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"Evaluation of fertilizer location in the Horn plantain (*Musa* AAB) mother´s pseudostem after harvesting on growth and production variables".

M. Labarca[1], L. Sosa[1], D. Esparza[1] C. Nava[1], L. Fernandez[1] and A. Villar[1]

[1]Facultad de Agronomía. Instituto de Investigaciones Agronómicas. Apartado 15205. Universidad del Zulia. Maracaibo-Zulia. ZU4005 Venezuela.

Abstract

In order to compare the fertilizer application through the mother's pseudostem after harvesting with soil fertilizer application, from 1998 to 2000 an experiment was carried out in Francisco Javier Pulgar municipality, Zulia state. To this effect were used three kinds of fertilizers (urea, potassium chloride and urea-potassium chloride combination), placed at three height levels, two in the mother plant after harvesting (at 0.75 m and at 1 m tall) and another on the soil. An additional treatment was included; it was based on the farm's fertilization. The statistical design was a 3^2+1 factorial arrangement in randomized blocks with four replications and ten treatments. The highest values, both for the growing, production and for the relative economic index (REI), were obtained with the application of urea-potassium chloride combination in the mother's pseudostem at 0.75 m tall (T7). For the production variable bunch weight, the maximum value was 15.23 kg similar to the values obtained with the application of the combination at 1 m tall in the mother's pseudostem (T8) and the application of 150 gr of potassium chloride in the mother's pseudostem at 0.75 m tall (T4). In the same way this treatment produced the highest value of the REI (2.185,22 Bs. $Plant^{-1}$). These results allow to recommend this fertilizer practice to plantain producers, in order to get a better fertilizer efficiency use for the plant.

Key words: *Musa* (AAB), Horn, fertilizer, location, pseudostem.

Introduction

The crop of "Harton" plantain (*Musa AAB*) is one of the most important in Venezuela but specially in Zulia state, since the southeast area of Maracaibo's Lake represents the location with higher potential for the production of this crop in the country. Nowadays, the main concern

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[1]Author email: mlabarca@luz.edu.ve

of producers is to obtain fruits of great quality and high yields by surface unit, therefore the aim of this research is to obtain a higher efficiency in each of the agronomical practices that are done in the area, among these practices one that rises the production costs is the fertilization.

The alter explains why this crop requires the application of high doses of nutrients, mainly of K^+, besides in the soils where plantain is sowed the nutrients content is generally medium to low. Consequently, it is necessary to do further researches about the rational use of fertilizers in order to contribute to the knowledge of the crop's fertility of plantain.

This fertilizer is generally applied to the soil in this crop; however, it seems to have some disadvantages due to lixiviation lost and by volatilization. Therefore, other more efficient application alternatives must be searched, and one of these is using the pseudostem that remains after sowed the mother plant. It is proved that there is communication between the corm of the mother plant and the successive sons after sowed the plant, this communication keeps for a period of time. In Trinidad, working with the banana clone "Robusta", P^{32} was applied to stumps (pseudostem of the mother plant after harvested) of 30-60cm height, at 0 and 1 week after sowed, sons were sampled ten days later; showing that there was transference of P^{32} of the mother plant to the sons of the same strain, realizing that the P^{32} reduced at the time that the harvested pseudostem was older (11).

Not only the translocation of P^{32} of the mother plant to the son has been proved, but also in the insecticide-nematicide application. This methodology was used in Brazil in the «Giant Cavendish» clone, reducing lost by lodging of plants caused by nematodes of 12% at 3%, likewise the population of banana weevil (*Cosmopolites sordidus)* reduced from 32 to practically zero (8).

Considering the previous mentioned, the purpose of this study was to evaluate the effect of three types of fertilizers (urea, potassium chloride, and the mixture of both), and of three heights of application of these fertilizers (two in the pseudostem of the mother plant and one in the soil), on growth variables and production in the plantain crop, to offer the producer an economical alternative of the fertilizer application that would allow a better use of this.

