# Response of Plantains to Banded and Broadcast N and to P Applications at Planting and to Residual P on an Ultisol[1, 2]

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**ABSTRACT**

Two consecutive plantain crops were harvested from an experiment on an Ultisol with high P-fixing capacity, designed to measure the response of plantains to various levels of banded or broadcast N and to P applications at planting, as well as to residual P. N and Mg deficiencies were observed in plants from the O-N plots and verified through leaf tissue analysis. Data on yields from the plant crop can be summarized as follows: Bunch weight was significantly higher from plants receiving 224 kg/ha of banded N than from plants receiving the same amount of broadcast N. Number of fruits and weight of fingers in the third hand were also significantly higher from the 224 kg/ha banded N treatment than from the O-N. No difference as to number of fruits per bunch was measured at the same N levels either banded or broadcast. Bunch and fruit weights increased with increments in P fertilizer from 0 to 56 kg/ha applied at planting or with 179 kg/ha of residual P. Lack of P reduced weight and pulp content in the fingers of the third hand. Data on the ratoon crop reveal no effect of N on bunch weight and no response to P fertilizer. The ratoon crop yielded only 13% less than the plant crop. Over 300,000 fruits/ha were harvested from the two crops.

## INTRODUCTION

Plantains (*Musa acuminata* × *M. balbisiana,* AAB) are a major source of food in the humid tropics. They can provide good soil protection even on steep slopes, if carefully managed (9). They can be planted throughout the year and can produce more than one crop without replanting, provided that systemic pesticides are used (6) for the control of soil pests. They can be cooked in a variety of ways. Under conditions in Puerto Rico, the home garden and commercial production of plantains have been increasing steadily in recent years. A dramatic increase in the farm value of the crop was registered in 1973–74 when it reached almost $19 million; for 1974–75, it was $21.6 million (5).

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Most of the plantains in Puerto Rico are grown in the humid soils of the interior, primarily on Oxisols and Ultisols. These are deep, well-drained, extremely acid and relatively infertile soils, but with favorable structure. According to the best available estimates, there are some 1.5 billion acres of these soils in the tropics, which are potentially arable yet mostly uncultivated (2). They are generally low in available P and N, and their capacity to fix P is reportedly high (2). Research by various investigators on these kinds of soils indicates that they can be very responsive to fertilizers in combination with appropriate management practices (1, 9).

Research on fertilizer response of plantains in Puerto Rico and other tropical regions over the past years has been rather limited. Caro-Costas et al. (1), working on an Ultisol at Orocovis, obtained yield responses to both N and P. Vicente-Chandler and Figarella (9) studied in an Ultisol at Orocovis the effects of fertilization and liming with sod-planting and strip cultivation of plantains, cf. Maricongo. They concluded that response of plantains to P fertilization on that soil could be expected with less than 40 lb P soluble in dilute acid per acre (45 kg/ha). Application of P in the hole at planting time seemed a desirable practice to reduce fixation in view of the strong acidity and high free iron oxide levels in the soil. Responses to micronutrients and Mg have also been reported by Hernández and Lugo-López with the Enano cultivar at Corozal (5).

This paper reports on the results of a 2-year research project with the major objective of determining the response of plantains on an Ultisol, with a high P-fixing capacity, to various levels of banded and broadcast N and to P applications both at planting and residually.

## MATERIALS AND METHODS

The experimental field was located at the Corozal Substation farm, 250 m (820 ft) above sea level, with a mean annual rainfall of 200 cm (78 in). The average summer maximum and minimum temperatures are approximately 29° C and 21° C, respectively. In winter these are about 3° C lower. Solar radiation ranges from an average of 300 langleys/day in winter to 500 langleys/day in summer. The soil has been classified as Humatas, Typic Tropohumults, clayey, kaolinitic, isohyperthermic.

