Tropical and Subtropical Agroecosystems, 14 (2011): 261 -270

EFFECT OF THE TIME OF POULTRY MANURE APPLICATION AND CULTIVAR ON THE GROWTH, YIELD AND FRUIT QUALITY OF PLANTAINS (*Musa* spp. AAB)

[EFECTO DEL MOMENTO DE LA APLICACIÓN DE GALLINAZA Y EL CULTIVAR SOBRE EL CRECIMIENTO, PRODUCCIÓN Y CALIDAD DE PLATANO MACHO (*MUSA* SPP. AAB)]

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SUMMARY

The influence of time of poultry manure application: no application, at planting, 1, 2 and 3 months after planting (MAP) were determined on the growth, yield and fruit quality of two plantain (*Musa* spp. AAB) cultivars (PITA 17 and French Reversion). PITA 17 significantly produced more standing leaves, fruits with longer green and shelf life. French Reversion significantly produced taller plants, heavier bunches and fruits, wider and longer fruits. Dry matter partitioning to the pulp, pulp degree of lightness and redness were also higher for French Reversion than PITA 17. The application of poultry manure at 2 MAP produced heaviest bunches and the highest yield components while pulp dry matter and fruit shelf life duration were highest with manure application at 3 MAP. Bunch and fruit weights were heaviest in French Reversion plots applied with poultry manure at 2 MAP whereas shelf life was longest with PITA 17 that received manure application at planting.

Key words: Poultry manure; Application time; Plantain; Bunch yield; Fruit quality.

RESUMEN

Se evaluó la influencia del momento de aplicación: no aplicación, 1, 2 y 3 meses después de siembra (MAP) sobre el crecimiento, producción y calidad del fruto de dos cultivares de plátano macho (*Musa* spp. AAB) (PITA 17 y Frech REversion). PITA 17 produjó más hojas y frutos con mejor tiempo de vida verde y de anaquel. French Revesion produjó plantas más altas frutos más pesados, anchos y largos. Las características del fruto fueron mejores para French Reversion. La aplicación de gallinaza a 2 MAP produjó los racimos más pesados y los mayores rendimientos de componentes del fruto, mientras que el contenido de materia seca y la vida de anaquel fue mejor cuando la pollinaza se aplicó 3 MAP. Los racimos y los frutos fueron más pesados en las parcelas de French Reversion con gallinaza 2 MAP mientras que la vida de anaquel fue mayor para PITA 17 con aplicación de gallinaza a la siembra.

Palabras clave: Gallinaza; momento de aplicación; plátano macho; producción de racimos; calidad del fruto.

INTRODUCTION

Plantain (*Musa* sp. AAB) is one of the important staple foods in the tropical and sub-tropical regions of the world (Englberger *et al*., 2006). The fruit is an important source of carbohydrate, vitamins, proteins, potassium, iron, calcium, carotenes and ascorbic acid and also contains moderate amounts of thiamine, riboflavin, nicotinic and folic acid (Rasheed, 2003). Per capita consumption could be as high as 150 kg in some traditional production areas of West and Central Africa (Vuylsteke *et al*., 1997). Plantain therefore plays a key role in the economy and food security of producer countries.

The demand of nutrient by a growing crop generally varies through the growing season, with the highest uptake associated with the period of most rapid growth. Timing of nutrient application, therefore, ensures the availability of the nutrient when the crop needs them. This will also avoid nutrient losses which can be before and after periods of crop demand which in the long run results in waste of resources. Magdoff (1995) reported the essentiality of the synchrony of plant-available soil nutrients and crop nutrient demand for optimum crop performance and environmental protection.

Plantains require high amounts of nutrients for optimum growth and fruit production but these nutrients are often supplied in part by the soil (Lahav, 1995). This is one of the reasons why in the West and Central African regions, the crop is predominantly cultivated in the home gardens where it receives continuous supply of organic matter and nutrients from household refuse (Baiyeri and Tenkouano, 2007). There is, therefore, the need for external inputs of nutrients, especially for commercial plantain production. This could either be organic materials (such as animal waste, which is mostly in the form of feaces, compost manure and farmyard manure) or inorganic fertilizers. Animal manure is a source of nutrients and organic matter, which could improve soil bio-physical conditions (Munoz *et al*., 2004) for sustainable food production. The superiority of poultry manure over other organic manures had been reported by Follet *et al*. (1995). Jinadasa *et al*. (1997) also reported that poultry manure increased soil pH, organic matter content, available phosphorus, exchangeable cations and micronutrients as well as reduced soil salinity and extractable ions.