Materials and methods

Description and location of the area: this research was carried out from 1998 to 2000 in the production unit "El Alamo C.A", Francisco Javier Pulgar municipality, Zulia state. The area represents an average precipitation of 1560 mm.year^{-1} and an annual mean temperature of 27ºC, the weather corresponds to the Tropical Humid Forest (4). According to soil analysis done at the Agronomy Faculty of Zulia University, soils are loamy-lime

texture, taxonomically classified as Fluventic Eutropets (6), this oil has a pH of 7.10 and an electrical conductivity of 0.252 dS m^{-1}. The content of organic carbon was of 12.4 kg^{-1}, the content of P by Bray I was of 4.7 ppm and contents of K^+, Ca and Mg were 0.08 cmol (+) kg^{-1}, 8.0 cmol (1/2 Ca) kg^{-1} and 8.8 cmol (1/2 Mg) kg^{-1}.

Establishment and handle of the essay: the experimental unit was a plot of 6 "Harton" plantain plants (*Musa* AAB) previously identified, which were in that moment about to be harvested. Plants with the following characteristics were selected:

- Perimeter in the stump of the mother plant between 50 and 60 cm,
- Height of the stump of 1.00 m
- Maximum of two successive sons; from which a son was selected from 0.80 to 1.20 m height and approximately from 2 to 3 months old (in that moment it depended on the mother plant).

During the essay, different agronomical practices typical of this crop were done, such as desuckering and defoliation, besides aerial fumigation were done to control black sigatoka (*Mycosphaerella fijiensis* M.) and weeds control was done chemically using glyphosate alternating it to mechanical control (cutter). Crops were done every 15 days for 4 months approximately.

Statistical methodology

Factors and levels of the study: were evaluated the following factors effect and levels:

- Type of fertilizer, this was considered at three levels: f_1=150 g of urea per plant as source of nitrogen, f_2=150 g of potassium chloride per plant as source of potassium and f_3= mixture of 150 g of urea and 150 g of potassium chloride per plant.

- Height of the application of the fertilizer, three application heights were compared: two in the stump and one in the soil: a_1=0.75 m in the stump doing a cut with triangle shape, a_2=1 m in the stump doing a hole in the superior area, a_3= in the soil with mid-moon shape with a distance of 30 cm in front of the mentioned successive son (figure 1).

The levels combination of the factors under study generated 9 treatments and an additional treatment 10 (65 g of Sulpomac.$plant^{-1}$, 99 of urea.$plant^{-1}$ and 33 g of special phosphate.$plant^{-1}$), applied in the soil (table 1).

The statistical design used consisted on a split plot design (3^2+1) with blocks at random with four replications.

Measured variables: these were taken in the higher son of succession at the flowering moment and in the harvest. At the flowering moment the information of the following variables was taken:

- Height of the plant (AP): height in m. was measured, from the soil until the production point of inflorescence.
- Number of healthy leaves (HS): leaves that had more than 75% of photosynthetic active area were counted.
- Perimeter of the pseudostem (PS): measured at one meter height (cm).

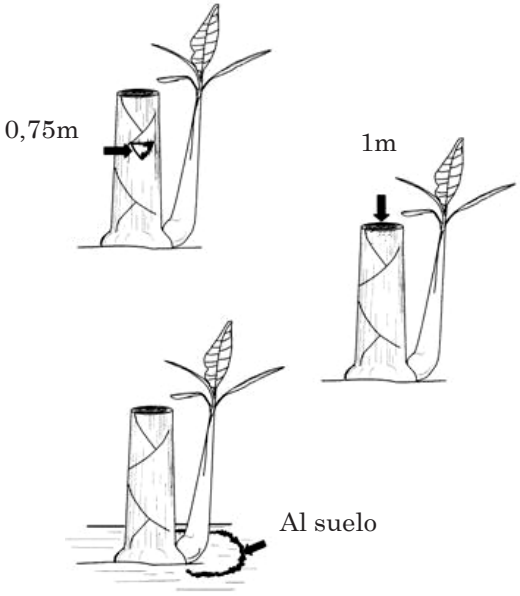

Figure 1. Way of the use of the fertilizer

The following variables were measured in the harvest:

- Number of healthy leaves (HS): leaves with more than 75% of photosynthetic active area were counted.

- Weight of the bunch (PR): every bunch was weighted in a weightier (kg).

- Length of the bunch (LR). Taken 10 cm over the first hand to the apex (cm).