Prior to the plantain crop, sorghum and corn experiments were planted on November 18, 1970 and May 7, 1971, respectively, to study the relative efficiency of banded P vs. broadcast P and its residual effect. Three soil samples from the 0 to 15 cm depth were taken on December 1, 1971 from individual plots to measure pH and residual P.

Available P was determined by the Bray No. 2 method. The pH of the soil was around 4.8, while available P ranged from 19 to 67 p/m.

The N and P plantain experiment was planted on January 20, 1972 on the same plots previously utilized for the sorghum and corn experiments. A total of 1.8 metric tons/ha of lime were applied prior to planting and incorporated into the soil by harrowing. Again, 2.7 metric tons/ha of lime were applied 6 months after harvesting the plant crop.

The experiment included 10 treatments replicated 5 times in a randomized block design. The treatments were as follows: a) 5 rates of P[4] (0, 56, 112, 179 and 1121 kg/ha) of which the 179 and 1121 rates were applied previously in 1970 and are therefore considered as residual treatments (table 1); b) 3 levels of banded N (112, 224 and 336 kg/ha; and c) 2 levels of broadcast N (112 and 224 kg/ha). There was also a no-N and 112 kg P/ha treatment (treatment 5, table 1).

Plots consisted of 15 plants, 3 rows of 5 plants each 1.53 m (5 ft) apart and 1.83 m (6 ft) between plants for a plant population of 3,586 plants/ha. A high-yielding cultivar, Maricongo, was used. Corms used as planting material weighed from approximately 0.23 to 0.68 kg each. The three central ones in each plot were selected from parents having over 40 fruits/bunch and a weight of 0.46 kg each. The corms were dipped for 5 min in a nematocide-insecticide solution containing 13 ml of Nemagon[5] (DBCP) 70–75 E.C. per gallon of water. In addition, planting holes were sprayed at planting with one gallon of a solution of 5 ml Nemagon/gallon of water.

In the plant crop, weeds were controlled with one preemergent application of Ametryne 80% WP at the rate of 5.6 kg/ha. Gramoxone (Paraquat) applications, as postemergent, were made whenever needed and up to 6 months (when the planting closed in) at the rate of 4.6 l/ha. For the ratoon crop, only one application of Gramoxone, at the previously indicated rate, was made soon after harvesting the plant crop.

For the plant crop, a blanket application of 336 kg/ha of $K_2O$, 168 of Mg and 22 kg/ha of Zn, as sulfate in each case, was made. The $K_2O$ was split into three equal applications. It was applied together with the N treatment differentials (table 1) in circular bands approximately at .46 m (1.5 ft) around the pseudostems 1.8, 5.3, and 9.5 months after planting. The Mg was split into two equal applications of 168 kg each

[4] The 56 and 112 kg/ha rates were applied in the hole at planting time.

[5] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment or materials not mentioned.

at 1.8 and 5.3 months. Zn was also added to the last application of N and K at 9.5 months.

An additional application of Mg at 168 kg/ha was made 6.2 months after planting. P applications, mixed thoroughly with the soil in the planting hole were made at planting time. Residual P treatment had previously been applied in 1970.

The ratoon crop received a total of 336 kg/ha of $K_2O$ and 202 kg/ha of Mg, as sulfate, at the time the N treatment differentials were applied, i.e., immediately after harvesting the plant crop, as already described. A second application, consisting of 168 kg of Mg, 20 kg/ha of Zn and 67 kg/ha of B, as borax, was made 7 months after harvesting the plant crop.