There is scarcely any information on the time of poultry manure application to plantain despite the fact that the crop is predominantly cultivated in mono-as well as mixed-cropping systems with the application of organic materials. There is need to determine the right time to apply the manure in order to boost bunch yield and fruit quality. This investigation was, therefore, carried out to study the growth, yield and fruit quality responses of plantain to time of poultry manure application.

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 south-south Nigeria between 2006 and 2008 (two consecutive cropping cycles). The meteorological data (Fig. 1) showed that the distribution pattern of the annual rainfall, monthly rainfall and evaporation varied across the two years. It was observed that there was a moisture deficit in some months of the first cropping cycles (from November 2006 till January 2007) whereas moisture was adequate in the corresponding period in 2007/2008. Composite soil sample from ten (10) points depth of 0-15 cm within the experimental site was used for routine analyses. A sample from the poultry manure used was also analysed for some physicochemical properties. The soil sample and poultry manure analyses (Table 1) indicated that the soil of the experimental site was sandy loam with acidic reaction and relatively low in nitrogen (N), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn) and iron (Fe) and the poultry manure contained high amount of organic carbon, N, K, Ca, Mg, Zn and Fe. The pH of the manure was relatively neutral (7.2) which should be able to reduce the level of acidity as found in the experimental site.

Table 1. The physicochemical characteristics of the soil (0-15 cm depth) and the poultry manure

	Substrate	
	Soil	Poultry manure
Physical properties		
pH (H_20)	5.30	7.20
Sand (%)	76.67	-
Silt (%)	8.00	-
Clay (%)	15.33	-
Textural class	Sandy loam	-
Chemical properties		
Nitrogen (g/kg)	1.3	15.6
Phosphorus (mg/kg)	49.10	14.0
Potassium (g/kg)	1.4	17.9
Calcium (cmol/kg)	2.06	3.76
Magnesium(cmol/kg)	0.13	0.41
Organic carbon (%)	1.37	42.95

Four different times of poultry manure application were compared. These were at planting (ATP), 1, 2, and 3 months after planting (MAP). No manure application was used as the control. Baiyeri and Tenkouano (2007) recommended 20 t/ha poultry manure for plantain cultivation.Two plantain cultivars namely, PITA 17 and French Reversion were the test cultivars. The PITA 17 is a tetraploid plantain hybrid which is characterized by high yield with black sigatoka disease resistance, earliness to flowering, short stature and faster cycling (Ortiz and Vuylsteke, 1998). The French Reversion, a landrace is a false horn plantain cv. Agbagba reversed into French plantain following *in vitro* propagation (Vuylsteke *et* al., 1991). It is characterized by heavy bunches (Swennen *et al*., 1995). Horticultural propagation of corm explants using sawdust medium (Tenkouano *et al*., 2006) was the source of the suckers. The experimental layout was a 2 x 5 factorial arrangement fitted into randomised complete block design with three replications. Each of the replicates consisted of the two cultivars with single-row plots of four plants per time of poultry manure application. The poultry manure rate was 20 t/ha and was applied according to the treatment specification in the plant crop. The application in the ratoon crop was at the onset of flowering. The plant spacing was 3 m x 2 m, giving a total of 1667 plants/ha. Weeds were controlled by the application of a systemic herbicide, 'Round-up'. Other crop management practices for plantain were carried out as recommended by Swennen (1990). The growth and black sigatoka disease data were taken at flowering. The youngest leaf spotted (by the black sigatoka fungus, *Mycosphaerella fijiensis*) and the index of non-spotted leaves (INSL) were parameters for assessing the black sigatoka disease response of the cultivars.

INSL= [(YSLF-1)/NSLF] x 100 (Craenen, 1998)

Where, YSLF=Youngest leaf spotted at flowering; NSLF= Number of standing leaves at flowering.