Table 1. Definition of the applied treatments

Treatment	Fertilizer	Height
1	f_1=150g of urea	a_1=0.75m
2	f_1=150g of urea	a_2=1m
3	f_1=150g of urea	a_3=soil
4	f_2=150g of potassium chloride	a_1=0.75m
5	f_2=150g of potassium chloride	a_2=1m
6	f_2=150g of potassium chloride	a_3=soil
7	f_3=Mixture of fertilizers	a_1=0.75m
8	f_3=Mixture of fertilizers	a_2=1m
9	f_3=Mixture of fertilizers	a_3=soil
10	Fertilization proper of the farm.	

-Rachis perimeter of the infrutescence (PRQ): taken 10 cm over the first hand (cm).

-Number of hands per bunch-1 (NM).

-Number of fingers (ND).

-Weight of the central finger of the second hand (PD).

-Length of the central finger of the second hand (LD)

-Relative economical index (IER): was determined with the following expression (1).

IER: Pu Vp-Crt

Where:

Pu= production of each experimental unit or plot, the total weight of the production of each experimental unit was considered.

Vp= production value, the averaged price of the area during the harvest months was considered.

Crt= production cost relative to each treatment.

The information generated by the experiment were expressed in absolute values and processed using the statistical software SAS (version 6, 1996), using the general procedure for linear modes (Proc GLM) for the variance analysis of variables under study, and the method of mean test by minimal squares (LSMEANS) for the separation of means (10).

Results and discussion

Growth variables measured at flowering: in table 2 are shown means for variables that presented the differential behavior ($P<0.05$) in Anadeva (table 3), by effect of treatment: AP, HS and PS; where was observed that the application of 150 g of urea and 150 g of potassium chloride in the stump at 0.75 m height (T7) was the one that produced the best numerical averages in the three mentioned variables, being these 4.10 for height of the plant, 12.12 healthy leaves and 69.62 cm for the variable perimeter of the pseudostem. For variables AP and HS, was seen that the obtained averages by the application of T7 were similar to those obtained when applying T8. For the variable PS, averages of treatments 4 (potassium chloride at 0.75 m in the stump), 7 and 8 did not present significant differences ($P<0.05$), differing treatment 7 to the rest and presenting the highest averaged value.

As it is seen, in all variables the observed results were similar which might had been because N is a very important element for plants, because C, H and O are more abundant than N as constituents of vegetal tissues (2). N influences in the composition of chlorophyll, amino acids, nucleic acids and proteins among other organic substances, which have an important role in the growth, development and reproductive processes. At the same time, K^+ as well as nitrogen and calcium, are the most absorbed elements by the plant, its function is considered as catalytic , related to the metabolism of the nitrogen and the carbon hydrates, synthesis of proteins, activation of enzymes and neutralization of organic

Table 2. Means comparison for variables height of the plant (AP), number of healthy leaves (HS) and perimeter of the pseudostem (PS) by treatment in the cultivation of plantain. Francisco J. Pulgar municipality, Zulia state.

Treatment	AP* (m)	HS*(Nº)	PS* (cm)
1	3.84^{ab}	10.81^{ab}	61.94^{a}
2	3.69^{a}	10.87^{ab}	61.79^{a}
3	3.81^{ab}	11.04^{abc}	62.33^{a}
4	3.84^{ab}	11.29^{bc}	65.54^{abc}
5	3.73^{a}	10.65^{ab}	63.35^{ab}
6	3.78^{ab}	10.53^{a}	62.25^{a}
7	4.10^{c}	12.12^{d}	69.62^{c}
8	3.93^{bc}	11.67^{cd}	67.13^{bc}
9	3.82^{ab}	11.16^{abc}	63.12^{a}
10	3.77^{ab}	10.97^{ab}	62.60^{a}

* Means followed by different letters differ statistically (P<0.05) by the separation meted of square minimum means (LS MEANS) of SAS.

acids, participating in all metabolic changes. Therefore, the use of both elements during this growth phase constituted an ideal combination to favor the development of the plant (3).