TABLE 1.—*Leaf nutrient composition of plantains 4.7 months after planting, Corozal Substation*[1]

| No. | Treatment | | | Level of indicated nutrient | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P 1970 | P 1972 | N | P | K | Ca | Mg | Fe | Mn | Zn |
| | | *Kg/ha* | | | | % | | | *P/m* | *P/m* | *P/m* |
| 1 | 336 | 0 | 0 | 4.00 | .23 | 4.18 | .66 | .24 | 95 | 562 | 14 |
| 2 | 336 | 179[2] | 0 | 3.84 | .24 | 4.11 | .71 | .26 | 99 | 602 | 12 |
| 3 | 336 | 1121[2] | 0 | 3.81 | .23 | 3.72 | .70 | .31 | 91 | 548 | 17 |
| 4 | 336 | 45 | 56 | 4.06 | .26 | 5.31 | .77 | .34 | 100 | 532 | 14 |
| 5 | 0 | 90 | 112 | 2.82 | .23 | 4.90 | .62 | .15 | 85 | 565 | 16 |
| 6 | 112 | 359 | 112 | 3.83 | .26 | 4.93 | .74 | .26 | 108 | 594 | 12 |
| 7 | 224 | 359 | 112 | 3.62 | .22 | 3.74 | .71 | .26 | 93 | 606 | 14 |
| 8 | 336 | 404 | 112 | 4.02 | .23 | 4.64 | .75 | .28 | 93 | 623 | 14 |
| 9 | 112[3] | 90 | 112 | 3.80 | .23 | 4.29 | .77 | .29 | 103 | 704 | 12 |
| 10 | 224[3] | 179 | 112 | 3.78 | .24 | 5.23 | .75 | .32 | 101 | 643 | 12 |

[1] Mean of 5 replicates.

[2] Residual treatments where P was originally applied in 1970.

[3] Broadcast N.

For the stem borer (*Cosmopolites sordidus*) and nematode control in the two crops, Dasanit (Terracur P) at the rate of 202 kg/ha (56 g/plant) was applied in circular bands around the pseudostems every 6 months.

To control the Sigatoka leaf spot disease (caused by *Cercospora musae*) in the plant crop, orchard oil was applied every 15 to 21 days 6 months after planting. Again, for the ratoon crop, spraying with orchard oil was initiated approximately 5 months after harvesting the plant crop and continued at the same time intervals.

A strip from the central section of the lamina of the third oldest leaf from the middle three plants of each plot was taken at 4.7, 8.1, and 11.4 months (at shooting) after planting. Leaf samples were taken in a like manner for the ratoon crop only after applying all the fertilizer. All samples were analyzed for NPK and micronutrients.

The harvest of the plant crop started on April 19, 1973 and continued until August 2, 1973. Bunches were harvested at 100 to 110 days after bunch shooting (7) when the pulp content was around 60 to 66%. Fruits from the third hand of the bunch from the plant crop were also examined. Data on mean fruit weight, mean number of fruits, external fruit length (measured with a caliper, cm), narrowest and widest diameters, pulp-peel ratio, and texture were recorded using procedures described by Sánchez-Nieva et al. (7) and statistically analyzed. Harvesting the ratoon crop was initiated on June 14, 1974 (10 months after the plant crop was harvested) and continued until October 3, 1974, at 100 to 110 days after shooting (7). Data obtained from only the three central plants in each plot (plants from parents which produced at least 40 fruits per bunch) were used for the analysis of variance.

## RESULTS AND DISCUSSION

### LEAF NUTRIENT LEVELS

Information obtained from the first leaf tissue samples, taken 4.7 months after $^1/_3$ of the N and K and $^1/_2$ of Mg were applied, revealed high K values in the third leaf (table 1). K levels averaged 4.51%, while Mg averaged .27%. Apparently, leaf K was too high and probably interfered with the absorption of Mg. An additional application of Mg of 168 kg/ha was therefore made 6.2 months after planting. At this stage, plants had already received $^2/_3$ of the N and K and 168 kg Mg/ha.

N and Mg deficiencies were observed in plants from all plots which had not received N during drought conditions. Values for these nutrients on the no-N plots averaged 2.82 and .15%, respectively (table 1). Similar deficiencies were observed by Vicente-Chandler and Figarella (9), working with the same crop, also in an Ultisol at Orocovis, with levels of both N and Mg in the third leaf at 7 months, as those herein reported. Plants appeared to recover from this deficiency as more Mg was added.