The yield and yield components were taken at harvest. Data collected were subjected to analysis of variance using GENSTAT Release 7.2DE, Discovery Edition 3 (GENSTAT, 2007). The data analysis was carried out as a combined analysis since there was non-significant differences (P>0.05) in most of the parameters in the plant and ratoon crops.

RESULTS

Phenology and growth responses

Flowering and harvest were 59 and 39 days earlier, respectively in the cultivar PITA 17 than the French Reversion (Table 2). The French Reversion was however, taller and the fruits filled earlier (97 days) than PITA 17 (114 days). The values for total number of leaves at flowering, youngest leaf spotted, index of non-spotted leaves and height of tallest sucker at flowering were significantly (P<0.05) higher with PITA 17.

Among the growth parameters, the time of poultry manure application influenced only the number of days to flowering and harvesting (Table 2). The application of poultry manure at planting reduced the number of days to flowering and harvest by 20 and 17 days respectively, in comparison with the control. The poultry manure application at 3 MAP had the longest duration for both number of days to flowering and harvesting. Fig. 2 showed that the cultivar x time of poultry manure application interaction significantly (P<0.05) influenced the number of days to flowering and fruit filling with PITA 17 cultivar flowering earlier but the fruits took longer time to fill than French Reversion at any time of manure application and even at no application. The application of poultry manure application at planting in either of the cultivar reduced the number of days to flowering, PITA 17 being the most responsive. This reduction was greater in PITA 17 when it received poultry manure at 2 MAP. Fruit filling period was earliest in French Reversion without poultry manure but longest in PITA 17 irrespective of the time of poultry manure application.

Bunch yield and fruit characteristics

Bunch weight per plant, bunch yield per hectare, number of hands per bunch, fruit weight, fruit circumference and length as well as pulp dry matter content were significantly (P<0.05) higher for French Reversion than PITA 17 but the number of fruits per bunch and pulp moisture content were higher in PITA 17 (Table 3). The above ground biomass, harvest index (economic yield) and fruit edible proportion (the pulp) however, were statistically similar for the two cultivars. The application of poultry manure at 3 MAP produced significantly lowest economic yield (19.31%) and accumulated the least moisture in the pulp while the application of poultry manure at 1 MAP had the highest value (21.54%) for economic yield and pulp moisture content (Table 3). The pulp dry matter content was highest with poultry manure application at planting and 3 MAP.

The bunch weight per plant, number of fruits per bunch, fruit weight, fruit circumference and bunch yield/ha were significantly (P < 0.05) affected by the interaction of the cultivar and time of poultry manure application (Table 4). The interaction also influenced the pulp dry matter and pulp moisture content (Figs. 3 and 4). The application of poultry manure to French Reversion at 2 MAP produced heavier fruits (192.3 g) and bunches per plant (16.42 kg) and per hectare (27.38 t/ha) than the other manure treatments. French Reversion always had higher pulp matter content, heavier and bigger fruits than PITA 17 at all times of poultry manure application whereas PITA 17 had more number of fruits per bunch and higher moisture content in the pulp than French Reversion irrespective of the time of manure application. Within and between cultivar comparisons showed that the application of poultry manure at 3 MAP had least moisture accumulation in the pulp with French Reversion being the most responsive.

Table 2. Main effects of cultivar and time of poultry manure application on plantain phenology, growth and black sigatoka disease response parameters.

Parameter	Number of days to flowering	Number of days to fruit filling	Number of days to harvest	Plant Height (cm)	Plant girth (cm)	Number of standing leaves	Youngest leaves spotted	Index of non spotted leaves (%)	Height of tallest sucker at flowering (cm)
Cultivar									
PITA 17	357.70	114.47	469.6	362.70	67.10	10.98	8.66	68.77	189.30
French Reversion	416.80	97.18	508.40	392.80	66.34	9.39	7.10	64.88	134.00
$LSD_{0.05}$	10.46	2.97	10.03	10.38	ns	0.40	0.45	3.12	19.90
Time of poultry manure application									
ATP	375.00	106.97	473.60	373.40	67.41	10.13	7.85	66.52	175.90
1 MAP	386.30	106.56	490.70	377.30	66.58	9.80	7.75	68.18	147.40
2 MAP	378.60	105.41	482.00	372.50	66.30	10.66	8.26	67.70	163.10
3 MAP	401.30	106.25	500.10	385.50	66.65	10.14	7.78	66.58	155.20
Control (No application)	395.00	103.94	498.80	380.30	66.66	10.22	7.74	65.15	166.70
$LSD_{0.05}$	16.55	ns	15.85	ns	ns	ns	ns	ns	ns