For the three studied variables: AP, HS and PS, the height of the application of the fertilizer that had the best results was at 0.75 m in the stump once sowed (table 4), for AP variable the value was of 3.93 m with significant differences (P<0.05) (table 5) between means resultant when using the other two heights of application, for variable HS the highest value was 11.41 leaves, being similar to the one obtained by the application height at 1 m (11.06

Table 3. Variance analysis for variables height of the plant (AP), number of healthy leaves (HS) and perimeter of the pseudostem (PS) of the applied treatments.

F.V.	Gl	AP	HS	PS
Total	39			
Treatment	9	3.18**	4.13**	2.98**
Repetition	3	6.71**	0.61	4.47**
Error	27			
C.V.		3.40%	4.27%	4.75%
$\bar{y}$		3.84	11.11	63.97

*significant (P<0,05) **Highly significant (P<0,01)

Table 4. Means comparison for variables height of the plant (AP), number of healthy leaves (HS) and perimeter of the pseudostem (PS) of the application height in the plantain crop. Francisco J. Pulgar municipality, Zulia state.

Heigth (m)	AP* (m)	HS*(N°)	PS* (cm)
0.75	3.93[b]	11.41[b]	65.70[b]
1.00	3.69[a]	11.06[ab]	64.09[ab]
To the soil	3.81[a]	10.91[a]	62.57[a]

*Means followed by different letters differ significantly (P<0.05) by the separation method of square minimum means (LSMEANS) of SAS.

leaves); however, the result observed to the application of the fertilizer in the soil was of 10.91 leaves, being this different (P<0.05) to the highest average. Likewise, for variable PS, the highest value obtained was 65.70 cm and showed significant differences (P<0.05) only to the fertilization applied to the soil.

The reason of the application height of 0.75 in the stump that had the best results for variables AP, HS and PS is explainable due to when using the fertilizer at this height inside the stump was absorbed more easily by the plant and was translocated to the sons more rapidly than putting it in the soil. In fact, the movement of phosphorus was studied in the banana clone «Robusta» from the mother plant to the son, proving that the dependence of sons with the mother plant in relation to the requirements of phosphorus was approximately 90% during the vegetative phase, besides it was also proved that the translocation keeps even after 45 days, these results

Table 5. Variance analysis for variables height of the plant (AP), number of healthy leaves (HS) and perimeter of the pseudostem (PS) of the type of fertilizer and application height.

F.V.	Gl	AP	HS	PS
Total	35			
Fert	2	6.54**	12.10**	7.69**
Alt	2	4.19*	3.76*	3.47*
Fert*Alt	4	1.27	2.09	1.48
Rep	3	5.65**	0.60	4.82*
Error	24			
C.V.		3.45%	4.09%	4.54%
$\bar{y}$		3.84	11.13	64.12

*significant (P<0.05) **Highly significant (P<0.01)

clearly showed the benefit of conserving the mother plant after sowed its bunch for the movement of a huge quantity of nutrients from the mother plant to the son (5).

Production variables measured at harvest: in relation to the production variables where a significant effect (P<0.05) (table 6) due to the type of fertilizer used, the highest result (19 cm) was obtained for variable PRQ with the application of the combination of two types of fertilizers urea and potassium chloride, showing differences (P<0.05) compare to the application of urea (table 7).

This same tendency was observed for variables ND and PD, where the combination presented the following values: 41.21 finger.bunch^{-1} and 296.23 g weight of the central finger of the second hand respectively, differing (P<0.05) (table 6) to the relative values of the application of 150g of urea (table 7).

Through these results was seen a positive answer in the application of K^+ when applied alone or combined with urea, which might had been due to two reasons; the first was that this element is the most important in the nutrition of musaceae throughout its life cycle; in banana, a production of 70 TM of fresh fruit might extract even 400 kg of K^+ ha^{-1} year^{-1} (7); and the second reason was that the content of this element in the soil where this essay was carried out was from intermediate to low.

In function to the effect of the application height of the fertilizer on the production variables, this turned to be significant (P<0.05) (table 6) only for variable weight of the bunch, where the best application height resulted to be in the stump at 0.75 m and it produced an average per bunch of 14.76 kg, being similar to the value obtained when applying the fertilizer in the stump at 1m (14.60 kg) and differing both averages from the generated value, when applying the fertilizer to the soil, which was of 14.24 kg (table 8). This is explainable because it has been proved that there is translocation of nutrients from the mother plant once cultivated toward the succession sons, which is kept for some days (11).

