330.

Krauss, U., Figueroa, R., Johanson, A., Sreralo, E., Anguiz, R., Cabezas, O. & Garcia, A.: 1999. *Musa* Clones in Peru: Classification, uses, production potentials and constraints. INFOMUSA 8(2): 19-26.

Lahav, E.: 1995. Banana nutrition. In: Banana and plantains [Gowen, S., ed.], Chapman and Hall, London, 258 –316.

Luckwill, L. C.: 1980. Hormones and the productivity of fruit trees. Scientia Horticulturea, 31: 60-68.

Lusty, C., Akyeampong, E., Davey, M. W., Ngoh Newilah, G. & Markham, R.: 2006. A staple food with nutritious appeal. INFOMUSA 15: 39-43.

Morton, J.: 1987. Banana. In: Fruits of warm climates, Julia F. Morton, Miami, 29-46.

Ngoh Newilah, G.: 2005. Utilisation alimentaire, caractérisation physico-chimique et biochimique des fruits de vuelques cultivars et hybrides de bananiers et plantains produits au Cameroun. PhD Thesis, Université de Yaoundé. 131pp.

Ortiz, R., Austin, P. D. & Vuylsteke, D.: 1997. IITA high Rainfall Station: Twenty years of research for sustainable agriculture in the West African Humid Forest. Hortscience 32(6): 969-972.

Patriquin, D. G., Baines, D. & Abboud, A.: 1995. Diseases, pests and soil fertility. In: Soil management in sustainable agriculture. [Lee, J. A. & Cook, H. F., eds.], Wye College Press, England, 161-174.

Prasannakumariamma, A. S., Babylatha, A. K., Pushkaran, K. & Kurien, T. M.: 1986. Studies on the effect of removing terminal hands and male bud on the yield and fruit size of banana *Musa* (AAB group) ‘Palayankodan’, South Indian Horticulture 34(4): 204-209.

Quintero, J. A. S. & Aristizabal, M. L.: 2003. Effects of dehanding on the production characteristics of plantain ‘Dominico Harton’ and ‘Africa’ in Colombia. InfoMusa 12(1): 44-46.

Relf, D.: 1997. Fruit Thinning. In: The Virginia Gardener Handbook, Virginia Tech, Blacksburg, Virginia Co-operative Extension Electronic Publication,VA24061-0327.

Rice, R. P., Rice, L. W. & Tindal, H. D.: 1994. Fruits and vegetable production in warm climates, Macmillan Press Ltd, Hong Kong, 486pp.

Rodriguez-Amaya, D. B.: 1997. Carotenoids and food preparation: the retention of provitamin A carotenoids in prepared, processed and stored foods. OMNI project, 88pp.

Rodriguez, J. A., Irizarry, H. & Rivera, E.: 1988. Efecto de la poda de manos en el rendimiento calidad de las frutas del platano (*Musa* acuminate x *Musa* balbisiana, AAB) In: ACORBAT memories VIII reunion (Jaramillo, R., Restrepo, A. & Bayona, R., eds.) AUGURA, Medellin, Colombia. 537-541.

Stover, R. H. & Simonds, N. W.: 1987. Banana (3rd ed.) Longman Scientific and Technical, England. 468pp.

Swennen, R.: 1990. Plantain cultivation under West African conditions: a reference manual. IITA, Ibadan, Nigeria. 24pp.

Tourjee, K. R., Barrett, D. M., Romero, M. V. & Gradziel, T. M.: 1998. Measuring flesh colour variability among processing Clingstone Peach genotypes differing in carotenoid composition. Journal of American Society of Horticultural Science 123 (3): 433-437.

Weerasinghe, S. S. & Ruwanpathirana, K. H.: 2004. Effect of de-handing on bunch characteristics of banana. Annals of the Sri Lanka Department of Agriculture 6: 227-235.

Weil, R. R. & Kroontje, W.: 1979. Physical condition of Davision Clay Loam after five years of poultry manure application. Journal of Environmental Quality 8: 387-3.