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Article *in* Asian Journal of Microbiology, Biotechnology and Environmental Sciences · June 2017

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Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 19, No. (3) : 2017 : 1-8

ISSN-0972-3005

EFFECT OF THE CONVENTIONAL AND ORGANIC FERTILIZATION ON FRUITING EFFICIENCY AND ON EVOLUTION OF THE EDAPHIC MACROFAUNA IN BANANA CULTIVARS

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(Received 23 March, 2017; accepted 7 May, 2017)

Key words : *Musa AAB, Variety, Dwarf Curaré, fertilizer inorganic, Fertilizer organic, Nitrogen absorption.*

Abstract - This study was designed to evaluate the effect of inorganic and organic fertilizers on banana fruiting, as well as its effect on edaphic macro fauna in banana cultivars in Ecuador. In this study, Dwarf Curaré variety meristematic banana plants were used with different inorganic fertilizers included: CH_4N_2O, KCl, $(NH_4)_2HPO_4$, $CaH_4P_2O_8$, K, Mg. Organic solid fertilizers were used as a counterpart. The treatments used to be: (T1) without nitrogen fertilization; (T2) 60; (T3) 120; (T4) 180; (T5) with 240 kg ha-1 of N respectively; (T6, T7, T8) with 1, 2 and 3 kg of organic solid fertilizer per plant1; (T9) mix of T3+T6; (T10) mix of T2+T7. It was found that the application of nitrogen reduced the flowering time by 35 days. Also, it was noted that the use of organic nitrogen did not have the same effect as inorganic nitrogen on fruiting and finally nitrogen accumulation in bunches and fruits. The application of organic and inorganic fertilizers, did not affect the biomass of organisms in the soil

INTRODUCTION

According to the National Information System of the Ministerio de Agricultura, ganadería y pesca MAGAP), Ecuador cultivated 139,000 ha of banana in 2013. Manabí province is reported to be the largest banana producer with 40,078 ha (29%), followed by Santo Domingo de los Tsáchilas and Esmeraldas provinces with 16,812 ha (12 %) and 13,467 ha (10%), respectively (Sinagap, 2014). The production of banana (barraganete) for exportation in Ecuador, is currently in the hands of more than 7000 farmers whose lands are between 4 and 8 ha. In El Carmen, this activity generates direct employment for 140,000 people (Fenaprope, 2011). Despite being one of the biggest banana exporters in the world, fruit production in Ecuador is relatively low in comparison to its potential. In 2012, the areas dedicated to the cultivation of banana produced is 5,60,000 tons, an average efficiency of 6 tons ha^{-1} (Sinagap, 2014). This variation is below average production in Colombia, which is valued at 8 tons ha^{-1} (Piedraita, 2012). This lack of efficiency in Ecuador is because farmers not adopting newer technologies for the cultivation of banana. For instance, only a few producers use tools to diagnose the nutritional needs of the cultivars. Additionally, the recommended use of fertilizers is based on prescribed doses, which have poor academic and practical foundations, resulting in inefficient use of a resource (Hernández, Marín, & García, 2007).

The nutrients to which banana is more responsive include: nitrogen (N) and potassium (K). While it is well known that N is the limiting nutrient in musaceous fruit production

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(Schlesinger, 2009), there are several environmental issues related to the excessive use of mineral and organic nitrogen on crops. The primary environmental issues associated with the excessive use of N are lixiviation, NO3 of nitrification and volatilization of gases such as N_2O and NH3 (Schlesinger, 2009; Snyder, *et al*.,, 2009). Therefore, use of nitrogen as a fertilizer is inefficient as it increases the cost of banana production and significantly increases the risk of contamination. For the reasons mentioned above, it is necessary in order to study the use of nitrogen in cultivation in order to increase production and profitability while limiting environmental issues caused by the excessive use of nitrogen (García & Dorronsoro, 2000). There is a need to improve the production of banana in Ecuador by using organic and inorganic fertilizers in an efficient way while reducing their environmental impact.

