

## Research article

# Effects of two production systems in the mineral content in the fruit of *Musa* AAB Simmonds

## Efectos de dos sistemas de producción en el contenido de minerales en el fruto de *Musa* AAB Simmonds

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Rec.: 10.05.11    Accept.: 23.12.11

### Abstract

Organic and/or ecological production systems aim to ensure the sustainability and renewal of natural base by limiting the use of chemical synthesis products to promote the environment and human health. Regarding these benefits, we studied the effect of organic and conventional production systems on mineral nutrient contents of the plantain fruit (*Musa* AAB Simmonds) during the ripening process. Measurements were performed at the University of Córdoba (Montería, Colombia) in order to differentiate the mineral content of fruits between the two systems, and at different stages of maturity. A complete randomized design with 2 x 5 factorial arrangements with five replications was used. The factors were: production system and stage of maturity. The five levels of the second factor corresponded to the following levels of maturity: dark green (V), light green (VC), yellow-green (AV), yellow (A) and very yellow (MA). The results showed that the two production systems and the different degrees of maturity had significant differences ( $P < 0.05$ ) in Calcium, Magnesium, Potassium, Sodium, Iron and Zinc contents.

**Key words:** Organic and conventional agriculture, nutritional quality, minerals, post-harvest.

### Resumen

Los sistemas de producción orgánico y/o ecológico tienen como objetivo garantizar la sostenibilidad y la renovación de base natural, mediante la limitación del uso de productos de síntesis química para favorecer al ambiente y la salud humana. Teniendo en cuenta estas características, se estudió el efecto de los sistemas de producción orgánico y convencional sobre el contenido de nutrientes minerales del fruto de plátano Hartón (*Musa* AAB Simmonds), durante el proceso de maduración. Las determinaciones se realizaron en la Universidad de Córdoba (Montería, Colombia) con el fin de establecer las diferencias en el contenido de minerales en los frutos en ambos sistemas y en diferentes estados de maduración. Se utilizó un diseño completamente al azar con arreglo factorial 2 x 5 con cinco repeticiones. Los factores fueron: sistema de producción y estado de maduración; los cinco niveles del segundo factor correspondieron a los grados de maduración: verde-oscuro (V), verde-claro (VC), amarillo-verde (AV), amarillo (A) y muy amarillo (MA). Los resultados obtenidos muestran que entre ambos sistemas de producción y en distintos grados de maduración, se presentan

diferencias significativas ( $P < 0.05$ ) en los contenidos de calcio, magnesio, potasio, sodio, hierro y zinc.

**Palabras clave:** Agricultura orgánica y química, calidad nutricional, minerales, poscosecha.

## Introduction

Organic agriculture is defined as the production system that integrates agronomic, economic and social aspects, based on the use of natural agricultural inputs as manure, recycling of plant residues, green manures and mineral powders that facilitate the conservation of the biota, improve soil fertility and, in general, reduce negative environmental impacts (Laprade-Coto and Ruiz-Barrantes, 1998). In Colombia the concept of organic farming is used, the Ministry of Agriculture and Rural Development (2006) defines it as any agricultural system that promotes environment, social and economic sustainable food production, which should occur without the use of synthetic inputs, taking only the soil fertility as the fundamental element for a successful production, respecting the natural capacity of plants, animals and soils to optimize quality in all aspects of agriculture and the environment. The conventional agriculture model is based on biocide pest control by using synthetic pesticides, thus it is not sustainable agriculture, because it meets some human needs in terms of food, but does so at a high cost in consumption and deterioration of limited resources. At the same time, causing collateral damage to human health and the environment, being necessary to consume even more the already limited resources available. Organic agriculture, trying to achieve the required balance and equilibrium for sustainable development, seeks to harmonize the need to produce food with limited resources of the ecosystem, from an economic, social and environmental perspective (Rosales et al., 1998).

The fruits of *Musa* are characterized by having a mineral content. The concentration of most of the minerals is greater in the banana fruit pulp of the plantain. The dry pulp of banana fruit at harvest time contains 0.28% nitrogen (N), 0.07% phosphorus (P), 1.1% potassium (K), 0.06% calcium (Ca), 0.12% magnesium (Mg), 20 - 40 ppm iron (Fe)

and 2.5 ppm zinc (Zn). The total nitrogen content in the pulp remains constant once the fruit has been removed from the mother plant and is extremely low in mature fruits (Cayon et al., 2000).

Studies by Arrieta et al. (2006) in the plantain "Papocho" (*Musa* ABB), to evaluate the effect of harvest time on the physico-chemical characteristics of the fruit, allowed to observe significant differences in the values of the moisture concentration, length, width, perimeter, sugar content and pH. These differences remain during the ripening process and are explained as a function of environmental conditions of cultivation. Other works report that the number of leaves or environmental conditions during fruit filling, significantly affect variables of production and the physical characteristics of the fruit during ripening (Barrera et al 2009, Arcila et al, 2000).