Table 6. Means comparison for variables perimeter of rachis (PRQ), number of fingers (ND) and weight of the central finger of the second hand (PD) of the type of fertilizer used in the crop of plantain. Francisco J. Pulgar, Zulia state.

Fertilizer	PRQ* (cm)	ND* (N°)	PD* (g)
Potassium chloride	18.60^{ab}	40.72^{ab}	285.01^{ab}
Mixture	19.00^{b}	41.21^{b}	296.23^{b}
Urea	18.25^{a}	40.29^{a}	278.69^{a}

*Means followed by different letters differ significantly (P<0.05) by the separation method of square minimum means (LSMEANS) SAS.

Table 7. Variance analysis for variables perimeter of the rachis (PRQ), number of fingers (ND), weight of the central finger of the second hand (PD) and weight of the bunch (PR) of the type of fertilizer and application height.

F.V.	Gl	PRQ	ND	PD	PR
Total	35				
Fert	2	3.42*	4.22**	5.18*	7.21**
Alt	2	2.93	2.48	0.46	4.96*
Fert*Alt	4	0.32	2.08	0.34	0.39
Repetition	3	0.83	4.57*	2.08	1.13
Error	24				
C.V.		3.76%	1.90%	4.71%	2.38%
$\bar{y}$		18.62	40.74	286.64	14.51

*significant (P<0.05) **Highly significant (P<0.01).

In this matter, in a similar investigation to this one the phosphorus movement in plantain straits was evaluated after cultivated the fruit, finding that the nutritional chain of the mother plant to the sons kept for at least 25 days after harvested the fruit, so when the fertilizer was put in the stump at 0.75 m height, was better absorbed by the plant and therefore transported to the succession sons, while when it is going to be applied in the soil the fertilizer must precede the solution to then be taken through roots and translocate it inside the plant (9).

The production variable of higher importance was the weight of the bunch, since is determinant in the production of the crop, in table 6 is seen the obtained yield in each treatment, including the additional treatment, where the highest value was 15.23 kg per bunch^{-1} correspondent to the application of the mixture of 150 g of urea and 150 g of potassium chloride, put in a stump at 0.75 m height (T7), presenting

Table 8. Means comparison for variables weight of the bunch (PR) of the application height in the crop of plantain. Francisco J. Pulgar, Zulia state.

Heigth (m)	PR* (kg)
0.75	14.76^{b}
1.00	14.60^{b}
To the soil	14.24^{a}

*Means followed by different letters differ significantly (P<0.05) by the separation method of square minimum means (LSMEANS) of SAS.

differences (P<0.05) (table 9) with average values provoked by the rest of treatments, excepting the other averages that remained from the application of T8 and T4, for this two the obtained values were 14.93 kg per.bunch^{-1} and 14.73 kg per.bunch^{-1}, respectively. Continuing in descendent order, the fourth position was occupied by T5, with an averaged value of 14.50 kg per.bunch^{-1}. Meanwhile, the yield obtained by the application of the witness treatment (T10) occupied the ninth place, being statistically different (P<0.05) than the other yields produced by treatments 7, 8 and 4.

These result prove the beneficial effect of K^+ in yield, due to treatments that provoked the highest treatments were based in the application of K^+, which main function is related to the transport and accumulation of sugars inside the plant, which allows the fill of fruits, guaranteeing a good weigh of the bunch (2), favoring the palatability and consistency of fruits, which improves its quality (3). In this production variable, was also seen that treatments where were observed the highest bunch averages agreed to the application of K^+ alone and with urea, and the height application of 0.75 and 1 m inside the stump of the mother plant.

In table 10, where is also seen the means for the rest of the production variables LR, ND and LD, in which a significant effect was observed (P<0.05) (table 9) due to treatment, indicates that the observed results resulted to be similar to the observed average for the variable weight of the bunch, being T7 the one that produced the highest values compare to the rest of treatments

Table 9. Means comparison for variables weight of the bunch (PR), length of the bunch (LR), number of fingers (ND), length of the central finger of the second hand (LD) and relative economical index (IER) of the treatment of the plantain crop. Francisco J. Pulgar municipality, Zulia state.