This study was designed to evaluate the effect of organic and inorganic fertilizers on fruiting and macro fauna behavior in banana crops: fruiting efficiency, the efficiency of nitrogen uptake and the soil macro fauna. With this information it was feasible to hypothesize that organic fertilization was similar to the conventional fertilization in terms of the fruiting efficiency, the use of nitrogen and the characteristics of the soil macro fauna.

METHOD

Location

This study was conducted from February 2012 to May 2013 in two locations: San Miguel Ranch, located in El Carmen Canton, Manabí Province and in the Zoila Luz Ranch of the Army University (affiliation to ESPE), Santo Domingo de los Tsáchilas Province.

Factors, treatments, experimental design and variants in the study

Factor of study and treatments

The factor studied was: N doses applied as conventional chemical fertilizers and as an organic fertilizer derived from composted slaughterhouse and its waste (Table 1).

Experimental design

A completely randomized block design with three repetitions was used. For this, octagonal comparisons and a combined analysis between locations was used. A Tukey's range test at 5% was used to compare the treatments and regressions were calculated for the organic and inorganic nitrogen doses.

Variables studied

Plant height, diameter of pseudo stem, days before flowering, number of leaves, weight of the bunch (head), fruit production, dry weight of the fruit, length of the banana (finger), weight of the finger, number of fingers per head, agronomic efficiency, macrofauna evaluation.

RESULTS AND DISCUSSION

Height of the plant

Following eight months of cultivation, carried out in Luz de América found the following treatment groups show highly significant differences in height; the comparison of the treatment without nitrogen against the chemical treatments (T2, T3, T4 and T5); and the comparison of the chemical treatments (T1, T2, T3, T4 y T5) against the organic treatments (T6, T7 y T8). Control (T2) against the chemical treatments containing nitrogen (T3, T4 and T5) showed significant differences in height. In the evaluation carried out in "EL Carmen", it was found that there were significant differences in the heights of plants only in chemical versus organic treatments.

In the combined analysis of the two locations, it was found that highly significant statistical differences existed between the following treatments; in the comparison of treatments with versus without nitrogen; in the chemical treatments; and in chemical treatments versus organic treatments.

These differences were supported by the Tuckey's range test 5% (p=0.05). In "Luz de América", the treatment without nitrogen (T1) was found to produce the shortest plant. The treatments, belonging to the chemical group, G1 and T6 that contained the smallest quantities of nitrogen generated the shortest plants in this group. On average, the tallest plants resulted from the application of following doses of chemical N sources: 120, 180 and 240 kg N ha^{-1} (T3, T4 and T5). However, these treatments proved to be statistically equal to the mixed treatments (T9 and T10), the organic treatment with the highest concentration of nitrogen (T8) and the control. The same pattern was observed in the combined averages of the two locations, as showed in the Figure 3.1. Treatment without nitrogen only changes recorded and integrated it with treatments higher. The results of inorganic fertilizers in this experiment are similar to those reported by Amador and López (2013) in Honduras, who reported the use of Mycoral biofertilizer resulted in the tallest plants (217.2 cm).

Pseudo-stem diameter

Analysis of the diameter of pseudo stems after 8 months in Luz de América and El Carmen found no statistical difference. In the combined analysis, the treatments showed highly significant differences as did the comparison of chemical treatments (T1, T2, T3, T4 and T5) versus organic treatments (T6, T7 and T8). In addition, there were significant differences in the comparison of treatment without nitrogen (T1) versus chemical treatments (T2, T3, T4 and T5), organic treatment (T7) versus T8, and the organic and inorganic treatments (T1, T2, T3, T4, T5, T6, T7 and T8) versus the mixed treatments (T9 and T10). These differences were supported by the Tuckey's range test (p=0.05) as showed in Figure 3.2. The narrowest pseudo-stems were the result of treatment T7 of the organic group (G2) and the T1 of the inorganic group. The highest length averages were the result of the treatments with 180 and 240 kg ha-1, but were statistically equal to the mixed treatment T10. The values of the pseudo-stem's diameter in this experiment were similar to those obtained by Caballero (2010) using the Curaré banana in Honduras.

