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Evaluation of Iron, Zinc, Potassium and Proximate Qualities of Five *Musa* Genotypes

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ABSTRACT

Objective: The study was conducted to determine iron, zinc and potassium contents and the proximate qualities of ripe and unripe fruits of five *Musa* genotypes ('Agbagba', 'FHIA 21', 'PITA 14', 'PITA 24' and '30456-2').

Methodology and results: The genotypes were grown under organic and inorganic fertilizer application systems. Three bunches per genotype were harvested from each system. Fruit samples were obtained from the second proximal hands of each bunch. Fruit metric traits (weight, circumference, length and edible proportion), proximate qualities, Fe, Zn and K were determined. Genotypes varied significantly ($P < 0.05$) in all the fruit metric traits and some proximate quality traits, notably ash and carbohydrate contents. Although the landrace (Agbagba) produced larger fruit size, the hybrids had significantly higher Zn and Fe contents. Genotypes 'PITA 14' and '30456' had higher values for Zn and Fe, respectively. Proximate traits except percent ash and carbohydrate were statistically the same across the genotypes. Organic fertilizer use improved fruits metric traits but most proximate traits were similar in the organic and inorganic fertilizer systems. The concentrations of Fe, Zn and K were statistically similar in both fertilizer systems, although fruits harvested from inorganic fertilizer system tended to have higher values. Unripe fruits had higher energy value but the ash, Fe, fat, fibre and protein contents were higher in the ripe fruits.

Conclusion and application of findings: The study revealed that producing plantains with organic fertilizer alone, does not in anyway result to fruits deficient in basic nutrients. Besides, higher values of Zn were obtained in the unripe than in the ripe fruits of 'FHIA 21'and '30456-2'. In contrast, the values of Fe were higher in ripe fruits than unripe in most of the genotypes except 'FHIA 21'. The preponderance of key micronutrients in the hybrids suggests that micronutrient deficiencies could be alleviated if these hybrids are sufficiently produced and included in our diets.

Key words: Plantains, fertilizer management, ripeness, proximate qualities, micronutrients

INTRODUCTION

Bananas and plantains (*Musa* species) are perennial herbs in the family *Musaceae.* They are important food crops in the humid forest and mid altitude zones of sub-Saharan Africa. It has been estimated that plantain and other bananas provide nearly 60 million people in Africa with more than 200 calories (food energy) a day (Stover & Simmond, 1987). In tropical America and the Caribbean, they are of great socio-economic and nutritional significance and they generate

considerable export earnings and employment. They constitute the fourth most important global food commodity after rice, wheat and maize in terms of the gross value of production (INIBAP, 1992).

In West and Central Africa plantain fruits are traditionally roasted, boiled, pounded or fried as fruit vegetable, but occasionally, eaten raw in the ripe state and only a very small proportion is processed to storable products, like flour and chips. In some areas, the processed or preserved products are important in periods when other main foods are scarce. Earlier report by Adeniji and Empere (2001) showed that the conversion of cooking banana bunches into flour was a means of adding value to the fruits as well as extending the shelf life and facilitating transportation.

Seasonal changes during fruit development could impact on the nutritional value of flour processed. Earlier reports by Chandler (1995), Baiyeri (2000), Baiyeri and Onadike (2001), and Baiyeri and Tenkouano (2006) indicated that nutritional value of *Musa* fruits varies with ripeness, cultivar grown, season of harvest, soil nutrient status and climatic condition under which the fruits were grown.

In this study therefore, the effects of genotype, fertilizer management and ripening stage on some minerals and proximate composition of five *Musa* genotypes were evaluated. The specific objectives were to [1] investigate the proximate composition of ripe and unripe plantain fruits using 'Agbagba', 'FHIA 21', 'PITA 14', 'PITA 24' and '30456-2' as test genotypes; and [2] compare the qualities of fruits harvested from plants grown under organic and inorganic sources of nutrients.

MATERIAL AND METHODS

Trial site: The experiment was conducted at the experimental plot and analytical laboratory of the Department of Crop Science, University of Nigeria, Nsukka, between the months of April 2007 and November 2008. Nsukka is in the derived savannah agro-ecological zone located on latitude 06^0 52'N, longitude 07^0 24'E and 447.2 m above sea level. Rainfall is bimodal with an annual total of about 1500 mm. The relative humidity ranges from 70 to 80% and an ambient temperature of 20-30^{0}C during the rainy months. The soil is a sandy loam oxisol of Nkpologu series (Ndubizu, 1981).

