Effect of sources and dose of nitrogen on the production and quality of the fruit of the banana tree (Musa group AAA, subgroup Cavendish “Gran Enano” clon) in the alluvial plain of the Motatán River

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Abstract

With the purpose of evaluating the effect of three sources of nitrogen Urea (46% N Ammonium Sulfate 21% N and Ammonium Nitrate 32% N), two doses of application (150 and 300 kg N/ha/year), and a witness of 0 kg N/ha/year, on the production and quality of the banana tree in a Typic Ustropept soil. An experimental block design with a factorial arrangement was used at random 3 x 2 + 1, with 5 repetitions. Previous to the application of the treatments, the nitrogen contents of the soil and foliar were evaluated. The yield and quality through the weight of the bunch, length of the central fingers of the second and last hand, diameter of the central fingers of the second hand, the ratio and the number of hands by bunch were evaluated. The dose of nitrogen was broken up in six portions per year (bimonthly applications). The results obtained through the analysis of the variance and the media tests indicated that there were no significant effects for source, dose nor the interaction of these for the different variables measured, but it has been a significant effect for generation. The greater values were obtained by the third generation, being these: weight of the bunch 45.5 kg, ratio 2.8, fingers by hand 24, fingers by cluster 229.53, hands by bunch 11.94 cm., diameter of the central fingers of the second hand 45.88 degrees and length (cm) of the central fingers of second and last hand 28.46 and 29.71.

Key words: Banana trees, Musa AAA, Fertilization, Nitrogen, Typic ustropept.
Introduction

The musaceas crop (plantain, banana and bluggoe) has a big importance in our country, specifically in the alluvial plain of the Motatan river and the south of the Maracaibo Lake. It provides food and work to a big number of people, and the crop is increasing day after day taking away traditional crops like pastures. The land is so good that in this area are some bananas companies, with the final purpose of commercializing the product internationally, to which is required a quality in the product, in order to obtain a higher competitiveness.

The banana crop in the alluvial plain of the Motatan river, is being presenting certain difficulties, maybe related to nutritional problems, which originate a low efficiency and production of the plants. As a result there is a reduction of the competitiveness in the international market.

The nutritional awareness of the plants, the fertility levels of the soil, the capacity of interchange and other physical-chemical characteristics, plus the plantation management, are factors that must be known in order to optimize proficiency. Haddad (6) and Lopez (9) point that banana fertilization has an important figure in the management of the crop. Through this agronomy practice it is obtained an adequate nutrition that contributes that the bunch gather the best characteristics, in quality and weight.

The increment in the fertilizing costs, forces to optimize his use, to which is necessary knowing the nutritional status of the plantations under the different agroecology conditions and the existents management in the country, Haddad (6).

Basically the problem is centered in the few information that workmen have according to the more appropriate source and nitrogen doses to the banana crop in the area. Due to this problem, this research is been done with the purpose of evaluating the effect of the nitrogenous sources and doses on the production, fruit quality and the concentration of foliar nitrogen in the banana crop (Musa AAA) that are in the alluvial plain of the Motatan river.

Materials and methods

Description and location

The experimental phase of the research was made in the “Bana Oro” farm, in the alluvial plain of the Motatan river, road of Sabana Mendoza, in Sucre, Trujillo State. The area is a tropical dry forest, with a humidity regimen USTICO Ewel and Madriz (3), it means that annual or perennial, is the necessity of complementary irrigation in some times of the year, the annual temperature is of 27,5°C with a maximum of 34,1°C and a minimal of 20,9°C and the humidity tends to be superior of 89%, which implies a favorable environment to the development of illnesses in the crops.
The occurred precipitations during the essay were of 1200 mm, with two maximum highs, one during April-May and the other in August-September-October-December.

According to Noguera and Peters (15), the soils of this area, Typic Ustropept, are formed through the deposits by disintegration of metamorphic and sedimentary rocks of the highs of the Motatan river basin, which is characterized by having a high primary meteoric mineral content (micas, feldspar). In the soil fertility, there do not exist a high availability of nutritive elements to the crop, because most of them are in the potential form as primary elements. But because the farm is nowadays a production unit, the physical-chemical soil analysis show ranges to the banana, half of nitrogen and phosphorus; with low potassium content (13 cmol. (1/2 Ca\(^{+2}\)) kg\(^{-1}\) of soil) and a calcium concentration disequilibrium (13 cmol. (1/2 Ca\(^{+2}\)) kg\(^{-1}\) of soil) and magnesium (13-14 cmol. ½ Mg\(^{+2}\)) kg\(^{-1}\) of soil).