Days before flowering

This variable showed highly significant statistical differences in Luz de América for: - The comparison of the treatments without nitrogen versus chemical treatments (T2, T3, T4, T5). - T3 versus T4 - The comparison of inorganic and organic treatments (T1, T2, T3, T4, T5, T6, T7 y T8) vs. the mixed treatments (T9 y T10). In El Carmen location, the flowering also showed highly significant statistical differences in the comparison of treatment with no nitrogen versus the chemical treatments (T2, T3, T4, T5) and the comparison between chemical treatments T3 versus.T4 and T5.

The study revealed significant differences in:

- The comparisons of T6 versus T7 and T8,
- T7 versus T8,

The comparison of the organic and inorganic treatments (T1, T2, T3, T4, T5, T6, T7 and T8) vs. the mixed treatments (T9 y T10)

- The comparison between organic treatments T6 versus. T7 and T8.

Differences were found in the comparison of T7 versus. T8 and the comparison of organic and inorganic treatments versus the mixed fertilizers. For treatment groups exposed to the highest level of nitrogen, flowering begins on the 284 day in Luz de América and at the 299 day in El Carmen. For the treatments without nitrogen T1 (i), flowering occurred on days 363 and 339 in Luz de América and El Carmen, respectively. In two locations, it was observed that the doses of nitrogen had a direct effect at the time of flowering, with treatment groups exposed to higher concentrations of nitrogen flowering the earliest. The treatments with organic sources and the mixed treatments displayed a similar, but less pronounced, pattern. These results are similar to those reported in studies on the Hartón banana in Venezuela. The Hartón banana was reported to have a flowering period of 293 days under the treatment without nitrogen and 252 days under treatments that contained nitrogen. These results are consistent with those of the current study, suggesting that the application of N reduces the time for flowering (Hernández et al., 2007).

The combined analysis (Figure 3.3), shows highly significant differences in all comparisons within the groups G1, G3 and G3; and the comparison of the groups, with the exception for inorganic and organic combination of which have no statistical difference.

N Number of functional leaves before the harvest

Plants in Luz de América displayed highly significant differences in the treatments and for the combination treatments without nitrogen and other chemical treatments (T2, T3, T4 and T5). In El Carmen, no statistical differences were reported, however the combined analysis showed highly significant differences in the comparison of inorganic treatments versus organic treatments. Significant differences were found in the treatments, the combination of unfertilized treatments and chemical treatments (T2, T3, T4 and T5), and organic and inorganic treatments versus fertilized mixes.

As described in Figure 3.4, in Luz de América, the treatment with 120 kg ha-1 of N (T3) was found to have the highest number of leaves before harvesting (10.37). T3 was statistically different to the treatment with no nitrogen (T1), which was found to have 8.67 leaves prior to harvest. In the El Carmen location, the average number of functional leaves before harvesting of the treatments was 10,80. No significant statistical differences were found in the comparison of treatments. Plants in Luz de America were found to have an average of 9.59 leaves before harvesting, in comparison to the 10.80 in El Carmen. This had been the result of the difference in relative humidity between locations. The relative humidity was higher in Luz de América, facilitating fungal attacks and decreasing the life expectancy of the leaves. Experiments carried out in Honduras under similar conditions reported that Curaré reached 9.4 leaves before harvesting under optimal fertilization (Amador & López, 2013).