Layout: The field experiment was a factorial design laid out in a randomized complete block design (RCBD). The factors were five *Musa* genotypes and two fertilizer sources. The genotypes (obtained from the International Institute of Tropical Agriculture (IITA), Nigeria) were 'Agbagba', 'FHIA 21', 'PITA 14', 'PITA 24' and '30456-2'. The fertilizer sources were [a] poultry manure applied at the rate of 20 tons per hectare, and [b] inorganic fertilizer combination at 300 kg N and 550 kg K per hectare. Each genotype was established in a single-row plot of five plants replicated three times across the fertilizer types. Standard agronomic management was maintained as described by Swennen (1990) and bunches were harvested at full maturity as signaled by the yellowing of few fingertips.

Sampling and analysis: Fruit samples for analysis were obtained from the second proximal hands of each bunch following the recommendations of Baiyeri and Ortiz (2000). Fruits were analyzed at both unripe (green) and fully ripe stages (ripening was natural under laboratory condition). Peeled samples were oven dried at about 70 ^{0}C until permanent dry weight was obtained. Dry samples were ground to pass through one millimeter mesh sieve using Thomas Wiley laboratory mill (model 4).

The Fe, Zn and K contents of fruits were determined following standard methods described by Pearson (1976). The proximate compositions of the dried fruit samples were determined following the methods outlined by Pearson (1976) and AOAC (1990).

Data analysis: Data were collected across the treatment combinations in triplicates and subjected to analysis of variance following the procedures outlined for factorial arrangements in completely randomized design (CRD). Factorial analysis was necessary to capture the main effects and possible interactions between the genotypes, fertilizer sources and ripening stage. Data were analyzed with GENSTAT Discovery 3 Release 7.5DE (GENSTAT, 2007). Significant treatment means were compared using least significant difference (LSD) at 5% probability level.

RESULTS

There was a significant ($P < 0.05$) genotype effect on most of the fruit metric traits studied (Table 1). Agbagba, a landrace, had the largest fruit circumference while FHIA 21 had the smallest. 'Agbagba' and 'PITA 24' produced the longest fruits, but the other genotypes were statistically similar. 'PITA 24' produced the highest number of fruits in the second proximal hand, while 'Abagba' had the least; however, Agbagba fruits weighed the heaviest at both the unripe and ripe stages. Except in 'PITA 24', moisture loss was higher in the hybrids compared to the landrace "Agbagba'. Duration for ripening and percent dry matter of ripe fruits slightly varied with genotype while percent edible proportion was statistically similar. Percent ash and carbohydrate, and the quantity of iron and zinc were significantly ($P < 0.05$) influenced by genotypes (Table 2). 'PITA 14' had the highest quantity of ash, carbohydrate and zinc but the quantity of iron was highest in the hybrid '30456-2'. Other proximate quality traits were similar across the genotypes; however, the quantity of potassium accumulated was highest in fruits of 'PITA 14'.

Table 1: Main effect of genotype on post-harvest and fruit metric traits of plantains.

Genotype	FH_2	FC (cm)	FL (cm)	mFwtg (g)	mFwtr (g)	Wt-loss (%)	DCR	%Epg	%EPr	Pulpdmg(%)	Pulpdmr(%)
Agbagba	6.3	15.2	25.0	240.0	197.6	19.4	7.5	58.9	68.8	38.0	42.5
FHIA 21	13.6	10.7	17.8	88.6	54.1	36.8	10.3	51.3	68.1	37.3	25.7
PITA 14	14.0	12.3	18.5	123.0	92.6	25.3	7.8	57.7	73.2	40.6	28.0
PITA 24	15.3	11.7	25.0	131.0	126.1	6.4	7.1	53.7	60.6	32.2	25.5
30456-2	12.9	12.0	17.4	93.0	52.5	40.1	8.7	55.7	65.9	40.9	32.8
$LSD_{(0.05)}$	1.6	0.9	3.2	27.7	26.8	14.7	0.8	ns	ns	ns	9.8

FH_2 =Fruit count on hand-2; FC= Fruit circumference; FL= Fruit length; mFwtg = Mean fruit weight green; mFwtr = Mean fruit weight ripe; Wt-loss = weight loss; DCR= Days to complete ripeness; %EPg = Percentage edible proportion green; %EPr = Percentage edible proportion ripe; Pulpdmg = Pulp dry matter green; Pulpdmr = Pulp dry matter ripe; $LSD_{(0.05)}$ = Least significant difference at 5 % probability level; ns = Non-significant.