The farm “Bana Oro” shows soils with predominant textures between clayey muddy and clear muddy, and in some areas with slightly drainage problems. The soil reaction is neutral to moderate basic (pH 7,3-7,7) and without salinity problems (C.E.x10 between 0,2-0,5 mmhos/cm) in most part of the farm, excepting some areas with C.E.x10 between 0,5-0,6 mmhos/cm that indicate certain salinity presence. Noguera and Peters (15).

**Establishment and handling of the essay**

It was worked with a density between 1800-2000 plants/ha, following a production cycle from the initial development status or the called “production son”, to the crop (11-12 months of life-cycle). It was worked with three generations (mother plants, daughter plants and grand-daughter plants). To the production area were applied all the agronomical practices that require the crop, these were: defoliation, weeds control, propping up, collection, protection defoliation, salubrity defoliation, cleaning, deflection of sons, irrigation and drainage, chemical Zigatoka control, and fertilization, which was made one during a year according to the treatments, splitting up the doses in six parts (bimonthly applications), to warranty a good source of these elements in all the development phase of the plantation. The first application was made in the same moment of the essay, putting fertilizers at 30 cm of the plant or the production son in a moonlit shape Flores (5). A basic fertilization was applied with 400 kg/ha/year of K\(_2\)O.

Foliar and soil samples were done at the beginning and at the end of the essay. To the foliar samples, was selected leaf number 3 (labeling them from up to down) taking a part portion of the plants leaves of 10 cm wide of the central part of each semi limbo, Martin Prevel (12). With the foliar analysis was determined the nutritional plant status expressed as percentage. To the soil samples, were made sub-samples in three points around the plant at 30 cm deep with a drill, because as Avilan et al. (1) and Perez et al. (17) point, there is where concentrates the 75% of roots. Samples were taken at 40 cm of distance from
the plant, through the Kjeldahl method. Fernandez L. 1992 (4).

**Statistical Methodology**

**Factors and study levels**

In this experiment were evaluated the following factors of study:

**Nitrogen source:**

Were considered three sources of nitrogen: Urea 46%, ammonium sulfate 20% N (SA) an ammonium nitrate 32% N (NA)

**Doses:**

Were applied two doses of nitrogen (150 and 300 kg/ha/year). It was also applied a traditional treatment, where nitrogen is not applied (absolute witness).

**Treatments description**

The levels combination of the factor of study generated the following treatments (table 1).

**Statistical design**

Was used an experimental design in blocks at random with a factorial arrangement 3x2+1 with a total of 7 treatments and 5 repetitions organized in the more representative soil unit inside the farm. The soil unit selected is classified as Typic Ustropept, family fine muddy, according to Noguera and Peters (15).

**Experimental Unit**

The experimental unit was formed by a smallholding of 36 m² (6x6), in which were obtained around 7-10 plants. Were used as borders, the plants of the periphery, and as effective samples 3 plants located in the center of the smallholding. The experiment had 35 smallholdings that totalize an experimental area of 1260 m².

To the experimental information processing, were applied two linear models, which are following described:

**Model 1**

To evaluate all treatments including the witness, was used the following model:

\[ Y_{ij} = \mu + T_i + B_j + E_{ij} \]

\[ i: 1,....T:7 \]

\[ J: 1,....b:5 \]

This model created an analysis of the variance that allowed to compare the answers of the 6 treatments 3x2 with the answer of the witness treatment.

**Model 2**

Was used a second model to evaluate the effect of the main components and the factorial interaction.

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**Table 1. Sources and doses of nitrogen applied in the different treatments, in Bana oro farm 1999**

<table>
<thead>
<tr>
<th>Source</th>
<th>Doses (kg N/ha)</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>150</td>
<td>1</td>
</tr>
<tr>
<td>Urea</td>
<td>300</td>
<td>2</td>
</tr>
<tr>
<td>Ammonium sulfate</td>
<td>150</td>
<td>3</td>
</tr>
<tr>
<td>Ammonium sulfate</td>
<td>300</td>
<td>4</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>150</td>
<td>5</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>300</td>
<td>6</td>
</tr>
<tr>
<td>Witness</td>
<td>0</td>
<td>7</td>
</tr>
</tbody>
</table>
Yijk = µ + Fi + Dj + (FD)ij + Bk + Eijk

Where:
Yijk = observation of the variable associated with i- the source of nitrogen, the j- doses of nitrogen in the k- block
µ = general media of the selected population
Fi = effect of the i- source of nitrogen
Dj = effect of the j- doses of nitrogen.
(FD)ij = Effect of the interaction of i- source of nitrogen with j- doses of nitrogen
Bk = effect of the k- block.
Eijk = effect of the experimental mistake.