Individual weights

The individual weight of bananas grown in Luz de América, showed significant statistical differences between treatments, the combination of treatments without nitrogen and other chemical treatments (T2, T3, T4, T5, and the comparison of the farmer control (T2) versus T3, T4 and T5. The combination of the inorganic treatments (T1, T2, T3, T4, T5) versus organic treatments (T6, T7 and T8) showed highly significant differences. In El Carmen, no significant differences were found between treatments. In the combined analysis highly significant differences were observed between the treatments and the combination of the farmer control (T2) versus the chemical treatments (T2, T3 and T4). In addition, significant differences were found between the treatment with no nitrogen versus the chemical treatments (T2, T3, T4, T5).

In the analysis carried out in Luz de América, it was observed that the treatment with 240 kg N ha-1 achieved the highest fingers weight. The combined treatment with 180 kg N ha^{-1} reached the highest fingers weight in comparison to the treatment with no nitrogen (Figure 3.5). The finger weight had a direct effect on the efficiency. It has been demonstrated in banana, that, as a response of better nutrition, the increment of the fingers size supports the efficient accumulation and that there is no effect of nutrition on the number of banana hands (Espinosa *et al*., 1998).

Head weight

The evaluation of the head weight before harvest in Luz de América, showed that there were significant differences in the treatments and in the comparison of inorganic treatments (T1, T2, T3, T4, T5) versus the organic treatments (T6, T7, T8). There were found to be highly significant differences in the treatment with no nitrogen and the chemical treatments (T2, T3, T4 and T5). In El Carmen no statistical differences were noted, however, the combined analysis revealed highly significant differences between the unfertilized treatment versus chemical treatments (T2, T3, T4, T5).

In Luz de América, the lowest head weight was obtained in the treatment without nitrogen (T1), belonging to the chemical group (G1), and in T6, belonging to the organic group (G2). The heaviest head was found in chemical treatments with doses 120, 180 and 240 kg N ha^{-1} (T3, T4 and T5, respectively), in contrast to the organic and mixed treatments. The lowest weight (9,02 kg) within the inorganic treatments belonged to the treatment with no nitrogen (T1). The lowest weight (9,22 kg) within the organic treatments belonged was found in T6. The other treatments showed similar weight in the combined analysis. A trend of increasing the effectiveness with higher doses of inorganic nitrogen was observed. This was contrary to the compost which produced less fruiting despite containing the same amount of nitrogen. The greatest average head weight average was calculated by the treatment T5 (11,92 kg) and the lowest with T1 (9,02 kg) (Figure 3.6). These head weights were similar to those obtained in a related study carried out in Honduras. The Honduras study reported an average weight of 11.7 kg in dwarf Curaré banana from medium size corms (Amador & López, 2013).

Fruit production

The fruit production data showed that the behavior of accumulated efficiency was similar to those observed in the head weight data. In Luz de América, highly significant differences were observed in the treatments, the comparison of the treatment with no N versus the chemical treatments (T2, T3, T4, T5), and the comparison of the farmer control (T2) versus the treatments with nitrogen (T3, T4 and T5). Additionally, in the same location, there were found to be significant differences in the combination of inorganic treatments (T1 versus T1, T2, T3, T4, T5) versus organic treatments (T6, T7 and T8). In El Carmen, no statistical differences were found. The combined analysis found significant differences in the comparison of the farmer control (T2) versus the chemical treatments with nitrogen (T3, T4 and T5), and for the combination of organic treatments (T6) versus T7 and T8.

In Luz de América, the lowest fruit production was obtained with the treatment with no nitrogen (T1) belonging to the chemical group (G1) and T6 belonging to the organic group (G2). The highest fruit production was obtained by the chemical treatments with doses of 120, 180 and 240 kg ha-1 of N (T3, T4 y T5, respectively), in contrast to the organic and mixed treatments.