The N-deficient plants were, in general, stunted in growth. A progressive loss of green color, especially in the older leaves (leaves Nos. 7 to 9), was evident. This fading of the green color slowly extended toward the central vein as the plant aged, finally covering the whole leaf. At this stage, necrotic areas appeared near the margins of the affected leaves, extending toward the central vein, covering the whole leaf and resulting in a progressive death. Leaf sheaths became pinkish-yellow with dominant pink areas.

Contrary to the typical symptoms in bananas when deficient in this element, the rate of leaf production, as well as leaf size, did not appear to be affected. The chlorosis was more marked in older leaves, the first upper five looking greener than the lower ones.

Similar to the N-deficiency, a progressive loss of green color in the older leaves was observed in Mg-deficient plants. However, in this case the chlorosis extended toward the midrib section, the vicinity of the midrib remaining green. As the leaves aged, the chlorosis became more pronounced, developing a clear contrast to the small green strip remaining near the central vein. At a later stage, necrotic areas appeared, covering the whole leaf and causing death.

## PLANT CROP YIELD

Average bunch weight was significantly higher from plants receiving 224 kg of banded N than from those receiving 112 banded or 112 and 224 kg N/ha broadcast (table 2). The significant difference between 224 kg N/ha banded (treatment 7) and the same amount applied broadcast (treatment 10) was concurrent with the smaller number of plants which bore a crop in the broadcast treatment. Fewer plants also bore a crop in treatment 1. This was mainly due to plants affected with virus, which had to be discarded so as to prevent others from being infected. The number of fruits per bunch was significantly higher at the 224 kg/ha of banded N (treatment 7) level than in the no-N level, and the 112 kg N/ha broadcast plots (treatment 9). Yields from the 224 kg N/ha plots (treatment 10), applied broadcast were high, in spite of the fact that only 80% of the plants bore fruit. There was no difference in the number of fruits per bunch from plots receiving N at the same levels either banded or broadcast (treatments 6 vs. 9 and 7, and 7 vs. 10, table 2).

Table 3 shows significant differences at the 5% level, obtained as to number of fingers in the third hand between the 224 kg N/ha (treatment 7) and the control (treatment 5). However, there was no effect attributable to banded or broadcast N on number of fingers in the third hand. Fingers in the third hand were heavier from plots receiving 224 kg N/ha banded (treatment 7) than from those not receiving N (treatment 5) and 112 kg N/ha banded, respectively. No significant differences attributable to fertilizer N applied or to method of application were measured as to length or diameter of fingers, peel-to-pulp ratio, and percentage pulp.

Table 2 shows a significant (5% level) increase in both bunch and fruit weights when fertilizer P applied to the soil at planting increased from 0 to 56 kg/ha, and with 179 kg/ha of residual P (treatments 1, 4, and 2). In general, the number of fruits per bunch was not affected by P. However, significantly fewer fruits per bunch were produced from

TABLE 2.—*Effect of N and P fertilization on yield of plantains, cf. Maricongo, plant crop, growing on an Ultisol at the Corozal Substation*