Variables measures

Weight of the bunch: was made weighting with a weighty watch, all the bunches that were found in the experimental unit, obtaining the weight in each of them.

Numbers of fingers per hand (fingers/hand): this was carried out counting the fingers that had the second hand, counting from top to bottom each commercial bunches of the essay.

Numbers of fingers per bunches (fingers/bunches): consisted in counting all fingers that each commercial bunch had.

The Ratio (boxes/bunch): was made counting the number of bunch that are needed to fill a box of 18,14 kg, of a certain quality or trough the number of boxes that can be filled by a commercial bunch, it means, is the relation of the numbers of finger per bunch and the average of fingers per box, that was 105 (higher the value, better the production).

Central finger length of the second hand (cm): to obtain the result of this variable, were measured the external arch and the internal length of the central finger of the second hand.

Central finger length of the last hand (cm): for the results of this variable were measured the external arch, and the internal length of the central finger of the last hand.

Central finger diameter of the last hand (cm): for these results were measured the external arch and the internal length, of the central finger of the last hand.

Central finger Diameter of the second hand (measure): these results were obtained taking the central finger diameter of the second and last hand, through a measurement instrument called gauge, which measures diameters, this amount may be in a range between 42 and 48 degrees.

Numbers of hands per bunch (hands/bunch): this procedure was carried out counting the hands that had every commercial bunch, obtaining the total number of hands per bunch

Processing the experimental information

The experimental information obtained was statistically processed using the statistic software: Analysis statistics system S.A.S. Version 8.1, (18), was applied the general procedures for lineal models (Proc GLM), to the variance analysis; means test (LS Means), to compare means and the correlated procedure (PROC CORR) to evaluate the association between the variables.
The variance analysis to the variables, bunch weight, number of fingers per hand, number of fingers per bunch, ratio, central finger length of the second and last hand, central finger diameter of the second hand and number of hands per bunch; could be observed that there were not significant effects to the sources, doses, nor the interaction of these between the studied generations, finding a significant effect to generations (mother plant, daughter plant and grand-daughter plant). The average values obtained to each variables treated with different sources and nitrogen doses were: bunch weight, ammonium nitrate (NA) 150 27 kg, ammonium nitrate (NA) 300 26 kg, ammonium sulfate (SA) 150 26 kg, ammonium sulfate (SA) 300 26 kg, Urea (U) 300 24 kg, urea weight (U) 150 25.8 kg, and the witness 26 kg. The ratio, ammonium nitrate (NA) 150 1.1; Ammonium nitrate 300 1,2; ammonium sulfate (SA) 150 1,1; ammonium sulfate (SA) 300 1,1; Urea (U) 150 1,18; Urea (U) 300 1.1 and the witness 1,1 (figures 1 and 2).

These results differ from those obtained by Herrera (7), Lopez (9) and those of Lopez and Espinosa (10), where the last two say that in most of the bananas areas of Latin America, are used doses of 300 kg/ha/year. And the first authors say that with doses of 300 – 200 kg of N/ha/year generated the best profitability and the economical benefits. This may had been, because these researchers worked with a higher dose and there were a higher fertilizers divisions (8 applications/year) and this was for several years. Besides, in the area where took place this experiment, previous applications in the plantation arrangement have

![Figure 1. Bunch’s weight of the Big dwarf Cavendish Banana treated with different sources and doses of Nitrogen. Bana Oro 1999 (First generation).](image-url)
caused an accumulation of nitrogen to the arrangement levels established in the plantation, which indicates that there were a good dose of this element to satisfied the nutritional crop requirements.