As reported in the head weight analysis, greater fruiting efficiency resulted from the use of inorganic nitrogen than compost fertilizers. The treatment T5 was found to be the most efficient group, producing 2,1,925 kg ha-1 (Figure 3.7.), while T1 produced only 1,68,80 kg ha-1. A related study carried out in Quevedo, Los Ríos province, reported an efficiency of 21,500 kg ha-1 of "barraganete" plantain, cultivated with a density of plants ha-1 (Toapanta, Mite & Sotomayor, 2004).

Fruit dry weight

The fruit dry weight is a parameter that represents the effect of all growth factors. In the current study, the fruit dry weight displayed trends similar to the other variables that were analyzed. In Luz de América, significant statistical differences were found in the treatments, in the comparison of the farmer control (T2) versus the chemical treatments with nitrogen (T3, T4 and T5), and in the comparison of inorganic treatments (T1 versus T1, T2, T3, T4, T5) versus organic treatments (T6, T7 and T8). Additionally, highly significant differences were found in the treatment with no nitrogen versus the chemical treatments (T2, T3, T4 and T5). Finally, significant differences were noted in the combination or organic and inorganic treatments versus the mixed fertilizers. In Luz de América, the lowest production of fruit dry matter was obtained by the treatment with no nitrogen (T1) belonging to the chemical group (1) and T6 belonging to the organic group (G2). The highest weight (6,43,833 kg ha-1) was obtained from T5 and the lowest weight (4 30,033 kg ha-1) was obtained from T1. This was consistent with the statement that the use of inorganic N sources has an effect on the plantain production cycle.

In El Carmen, no statistical differences were observed. The combined analysis showed statistical differences according to the range separation of the treatment. The treatment that reached the highest dry fruit weight was T5, sharing a range with T10 (mixed fertilizers with organic and inorganic N sources). The lowest dry fruit weight was obtained with T1 (no nitrogen treatment) and the organic treatment T6 (Figure 3.8).

Agronomic N efficiency

Under the conditions of the current study, the results demonstrated that nitrogen from an inorganic source (urea) resulted in more positive results in the variables analyzed, compared to nitrogen from organic sources (slaughter house wastes compost). While the comparison may appear biased, since the liberation of N of the organic matter to the soil takes a longer time than the inorganic sources (Brady & Weil, 2014; Havlin et al., 2014), the compost used in the study came from the processed waste of a prominent meat processing company. As a result, the compost was expected to be soluble and so, be able to perform on par with the inorganic source. However, the result clearly indicated that this was not the situation. This study aimed to identify the growth and production of parameter of the dwarf Curaré banana, which is new to the region. Additionally, the current study experimented with high densities as a means of scheduling the fruit production and increase efficiency. In this context, various doses of nitrogen from different sources were evaluated to better understand the role of nitrogen in banana production.

Nitrogen analysis of the soil is not reliable in tropical conditions as it is rapidly transformed into diverse forms. Additionally, only a limited number of banana producers use this tool to plan fertilization strategies. New ways of estimating the amount of nitrogen that should be applied to the soil in order to increase sustainable production, are needed. One method for the estimation of nitrogen required is the determination of the N Agronomic efficiency of N (EAN) (Cassman et al., 2002; Espinosa & García, 2009). Agronomic efficiency is calculated using a linear regression of nitrogen doses with the fruiting efficiency. Utilizing this, it is possible to estimate obtained the amount of harvested product per kg of N applied to the soil. This method generates a parameter which quantifies the nitrogen required for maximum efficiency, based on the agro ecological environment (Snyder, 2009; Witt, Pasuquin & Dobermann, 2006). Since the variables analyzed in El Carmen did not show statistical differences between nitrogen doses, EAN was only determined in de Luz de América. The calculation of EAN for fruit production is illustrated in Figure 3.9 and the EAN for heat production is shown in Figure 3.10.