Due to the lack of knowledge of the chemical characteristics of the fruits of plantain obtained by organic production system, the goal of this experiment was to determine the differences in the mineral nutrient content during the ripening of Harton plantain in organic and/or ecological and conventional production systems. Thus, it comes to provide information to fruit producers and consumers, about the nutritional content of the fruit, according to the production system that was used.

## Materials and Methods

The fruits used in this research were harvested in two batches of commercial banana in Tierralta, Córdoba, where different production techniques were implemented, namely, organic and/or ecological. This crop was established and managed to accomplish the regulations of the Ministry of Agriculture and Rural Development of Colombia (2006) for organic production, and certified by a nationally accredited company for that purpose. Products of chemical synthesis were used for

the conventional system for all agronomic practices. In 2009, ten clusters of Hartón plantain were randomly selected from each batch. They had the same age or stage of development and, the 1<sup>st</sup>, 3<sup>rd</sup> and 5<sup>th</sup> hands were selected for the study. Treatments consisted of two production systems and fruits stage of maturity as described by Cayon et al. (2000). A completely randomized design (CRD) was used in 2 x 5 factorial arrangement with five replications per treatment; the two factors were the two production systems (organic and conventional), and the five stages of maturity of the fruits mentioned above and described as follows: dark green (V), light green (VC), yellow-green (AV), yellow (A) and very yellow (MA), according to the color scale for banana ripening given by Von Loesecke (1950) and adapted for Horn plantain (Cayon et al., 2000).

Bunches were stored, to continue their maturation process, at 28 ° C and 85% of relative humidity in the pilot plant at the University of Córdoba, Berástegui headquarters, located at 8° 40' 26" N and 75° 40' 44" W. Rejected units were those that had showed physical damage. Fruits were washed to improve the remains of flowers and trickling over them after cutting. Foreign particles were also removed from the surface of the plantains (soil, mud, fungicides and microorganisms) by immersion in drinking water plus a germicidal agent (Chlorine 200 ppm) for a few seconds (Ortega et al., 2004). Major and minor mineral nutrients were determined (wet method) in the fruit pulp. Analyses were performed in Perkin Elmer spectrophotometer, model 3110 of the Water Laboratory of the University of Cordoba (Barrera, 2004).

Information obtained was processed in the

statistical program XLSTAT (2008), analysis of variance was carried out according to the design to validate the assumptions of normality and homogeneity of variances and then performed a Tukey's comparison test with a margin of significance  $\alpha = 0.05$ .

## Results and discussion

### Mineral content

**Calcium:** Effects were observed for the interaction of production systems\*maturation stages (Table 1). Table 2 shows that the calcium content was higher in the organic system, and increases as fruit ripening process advances. The conventional system showed a different behavior since the highest levels were at the beginning and ending of ripening, which allows us to infer that the organic and/or ecological system provides better nutritional quality to consumers and agronomic traits such as greater tolerance to diseases, according to Parra et al. (2008). They reported that increasing calcium concentrations in nutrient solutions significantly reduced the presence of disease in the fruit, hence, less fruit affected per plant was found. Similar results were also reported by Perez-Perez et al. (2008), who found that the calcium content was higher in healthy than in diseased fruits, demonstrating the importance of this element in the management and postharvest quality of fruit.

**Magnesium:** Interaction between production systems and maturation stages showed significant difference in magnesium content (Table 1). Table 2 indicates the evidence that magnesium content varies significantly during the ripening process, and increases of this essential component was observed towards

**Table 1.** Effect of production systems and stages of maturity in the fruit mineral content.

Variable	R <sup>2</sup>	CV (%)	Anova Value - P			Normality	Homogeneity
			Stage	Treatment	Trat * Stage		
Ca	0.68	21.89	0.00016*	<0.0001	0.032	0.653	0.014
Mg	0.653	11.83	0.0003*	0.0003	< 0.0001	0.94	0.028
K	0.483	25.05	0.001*	0.038	0.0001	0.017	0.018
Na	0.196	22.1	0.079	0.04	0.055	0.012	0.011
Fe	0.268	22.02	0.475	0.028	0.004	0.187	0.012
Zn	0.463	22.05	0.244	<0.0001	0.0004	0.098	0.031

\* F significant test (P < 0.05).