ATP = At planting; 1, 2 and 3 MAP = One, two and three months after planting, respectively.

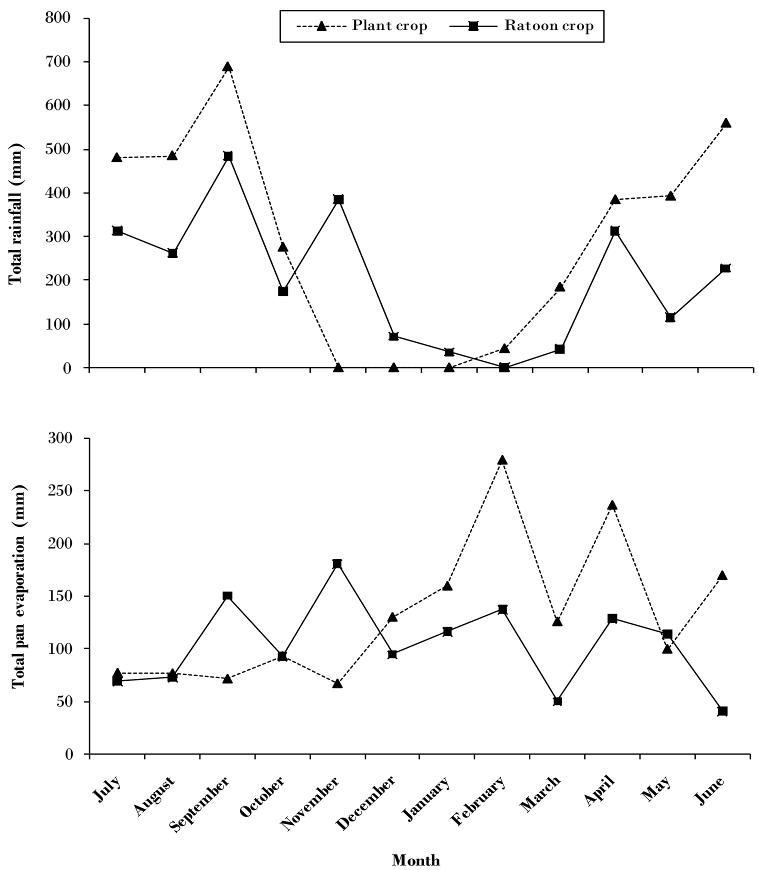

Figure 1. The total rainfall and evaporation of the experimental site in the plant and ratoon crops (July, 2006 to June, 2008). The durations for the plant and ratoon crops are July, 2006 to June, 2007 and July, 2007 to June 2008, respectively.