Table 2: Main effects of genotype on proximate composition of plantain fruits.

Genotype	Ash (%)	CHO (%)	Energy (Kj/100g)	Fat (%)	Fibre (%)	Protein (%)	Moisture (%)	Fe (mg/100g)	K (mg/100g)	Zn (mg/100g)
Agbagba	5.4	72.0	2129	5.7	1.6	3.3	6.4	5.9	116.3	8.6
FHIA 21	3.2	70.7	1745	5.9	1.4	3.3	6.2	6.2	129.1	11.7
PITA 14	7.1	72.6	2129	5.6	1.5	3.4	7.3	8.3	130.9	12.2
PITA 24	5.7	65.0	2153	6.3	1.6	3.4	6.3	7.8	120.2	11.7
30456-2	5.7	58.9	2483	5.8	1.8	3.9	6.9	9.2	115.6	11.6
$LSD_{(0.05)}$	1.4	9.4	ns	ns	ns	ns	ns	2.8	ns	3.6

CHO = Carbohydrate, ns = Non-significant at 5% probability level.

Organic manuring supported bigger fruit size (in terms of the weight, circumference and length); however, fruits that grew under inorganic fertilization had higher dry matter and lower weight loss (Table 3). Inorganic fertilization supported higher quantity of fibre and moisture, but other proximate quality traits were similar, statistically (Table 4).

Ripeness did not influence some of the proximate components of the fruits (Table 5). Percent ash and quantity of Fe were significantly higher in the ripe fruits; however, carbohydrate, energy and Zn content decreased with ripening. Fat, fibre, protein, and moisture were not significantly influenced by ripening.

A non-significant ripening phase by genotype interaction was observed for most of the proximate components of plantain fruit studied (Table 6). A significant interaction was, however, found in the ash, fat and Zn contents. 'PITA 14' and 'PITA 24' at unripe stage had the highest ash contents (7.3 and 7.0% respectively), while the ripe fruits of 'PITA 24' and

'30456-2' had the highest iron contents. Fat contents were highest in the ripe 'PITA 24' fruits followed closely by 'Agbagba' and 'FHIA 21' at the unripe stage. Zinc contents were highest in unripe 'FHIA 21' fruit followed closely by unripe '30456-2' and ripe 'PITA 14'. The least Zn concentration was found in ripe 'Agbagba' fruit.

Table 3: Main effect of fertilizer management on post-harvest and fruit metric traits of plantains.

Fertilizer	FH_2	FC (cm)	FL (cm)	mFwtg (g)	mFwtr (g)	Wt-loss (%)	DCR	%Epg	%EPr	Pulpdmg(%)	Pulpdmr(%)
Inorganic	12.7	11.8	19.6	107.2	83.2	26.5	8.2	53.7	68.0	43.1	32.2
Organic	12.1	13.0	21.9	163.1	130.0	24.7	8.3	57.1	66.7	32.5	29.6
$LSD_{(0.05)}$	ns	0.6	2.0	17.5	17.0	ns	ns	ns	ns	10.5	ns

FH_2 =Fruit count on hand-2; FC= Fruit circumference; FL= Fruit length; mFwtg = Mean fruit weight green; mFwtr = Mean fruit weight ripe; Wt-loss = weight loss; DCR= Days to complete ripeness; %EPg = Percentage edible proportion green; %EPr = Percentage edible proportion ripe; Pulpdmg = Pulp dry matter green; Pulpdmr = Pulp dry matter ripe; $LSD_{(0.05)}$ = Least significant difference at 5 % probability level; ns = Non-significant.

Table 4: Main effect of fertilizer management on proximate composition of plantain fruits.

Fertilizer managemen	Ash (%)	CHO (%)	Energy (Kj/100g)	Fat (%)	Fibre (%)	Protein (%)	Moisture (%)	Fe (mg/100g	K (mg/100g	Zn (mg/100g
Inorganic	5.4	65.0	2328	5.9	1.8	3.4	7.2	7.9	130.4	11.85
Organic	5.5	70.7	1926	5.7	1.4	3.5	5.7	7.0	124.4	11.67
$LSD_{(0.05)}$	ns	ns	ns	ns	0.3	ns	1.4	ns	ns	ns

CHO = Carbohydrate, ns = Non-significant at 5% probability level.