In the results obtained to the different generation variables, can be observed that there were significant differences to all them (figure 3, 4, 5), the reasons of this detections might be, first, for the fractionated applications of the fertilizer, which improve it efficiency when reducing the high lost product of leaching and run-off, giving the plant the nutritive elements in the most critical crop moments, it means, that there would be an optimum use of the fertilizer Pacheco et al (16). Second, to a better develop of the sons compare to the mothers, due to the direct effect of the fertilizer, because the application was made in a localize way, in front of the son, allowing it a better nutrients absorption Flores (5) and third, to nitrogen accumulation in the biomass (leaves, bounce fruits, rickets and pseudo- stems, and soil organisms), that once included in the soil create and improvement of the physical and chemical conditions, enhancing the structure and increasing the nutrients retention capacity, avoiding lost product of leaching, volatility and run-off of the fertilizer in the soil, and acting as an radicle system stimulator, which allow the plant a better adsorption of the essential nutrient elements to the develop Lahav and Turner (8). On the other hand, a higher nitrogen accumulation occur in the system, because the aerial biomass and the radicle biomass increased, causing a temporal interruption of this element in vegetal tissues, that have not yet been part of the soil, and it is giving up until it be part of the soil and release the nitrogen by decomposition, being available to the plant.

Figure 2. Banana Cavendish Big dwarf ratio, treated with different nitrogen sources and doses. Bana Oro 1999 (generation 1)
Figure 3. Bunch’s weight of the Big dwarf Cavendish Banana treated with different sources and doses of Nitrogen. Bana Oro 1999.

Figure 4. Ratio of the Big dwarf Cavendish Banana treated with different sources and doses of Nitrogen. Bana Oro 1999.

Figure 5. Central finger diameter of the second hand of the Big dwarf Cavendish Banana treated with different sources and doses of Nitrogen. Bana Oro 1999.
In the variance analysis made to this study, the effect of the different sources and doses of nitrogen on the concentration of this element in the leave, were not detected statistically significant differences. These results agreed with those of Turner (19), when studying the relations between soil analysis, foliar and the productivity of the banana crop in Australia, they found very poor associations in this variables. This is not unusual, because previously, Twyford and Walmsley (20) showed that the foliar concentration of an element, and the total quantity taken by the plant are not necessary associated. Lopez and Solis (11) found in the different bananas areas of Costa Rica, high differences between the nutrient contents in the soil, and in the foliar tissue, which not necessarily have and effect in the plantation. However, the nitrogen accumulation in the system occurs by a higher vegetal biomass production that has not been part of the soil.

In the test made to measure the correlation average that exist between the nitrogen concentration in the soil, plants and the banana production, were found that exist a significant correlation between soil nitrogen and plant nitrogen, once this elements increase happens an increment in the plant in the same proportion (PNITF 1 and PNTS 1), but do not happen between the nitrogen in the soil, plant and the different production variables measured (bunch weight $-0.10774$, fingers per hand $-0.18986$, fingers per bunch $-0.20867$, ratio $-0.20912$, central finger length of the second and last finger $-0.03955$, central finger diameter of the second hand $-0.16075$ and hands per bunch 0.01276. This might be that the nitrogen is considered an element that acts in the growing, development and production of dry matter inside the plant, and not with the transportation and accumulation of sweets, which allow the fill of the fruit, that is the primary function of potassium Devlin (2). This also agrees with Montagut and Martin Prevel (12), who sign that nitrogen is an element related to the plant development and production of vegetal matter, because in the first two months of the plantation, the consumption of this element is low, then the adsorption gets faster due to the plant necessities and the consumption increase rapidly to them suffer a reduction in about two months before the bloom.

In this phase, the plant changes the production rhythm of leaves, and instead of one leave every 4 to 5 days in the growing period, goes to 1 leave per week; the adsorption of N according to the previous situation, also delays, but the consumption continues until the sixth week after the bloom and even longer. The opposite happens with the potassium, where is observed that the adsorption increase very fast during first bloom period and filled of the fruit, then it seems to stop or reduce much later of the bloom.
Conclusions

The sources and doses of nitrogen used in the fertilization of the banana (Musa group AAA, Sub-group Cavendish Big dwarf clone) did not produce significant effects on the different studied levels inside the same generations.

To generations (mother plants, daughter plants and grand-daughter plants) were observed a significant effect to all studied variables, where in third generation was seen an higher increment than in the first and second generation.

The sources and doses used, did not produced differences in the concentration of this element in the banana leaves.

There exist a correlation between the nitrogen content in the soil and in the plant, but not between the soil concentrations and the plant, according to the measured production variables (hands per bunch, number of fingers per hand, number of bunch, length and diameter of the central fingers of the second and last hand, ratio and bunches weight.

Literatura cited