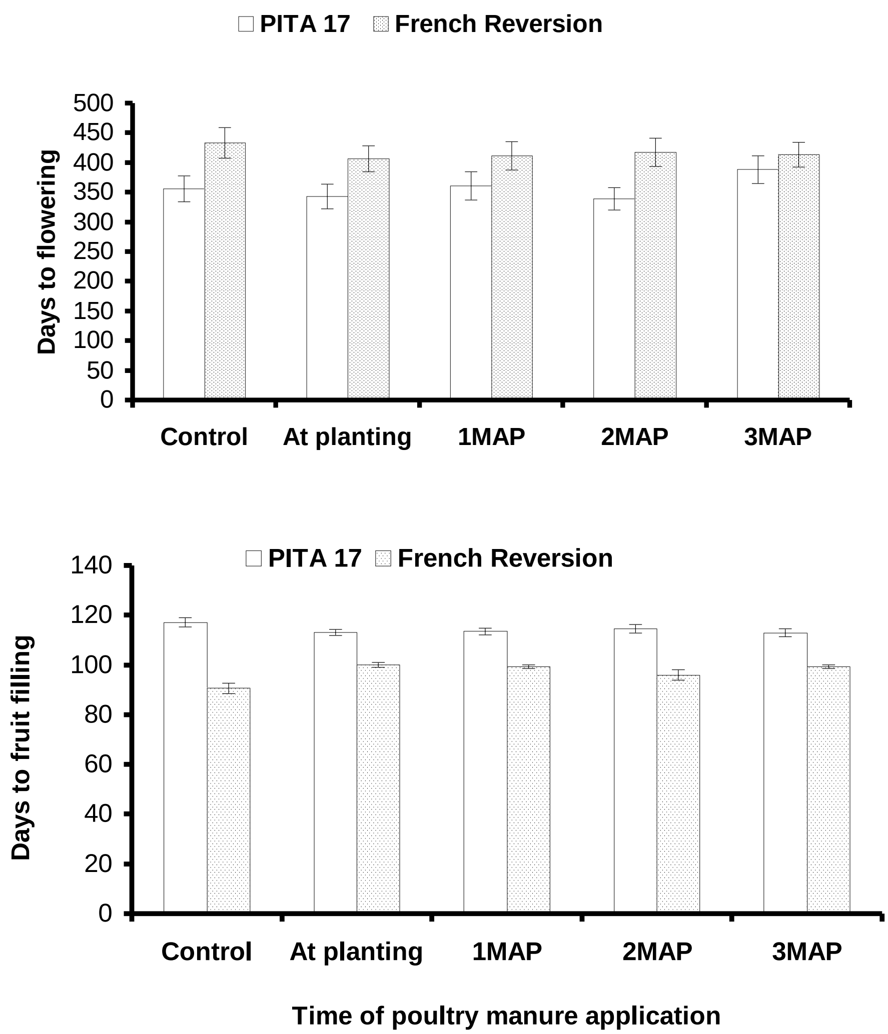

Fig. 2: Genotype x time of poultry manure application interaction on the days to flowering and days to fruit fillng of plantain. Vertical bars represent standard errors of means. 1, 2, 3 MAP = one, two and 3 months after planting, respectively

Table 3. Main effects of cultivar and time of poultry manure application on yield and yield components of plantain

Parameter	Bunch weight per plant (kg)	Number of hands per bunch	Number of fruits per bunch	Fruit weight (g)	Fruit circ. (cm)	Fruit length (cm)	Bunch yield (t/ha)	Pulp dry matter (%)	Pulp moisture content (%)	Fruit edible proportion (%)	Harvest index (%)	Above ground biomass (%)
Cultivar												
PITA 17	13.62	7.05	107.7	140.60	11.94	18.55	22.71	36.09	63.94	61.50	20.65	68.80
French Reversion	15.35	7.48	93.2	186.00	12.81	23.34	25.59	40.48	59.53	59.40	21.15	73.30
$LSD_{0.05}$	0.95	0.24	4.87	8.00	0.20	0.54	1.59	0.53	0.52	ns	ns	4.57
Time of poultry manure application												
ATP	14.65	7.29	100.1	161.60	12.37	21.01	24.41	38.32	61.74	68.10	21.35	69.80
1 MAP	14.76	7.38	100.4	165.30	12.47	20.69	24.61	37.67	62.37	58.70	21.54	70.50
2 MAP	14.81	7.43	103.1	167.10	12.46	21.17	24.70	38.14	61.89	58.20	21.37	70.60
3 MAP	13.60	7.12	97.7	157.40	12.09	20.81	22.67	39.15	60.82	58.30	19.31	71.70
Control	14.62	7.11	100.9	165.20	12.49	21.03	24.37	38.17	61.86	58.90	20.94	72.60
$LSD_{0.05}$	ns	ns	ns	ns	ns	ns	ns	0.83	0.82	ns	1.40	ns

ATP = At planting; 1, 2 and 3 MAP = One, two and three months after planting respectively.