DISCUSSION

In this study, the genotype, fertilizer management option, and ripening phase were important determinants of proximate quality, quantity of iron, zinc and potassium, as well as metric characteristics of plantain fruits. The results from this study corroborated earlier findings of Baiyeri and Unadike (2001) that reported significant variability in physicochemical properties of two Nigerian plantains due to ripening phase; it also supported the findings of Baiyeri and Tenkouano (2006 & 2008) that distinct variation existed in proximate qualities of ten *Musa* genotypes across seasons. The impact of manuring on fruit biochemical quality earlier reported by Ani and Baiyeri (2008) supported the significant effect of fertilizer management on some plantain fruit quality traits obtained in this study.

The landrace 'Agbagba' performed better than the hybrids in all the fruit metric traits (length, circumference and weight); the hybrids however, had higher number of fruits per hand, thus, higher fruit yield per hectare. These hybrids are certified to be sigatoka disease resistant and are readily adopted by most farmers (Vuylsteke *et al*, 1994). There was also more Zn and Fe in the hybrids compared to 'Agbagba' which supports the earlier observations by Tenkouano *et al.,* (2002).

Organic fertilization produced better fruit traits in terms of circumference, length, weight, and percentage edible portion; these are characteristics of great importance for attracting high market price due to consumers' preference. Organic manuring is notable for improving yield and yield attributes of fruit crops (Obiefuna, 1990; Ani & Baiyeri, 2008; Aba *et al*., 2009).

Although the proximate composition and mineral in fruits of both fertilizer management options were in some cases similar, organic fruit had higher contents of ash and utilizable carbohydrates. The percentage of ash in a food material is an indication of its mineral content (Baiyeri & Tenkouano, 2006).

Evidence from this study revealed that organic and inorganic fertilization produced fruits that were similar in most metric and nutritional qualities, suggesting that producing *Musa* fruits solely on organic manuring will not incur any metric or nutritional deficiency, rather, the fruits were in some cases of better quality. The landrace 'Agbagba' produced fruits of higher metric qualities, while the hybrid genotypes had higher micronutrient contents.

Table 5: Main effect of ripening phase on proximate composition of plantain fruits.

Ripening phase	Ash (%)	CHO (%)	Energy (Kj/100g)	Fat (%)	Fibre (%)	Protein (%)	Moisture (%)	Fe (mg/100g	K (mg/100g	Zn (mg/100g
Unripe	4.9	71.6	2213	5.8	1.5	3.4	6.3	6.6	118.2	12.7
Ripe	6.0	64.2	2041	5.9	1.6	3.5	6.5	8.3	126.6	10.9
$LSD_{(0.05)}$	0.9	6.0	ns	ns	ns	ns	ns	1.8	ns	ns

CHO = Carbohydrate, ns = Non-significant at 5% probability level.

Table 6: The effects of genotype and ripening phase on proximate composition of plantain fruits.

Ripening phase	Genotype	Ash (%)	CHO (%)	Energy (Kj/100g	Fat (%)	Fibre (%)	Protein (%)	Moisture (%)	Fe (mg/100g	K (mg/100g	Zn (mg/100g
Unripe	Agbagba	5.7	73.7	2159	6.2	1.5	3.3	5.3	4.6	105.7	9.1
	FHIA 21	4.9	75.5	1590	6.0	1.3	2.7	6.4	6.8	132.3	17.1
	PITA 14	7.3	72.8	2293	5.5	1.7	3.6	8.2	7.5	129.4	10.4
	PITA 24	7.0	72.8	2719	5.5	1.6	3.9	4.6	6.4	116.0	11.8
	30456-2	5.1	63.7	2305	5.7	1.6	3.6	7.1	7.9	107.8	15.1
Ripe	Agbagba	5.2	70.4	2098	5.2	1.6	3.4	7.4	7.1	126.9	8.1
	FHIA 21	3.0	66.0	1899	5.8	1.5	3.8	6.0	5.5	125.8	12.3
	PITA 14	6.8	72.5	1966	5.8	1.3	3.2	6.4	9.1	132.4	14.1
	PITA 24	4.4	57.8	1587	6.8	1.7	2.9	6.0	9.2	124.4	11.7
	30456-2	6.2	54.2	2655	5.8	1.9	4.2	6.6	10.5	123.4	8.1
$LSD_{(0.05)}$		2.0	ns	ns	0.9	ns	ns	ns	ns	ns	5.2

CHO = Carbohydrate, ns = Non-significant at 5% probability level.

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