Nutrient extraction

The production of dwarf Curaré is new to the productive region in Santo Domingo de los Tsáchilas and Manabí. For this reason, there is no data related to the total accumulation of nutrients in the different compartments of the plant, particularly in high density cultivars. In the current study, the nutrient accumulation in the rachis/spine and in the harvested fruit. The accumulated nutrient quantities in these two compartments of the plant showed a direct relationship with fruiting. The dynamics of nutrient accumulation in the rachis/spine and in his fruit, are described as follows:

Nitrogen: The absorption of nitrogen in the rachis/spine showed highly significant differences between the two locations. Plants cultivated in Luz de América showed the highest N accumulation of 1.70 kg ha^{-1}, comprising 13.51% of all nutrients absorbed by the rachis/spine in the T2 treatment. Those cultivated in El Carmen showed a nitrogen accumulation of 1.39 kg ha^{-1} (12.75%) with the same treatment (T2). In the fruit, the highest concentration of nitrogen was found in T3 with 59.30 kg ha^{-1} (33%), while T1 accumulated 46.94 kg ha^{-1} (26%).

Phosphorus: Phosphorus in the banana rachis/spine showed highly significant differences in both locations and treatments. The highest quantity of absorbed phosphorus was 0.20 kg ha^{-1}(1.59%), in T2. In El Carmen, the highest phosphorus absorption (0.19 kg ha^{-1}, corresponding to 1.89%) was observed in T7 rachis/spine. In the fruit, the highest P levels of 5.80 kg ha^{-1} (5.53%) were found in T5 and T9 showed an absorption of 4.49 kg ha-1 (2.80%).

Potassium: The extraction of potassium showed highly statistical differences between treatments. The highest values in rachis/spine were reported in Luz de América. Here, the T3 reached 9.90 kg ha^{-1} (79.26%) in contrast to El Carmen where T2 obtained 8.42 kg ha^{-1} (77.25%). In the fruit, the highest potassium extraction was found in El Carmen, where T10 reached 107.6 kg ha^{-1} (58,65%) in contrast to T4 in Zoila Luz that reached 104.8 kg ha-1 (44,79%). These results demonstrated that potassium and nitrogen are nutrients with highest concentration in plantains.

Calcium: Calcium accumulated in the rachis/spine was found to be statistically different depending the location. In Luz de América, the highest levels of accumulated calcium were the result of the T2 treatment which resulted in an accumulation of 0.68 kg ha^{-1} (5.41%), while in El Carmen T4 accumulated 0,59 kg ha^{-1} (6.39%). In the fruit, the highest level of magnesium was T5 with 19.32 kg ha-1 (18,44%), in contrast to the 16.78 kg ha^{-1} (9.15%) reached by T10 in El Carmen.

Magnesium: The highest concentration of magnesium in the rachis/spine was reported in plants of the T2 group in Luz de América which were found to contain 0.17 kg Mg ha^{-1} (1.35%) in comparison to the same treatment (T2) in El Carmen, that reached 0.14 kg ha^{-1} (1.28%). In the fruit, the treatment that accumulated the highest levels of Mg was T5 in Luz de América with 7.08 kg ha^{-1} (6.76%). In El Carmen, the highest levels of Mg in fruits were obtained with T10 accumulated 5.78 kg ha^{-1} (3.15%).

Sulfur: In Luz de América, T3 recorded the highest accumulation of sulfur in the rachis/spine with 0.26 kg ha^{-1} (2.08%). In El Carmen, T2 reached 0.23 kg S ha^{-1} (2,11%). In the fruit, T5 obtained the highest sulfur levels: 3.22 kg ha-1 (3.07%) in Luz de América and 2.56 kg ha^{-1} (1.56%) in El Carmen.