Table 4: Interaction effect of cultivar-by-time of poultry manure application on the growth and yield parameters of plantain

		Growth parameters				Yield parameters						
Cultivar	Time of manure application	Plant height (cm)	Plant girth (cm)	Number of standing leaves	Index of non spotted leaves (%)	Bunch weight kg)	Number of hands per bunch	Number of fruits per bunch	Fruit weight (g)	FCR (cm)	Fruit length (cm)	Bunch yield (t/ha)
PITA 17	ATP	357.50	68.63	11.00	69.07	13.91	7.06	107.00	142.10	12.1	18.65	23.18
	1 MAP	366.30	66.69	10.67	70.19	14.20	7.18	107.50	144.30	11.9	18.62	23.67
	2 MAP	351.40	66.59	11.60	69.77	13.21	7.06	106.50	141.80	12.0	18.86	22.01
	3 MAP	370.60	65.58	10.50	68.13	11.82	7.79	101.80	123.70	11.4	18.22	19.70
	Control	367.90	68.02	11.15	66.69	14.99	7.17	115.60	151.10	12.3	18.42	24.99
French Reversion	ATP	389.40	66.20	9.25	63.97	15.39	7.51	93.20	181.20	12.7	23.38	25.65
	1 MAP	388.30	66.47	8.93	66.18	15.33	7.58	93.30	186.40	13.1	22.77	25.55
	2 MAP	393.50	66.01	9.72	65.62	16.42	7.79	99.80	192.30	12.9	23.49	27.38
	3 MAP	400.30	67.72	9.78	65.04	15.38	7.44	93.50	191.00	12.8	23.40	25.63
	Control	392.70	65.29	9.29	63.61	14.25	7.06	86.20	179.30	12.6	23.64	23.75
$LSD_{0.05}$		ns	ns	ns	ns	2.13	ns	10.89	17.89	0.45	ns	3.55

FCR = Fruit circumference; ATP = At planting; 1, 2 and 3 MAP = One, two and three months after planting, respectively.

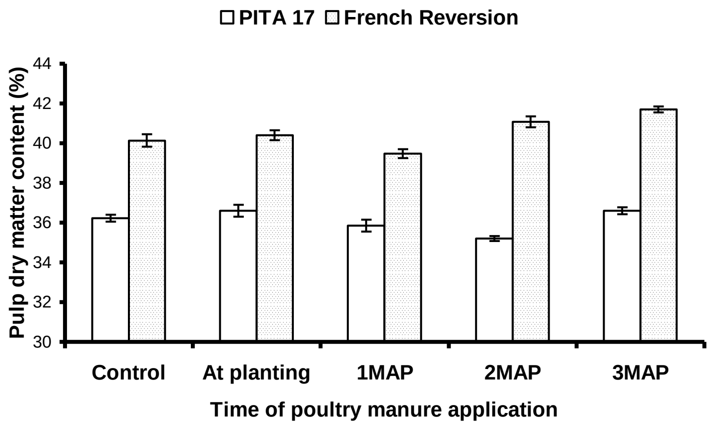

Fig. 3: Genotype x time of poultry manure application interaction effect on the plantain pulp dry matter content. Vertical bars represent standard errors of means. 1, 2, and 3 MAP = one, two and three months after planting, respectively

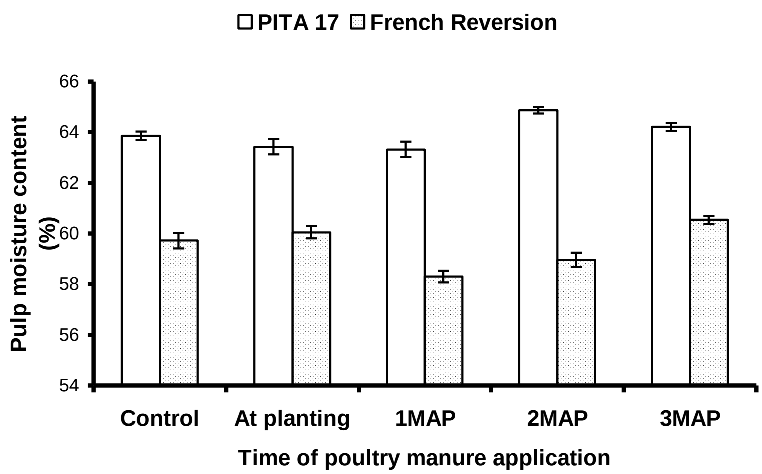

Fig. 4: Genotype x time of poultry manure application interaction effect on the plantain pulp moisture content. Vertical bars represent standard errors of means. 1, 2, and 3 MAP = one, two and three months after planting, respectively