**Table 2.** Mineral content in organic and conventional treatments.

Minerals	V	VC	AV	A	MA
<b>Calcium (%)</b>					
T <sub>1</sub>	0.023 bcd	0.030 abc	0.029 abc	0.045 a	0.032 ab
T <sub>2</sub>	0.015 d	0.009 d	0.007 d	0.007 d	0.026 bc
<b>Magnesium (%)</b>					
T <sub>1</sub>	0.050 c	0.062 bc	0.049 c	0.076 ab	0.083 a
T <sub>2</sub>	0.062 bc	0.052 c	0.057 c	0.050 c	0.054 c
<b>Potassium(ppm)</b>					
T <sub>1</sub>	0.206 bc	0.422 ab	0.686 a	0.351 abc	0.167 bc
T <sub>2</sub>	0.059 c	0.246 bc	0.269 bc	0.391 abc	0.514 ab
<b>Sodium (ppm)</b>					
T <sub>1</sub>	0.551 ab	0.460 ab	0.627 ab	0.568 ab	0.704 a
T <sub>2</sub>	0.666 ab	0.540 ab	0.519 ab	0.390 b	0.545 ab
<b>Iron (ppm)</b>					
T <sub>1</sub>	17.6 ab	10.40 ab	15.2 ab	24.8 a	7.2 a
T <sub>2</sub>	12.8 ab	8.4 ab	5.2 b	4 b	17.6 ab
<b>Zinc (ppm)</b>					
T <sub>1</sub>	10 b	12.8 ab	9.6 b	26.4 a	6.4 b
T <sub>2</sub>	7.2 b	5.6 b	4 b	4 b	10.4 b

T<sub>1</sub>: Organic; T<sub>2</sub>: Conventional; V: green; VC: light green; AV: yellow-green; A: yellow; MA: very yellow. Different letters indicate significant differences between means according to Tukey test (P ≤ 0.05).

the end of the maturation process. The organic and/or ecological, and conventional systems show significant increases in the green stage, and decrease its content in other stages with the same statistic. It is also important to note that the organic and/or ecological production system reported higher magnesium content at the end of ripening compared to the conventional system, which favors the nutritional quality of these fruits. These results indicate that the organic and/or ecological system improves the redistribution of this mineral to the economically important organs of the plant. In this sense, Pérez-Pérez et al. (2008) observed that application of calcium sulfate and organic matter in guava, individual or combined, significantly increased the mineral content in healthy fruits, which promotes their nutritional quality. Low mineral content was found in diseased fruits with the fungi *Dothiorella* sp.

**Potassium:** Significant variations were reported for the interaction of the systems and production stages of maturity (Table 1), showed increases in potassium content to the yellow stage and decreases towards the end of ripening. Fruit from conventional system showed a higher content of potassium in most

stages of maturity due to high applications of this element in crops (Table 2). These results indicate that the content of K in the soil and its availability favors its absorption as reported by Barrera et al. (2008), who observed that the highest content of this mineral in the banana plant was in both the rainy and dry season, but the highest concentration was obtained in the rainy season, due to its availability in the soil solution. Cayón and Bolaños (1999), when assessed the effect of defoliation on the distribution of mineral elements in the fruit and rachis of Dominico Harton, also found that the concentration of this mineral was similar in plants that kept their functional leaves, and increased when performing a total defoliation. The above statement indicates that the concentration of this element in the fruit correlates with physiological activity of the plant, which in fact accumulates in storage organs in extreme or unfavorable conditions. In general, contents reported in both production systems were lower than those reported by Cayón and Bolaños (1999).

**Sodium:** The sodium content showed significant differences between production systems (Table 1). It was observed that in both,

organic and/or ecological and conventional production systems, the values changed in the studied maturation stages. High contents of this element were shown at the end of the maturation process only for the organic and/or ecological system. Conventional system showed the major content of sodium at the beginning of ripening despite its similarity to the following stages of maturity (Table 2). These contents have similarity with those reported by Barrera (2004).

**Iron:** Significant differences were observed for the interaction of production systems and maturity stages (Table 1). Table 2 showed a variable behavior in both systems for iron content. Organic and/or ecological system reported higher mineral contents of the four initial stages of ripening compared to the conventional system, and decreases its contents to the final stage of maturation. Conventional production system reported higher contents at the beginning and at the end of ripening. The iron content for both systems was less than those reported by Barrera (2004) for clone Dominico Harton. These results differ from those reported by Belalcázar et al. (1991), who claims that the highest content of this mineral is more associated to the initial stages and then decreases towards the end of the fruit filling or commercial maturity.

**Zinc:** The ANOVA showed significant differences for the interaction between production systems and fruit ripening stages (Table 1). Table 2 shows that Zn content varies according to each passing maturity stage and highlights the organic production system as the one with higher content of this element during ripening. This production system enhances the absorption of this element due to its balanced nutrition, usually contrasted with the conventional system that shows deficiency of this essential mineral. Results show similarity with those reported by Cayón and Bolaños (1999) of 11 mg/kg of the mineral nutrient. However, Barrera (2004) found higher zinc content in both systems than those reported in this study, and did not observe significant effects of covering with leaves on the content of this element.

## Conclusion

The organic and/or ecological production system of Hartón plantain affects the mineral content in the fruit pulp with higher values than in the conventional system. An exception was the potassium content, which was favored by the conventional production system that indeed improved product quality for the consumer.

## Acknowledgements

The authors express their sincere thanks to William Arrazola Paternina PhD, Gerardo Salinas Cayón MSc and Elkin Yabid Agamez (biologist), for their valuable contributions in the development of this research.

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