Treatment	PR*(kg)	LR*(cm)	ND* (N°)	LD*(cm)	IER* (Bs/p)
1	14.32^{ab}	67.72^{ab}	39.99^{a}	30.55^{a}	2.059.53^{ab}
2	14.38^{abc}	68.44^{abc}	49.65^{ab}	30.52^{a}	2.081.53^{ab}
3	14.02^{a}	67.17^{a}	40.22^{ab}	30.46^{a}	2.031.22^{a}
4	14.73^{bcd}	70.33^{cd}	41.29^{bc}	30.64^{a}	2.126.27^{bc}
5	14.50^{abc}	69.47^{bcd}	40.37^{ab}	30.53^{a}	2.093.60^{ab}
6	14.34^{ab}	68.77^{abc}	40.51^{ab}	30.41^{a}	2.057.92^{ab}
7	15.23^{d}	71.53^{d}	42.11^{c}	31.62^{b}	2.185.22^{c}
8	14.93^{cd}	70.11^{cd}	40.91^{ab}	30.73^{a}	2.140.35^{bc}
9	14.47^{abc}	69.47^{bcd}	40.60^{ab}	30.62^{a}	2.076.81^{ab}
10	14.31^{ab}	69.07^{abc}	40.28^{ab}	30.15^{a}	2.061.47^{ab}

*Means followed by different letters differ significantly (P<0.05) by the separation method of square minimum means (LS MEANS) of SAS.

Table 10. Variance analysis of variables weight of the bunch (PR), length of the bunch (LR), number of fingers (ND), length of the central finger of the second hand (LD) and relative economical index (IER) of the treatment.

F.V.	Gl	PR	ND	LR	LD	IER
Total	39					
Treatment	9	3.02*	2.59*	2.78*	2.31*	2.59*
Repetition	3	1.73	6.55**	6.00**	3.50**	2.06
Error	27					
C.V.		2.83%	1.88%	2.22%	1.64%	2.75%
$\bar{y}$		14.51	40.69	68.21	30.62	2091.3

*significant (P<0.05) **highly significant (P<0.01)

including the additional treatment (T10). In relation to the interaction between the type of applied fertilizer and the application height of this, there was not significant answer in all production variables, that is, that at the same time it was explained in the growth variables each of the study factors acted independently.

From all studied variables, the one that most influenced the weight of the bunch was the number of healthy leaves, since the accumulation of photoassimilated in the fingers of the bunch depended on the capacity of leaves to do the photosynthetic process; therefore this variable must be first considered to predict the weight that a bunch can get considering the number of healthy leaves that the plant has at the flowering moment.

Likewise, the perimeter of the pseudostem, measured at the flowering time might give an accurate information of the weight that the bunch will have, by being a shrubby and sanity indicator that the plant has in that specific moment.

Means analysis for IER (table 10) determined that T7 had the highest value (2.185,22 Bs per plant^{-1}), which was an indicator of the higher profitability that might be obtained using this treatment instead of applying other treatments, this index was followed by the produced with the application of treatments 8 (2.140.35 Bs/plant) and 4 (2.126 Bs per.plant^{-1}) and resulted different (P<0.05) (table 9) from the rest of treatments. The treatment that produced the lower IER (2.031,22 Bs per.plant^{-1}) was the application of urea to the soil (T3).

Regarding the interaction between the applied fertilizer and height of the application, it must be mentioned that there was not a significant effect on any of variables under study.

Conclusions and recommendations

Regarding the way of the application of the fertilizer, the best results yielded for all measured variables were obtained applying it at 0.75 m and at 1.00 m in the stump of the mother plant once cultivated, compare to the application of the fertilizer directly to the soil in front of the successive son and with the common fertilization of the production unit.

It was seen the important role that N and K+ have for the good development of the plant through out its life cycle, thus the highest averages for each of the studied variables were produced when was done the application of the mixture of 150 gr of urea and 150 gr of potassium chloride, which produced a weight average per bunch of 14.88 kg.

It is necessary to determine in further investigations, correlations between the weight of the bunch (main variable of yield) to the rest of variables at flowering and at harvest, in order to predict its behavior based in obtained values of the other variables.

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