Fruit shelf life and pulp colour rating

The fruits of PITA 17 ripened and senesced later (longer green life and shelf life) than those of the landrace French Reversion (Table 5). The landrace had higher values for pulp lightness (**L***) and redness (**a***) while pulp yellowness (**b***) was higher in PITA 17. The time of poultry manure increased the shelf life especially the application at planting, 2 and 3 MAP. There was no cultivar x time of poultry manure application interaction effect on fruit quality, except the shelf life in which PITA 17 stayed longest when the manure was applied at planting or 2 MAP whereas French Reversion had the lowest shelf life at no manure or at 2 MAP (Table 6).

Table 5. Main effects of cultivar and time of poultry manure application on plantain green life, days to full ripeness, shelf life and pulp colour coordinates (L*, a* and b*)

Parameter	Green life (days)	Days to full ripeness (days)	Shelf life (days)	Pulp colour coordinates		
				L*	a*	b*
Cultivar						
PITA 17	5.60	7.86	18.32	71.10	2.43	43.07
French Reversion	4.76	7.18	16.12	72.42	6.20	42.18
$LSD_{0.05}$	0.64	ns	1.07	1.21	0.38	0.87
Time of poultry manure application						
ATP	4.92	6.90	17.65	72.13	4.36	42.35
1 MAP	5.17	6.94	16.26	72.44	4.42	42.93
2 MAP	5.23	7.51	17.43	71.75	4.49	43.03
3 MAP	5.24	8.60	18.51	72.50	3.89	42.98
Control	5.34	7.64	16.25	69.99	4.42	41.84
$LSD_{0.05}$	ns	ns	1.70	ns	ns	ns

L*, a* and b* = Mean values for pulp degree of lightness, redness and yellowness respectively (measured at harvest, 50% ripeness, complete ripeness and senescence); ATP = At planting; 1, 2 and 3 MAP = One, two and three months after planting respectively.

Table 6. Interaction effect of cultivar and time of poultry manure application on plantain green life, days to full ripeness, shelf life and pulp colour coordinates (L*, a* and b*)

Cultivar	Time of manure application	Green life (days)	Days to full ripeness (days)	Shelf life (days)	Pulp colour coordinates		
					L*	a*	b*
PITA 17	ATP	5.17	6.94	19.21	71.04	2.39	42.91
	1 MAP	5.64	7.46	18.15	71.73	2.49	43.05
	2 MAP	5.69	7.53	19.17	70.30	2.85	43.20
	3 MAP	5.85	9.36	18.08	71.60	1.75	43.05
	Control	5.67	8.03	17.00	70.84	2.67	43.15
French Reversion	ATP	4.76	6.86	16.08	73.21	6.34	41.79
	1 MAP	4.71	6.43	14.36	73.51	6.34	42.81
	2 MAP	3.78	6.25	13.25	73.20	6.12	42.85
	3 MAP	4.62	7.83	18.94	73.41	6.03	42.92
	Control	4.15	6.07	10.78	69.15	6.17	40.53
$LSD_{0.05}$		ns	ns	3.81	ns	ns	ns

L*, a* and b* = Mean values for pulp degree of lightness, redness and yellowness respectively (measured at harvest, 50% ripeness, complete ripeness and senescence); ATP = At planting; 1, 2 and 3 MAP = One, two and three months after planting respectively.

DISCUSSION

The hybrid PITA 17 flowered earlier, had healthier leaves with respect to black sigatoka disease and was harvested earlier than French Reversion. Early flowering and maturity is one of the selection traits in plantain. Ortiz and Vuylsteke (1994) reported that improved hybrids mature earlier than the landraces. On the other hand, there is a positive and strong relationship between the youngest leaf spotted and early flowering (Baiyeri *et al*., 2000a). The higher the value of the youngest leaf spotted and index of non-spotted leaves, the lesser the severity of the black sigatoka disease pathogen on the plantain leaves, which means healthier leaves and their consequent trapping of more light energy for the plant's physiological rapid growth and development in the presence of favourable environmental factors. The French Reversion was taller than PITA 17. Tenkouano *et al*. (2002) was of the view that improved hybrids should have shorter stature, as this would reduce lodging caused by wind or weight of the bunch on the plant.