Macro fauna

The evaluation of the macro-fauna within 30cm of the soil of both locations, showed the presence of 14 taxonomic groups: *Oligochaetes, Formicidae, Coleopteran, Araneae, Isopod, Isopteran, Myriapod, Dipteran, Lepidopteran, Palmonata, Hemipteran, Blattodea, Orthopteran*, and *Dermapteran*. At the cultivation site in Luz de América, 12 taxonomic groups were identified: *Oligochaetes, Formicidae, Coleopteran, Araneae, Isopod, Isopteran, Myriapod, Dipteran, Lepidopteran, Palmonata, Hemipteran* and *Blattodea*. In El Carmen, only 8 groups were found the following 8 taxa were identified: *Formicidae, Coleopteran, Araneae, Isopod, Isopteran, Myriapod* and *Palmonata*. At the beginning of the experiment, earthworms (*Oligochaetes*) were the most abundant taxa in the upper 10cm of the soil in both cultivation sites. By the fourth month of the experiment, it was found that earthworm's population had relocated to 10cm to 20 cm of the surface. The second most abundant group was Formicidae (ants), which were found in the first 10 cm of soil. However, there were found in 20 - 30cm layer under the Surface. Four months into the experiment, the presence of the taxonomic groups in both locations was consistent. However, Palmonata and Orthoptera in Luz de América and Dermapteran in El Carmen were absent. Eight months post-cultivation, the Orthopteran group was absent in Luz de América and Dermaptera disappeared in El Carmen.

The application of chemical and organic fertilizers did not influence in the population and biomass of the edaphic macro-fauna. However, it was observed that more individuals were found at the beginning of the cultivation. In T1 of Luz de América, 261 individuals m^{-2} were identified. In El Carmen, T10 was found to contain 299 individuals m^{-2}. In both locations, the smallest population and density of macro-fauna was found in T6 with 48 individuals m^{-2} in Luz de América and 85 individuals m^{-2} in El Carmen. It was demonstrated that there is a positive effect on fruit production when the biomass of earthworms is greater than 30 g m^{-2} (Ayuke *et al*., 2009; Brown *et al*., 2001; Kamu & Karanja, 2014). In the current study, the greatest biomass (22,4 g m^{-2}) was reported with T2 where 60 kg ha^{-1} of inorganic N was used. Four months post cultivation, it was observed that the macro-fauna population relocated from 10cm to 20cm from the soil surface. In addition, the population at 30 cm below the surface was drastically reduced in both locations. The situation of the macrofauna population before and after the cultivation remained unchanged.

CONCLUSION

The use of an inorganic source of nitrogen to satisfy the nutritional needs of dwarf Curaré plantain cultivated in high densities had a positive effect on the efficiency components of the plant such as: plant height, pseudostem diameter and number of leaves before the harvest. The application of nitrogen accelerated the flowering time by 35 days, which represent an advantage in the high density cultivation systems. High density cultivation systems and the agro climatic conditions of Luz de América, reached and efficiency of production of 25 tons ha^{-1} of heads, this value will serve as the efficiency objective for later works. The use of an organic source of nitrogen in the same doses of inorganic nitrogen, did not have the same effects on the components of efficiency It reached a fruit yield 25 and final accumulation of N in heads and fruits. In El Carmen, most of the organic and inorganic treatments did not lead to significant differences.

The inorganic nitrogen fertilizers were found to be more effective at increasing the efficiency of the plantain production in its first stage, compared to the organic nitrogen. Inorganic and organic fertilizers influenced the density and biomass of the macro-fauna in the soil. It was noted that the organisms of the macrofauna relocated from 10cm under the surface to 20cm in the first four months of the cultivation.

RECOMMENDATIONS

To design management experiments to test and adjust the EAN in the field. In other words, to design new ways to increment the head and fruit production efficiency per applied N unit. The EAN values developed in the current study are good parameters to start new studies.
- To continue testing organic nitrogen sources that are in a position of competing with inorganic fertilizers.

ACKNOWLEDGEMENT

The authors are grateful to: Universidad Tecnológica Equinoccial, Universidad de las Fuerzas Armadas ESPE-Santo Domingo, Soil Management Department INIAP, San Miguel Ranch and Plant Nutrition Program, for their valuable technical support.

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