Fruit filling period and days to flowering were influenced by cultivar x time of poultry manure application interaction. Generally, PITA 17 with poultry manure took longer time to fill its fruits in comparison to other treatment combinations, especially the no fertilized French Reversion which had fewer fruits. The fruit bulking period increased as the number of fruits per bunch increased. Fruit number per bunch could be promoted by poultry manure application because of the potential nutrients in the manure, which increased dry matter accumulation to the economic part of the plant. The implication is that management practices that will increase the number of fruits will also increase the bulking period. This explained why PITA 17 with poultry manure took longer period to fill its several fruits.

The bunch weight has been found to be significantly ($P<0.05$) affected by the number of hands and fruits per bunch (Swennen *et al*., 1995). In this study, the higher number of fruits per bunch in PITA 17 did not necessarily result in heavier bunches than the French Reversion. Baiyeri and Tenkouano (2008) using principal component analysis (PCA) detected that the contribution of number of fruits to the bunch weight was through the biological yield (above ground biomass). This suggested that cultivars that had high biomass yield might produce many fruits which resulted in heavier bunches. This explained why French Reversion had heavier bunches, as they had higher value for aboveground biomass than PITA 17.

It was observed that there was no rain in the first few months of the first cropping cycle. This should have affected the decomposition and the corresponding release and availability of nutrients from the poultry manure since moisture availability and soil fertility are among the most important environmental variables in determining the performance of banana and plantain in the tropics (Robinson, 1996; Baiyeri *et al*., 2000b). The application of poultry manure at 1 and 2 MAP produced higher economic yield and other bunch traits than other manure treatments. There might have been a stable and gradual release of nutrients from the poultry manure applied at planting and 1 MAP due to the little rainfall within these periods. This moisture availability could have initiated the process of decomposition of the nutrients which might have resulted in the good growth and yield performances of the plants that received poultry at 1 MAP. The performance of the plants that received poultry manure at 2 MAP was better but similar to those that received the manure at 1 MAP. The cumulative effect of poultry manure from the undecomposed manure in the first year (due to lack to moisture) and those applied in the second year might have provided more nutrients for the plant's utilization in dry matter. The cultivar x time of poultry manure interaction explained that bunch yields and the components will be higher when poultry manure was applied at 2 MAP to French Reversion.

Compared to French Reversion, the hybrid, PITA 17 accumulated higher moisture in pulp, yet it stayed longer period before senesce. This implied that the hybrid might have resistance for fruit fungal attack as one expected that the higher moisture content would predispose the fruit to fungi (mould) which would accelerate the fruit senescence. Also the increase in the duration before senescence with poultry manure application in either of the cultivars indicated that nutrients (such as calcium) were made available by the manure and absorbed which should have strengthened the cell membrane of the fruits hence prolonging the shelf life.

Lighter (whiter) pulp of French Reversion meant whiter flour and the subsequent lighter baked products, which would attract more consumer acceptability. Also the higher values of **a*** (degree of redness) and **b*** (degree of yellowness) for French Reversion and PITA 17, respectively implied that these cultivars could still be selection sources for carotenoids and anti-oxidant agents, hence promoting good health. Colour coordinates in CIE Laboratory system are related to the pigment content in the fruits especially carotenoids. Also strong significant relationship had been found between colour parameters (**a*** and b*****) and beta-carotene and total carotene contents (Gajewski *et al*., 2008).

CONCLUSION

The application of 20 t/ha poultry manure (on a soil that is averagely fertile) within the first two months of transplanting or planting suckers might represent the optimum period for nutrient release and availability for the root uptake, which consequently will produce heavier bunches and their components as well as increase the fruit quality.

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Submitted March 26, 2010 – Accepted August 17, 2010
Revised received November 17, 2010