| Treatment | N | P 1970 | P 1072 | Average bunch weight | Average fruits/bunch | Weight of fruits | Fruits | Plants bearing fruit |
|---|---|---|---|---|---|---|---|---|
| *No.* | *Kg/ha* | *Kg/ha* | *Kg/ha* | *Kg* | *No.* | *Kg/ha* | *No/ha* | *%* |
| 1 | 336 | 0 | 0 | 10.36 d[1] | 46.14 abc | 37,111.60 d | 156,799.05 a | 87 |
| 2 | 336 | 179[2] | 0 | 15.28 ab | 48.78 a | 54,723.18 ab | 174,947.13 a | 100 |
| 3 | 336 | 1121[2] | 0 | 13.71 abcd | 47.86 ab | 49,091.06 abcd | 171,647.21 a | 100 |
| 4 | 336 | 45 | 56 | 14.28 abc | 46.38 abc | 51,142.04 abc | 166,339.68 a | 100 |
| 5 | 0 | 90 | 112 | 12.67 abcd | 42.66 c | 45,379.87 abcd | 152,997.72 a | 100 |
| 6 | 112 | 359 | 112 | 11.74 cd | 45.40 abc | 42,026.96 cd | 162,824.37 a | 100 |
| 7 | 224 | 359 | 112 | 15.88 a | 49.32 a | 56,871.69 a | 176,883.61 a | 100 |
| 8 | 336 | 404 | 112 | 13.76 abcd | 48.60 ab | 49,286.56 abcd | 174,300.98 a | 100 |
| 9 | 112[3] | 90 | 112 | 12.39 bcd | 43.82 bc | 44,370.75 bcd | 157,158.19 a | 93 |
| 10 | 224[3] | 179 | 112 | 11.84 bcd | 45.98 abc | 39,129.63 cd | 154,144.79 a | 80 |

[1] Values followed by one or more letters in common do not differ significantly at the 5% level.
[2] P residual treatments.
[3] Broadcast N.

plots receiving 112 kg P/ha at planting and no-N than from those receiving 1121 kg/ha residual P at the highest levels of N.

Table 3 shows that there was no effect of fertilizer P on the number of fingers (third hand).

In the case of the number of fruits per bunch, significantly fewer fruits in the third hand were recorded with 112 kg P/ha applied at planting (treatment 5 ) than when compared to the two residual treatments, i.e., 179 and 1121 kg/ha. Lack of P significantly reduced the weight of fingers in the third hand (treatment 1 vs. 2). No further effect was found with increasing P levels.

TABLE 3.—*Effects of N and P fertilization on various fruit indices of plantain cf Maricongo plant crop, grown on an Ultisol at Corozal, 1973*

| Treatment | N | P | P | Fingers—3rd hand | Weight fingers—3rd hand | External length—fingers 3rd hand | Pulp |
|---|---|---|---|---|---|---|---|
| *No.* | | *Kg/ha* | | *Number* | *Gm* | *Cm* | *%* |
| 1 | 336 | 0 | 0 | 7.64 abc[2] | 1793 c | 19.5 abc | 57.0 b |
| 2 | 336 | 179[1] | 0 | 8.28 a | 2400 ab | 19.9 ab | 62.5 a |
| 3 | 336 | 1121[1] | 0 | 8.04 ac | 2155 abc | 19.4 abc | 62.3 a |
| 4 | 336 | 45 | 56 | 7.54 abc | 2209 abc | 19.0 bc | 63.4 a |
| 5 | 0 | 90 | 112 | 7.04 b | 1981 bc | 19.2 abc | 63.1 a |
| 6 | 112 | 359 | 112 | 7.64 abc | 1963 bc | 18.4 c | 61.0 a |
| 7 | 224 | 359 | 112 | 8.06 ac | 2504 a | 20.4 a | 64.1 a |
| 8 | 336 | 404 | 112 | 7.82 abc | 2219 abc | 20.0 ab | 63.5 a |
| 9 | 112[3] | 90 | 112 | 7.26 bc | 2105 abc | 19.6 abc | 62.0 a |
| 10 | 224[3] | 179 | 112 | 7.40 bc | 2142 abc | 19.8 ab | 63.4 a |

[1] P residual treatments.

[2] Values followed by one or more letters in common do not differ significantly at the 5% level.

[3] Broadcast N.

Length of fingers, fruit diameter, and peel-to-pulp ratio were not significantly affected by fertilizer P. However, lack of P significantly reduced the pulp content (treatments 2, 3, 4, and 5 vs. 1, table 3).

## RATOON CROP

There was no significant effect of fertilizer N on average bunch weight. However, applications of 224 kg/ha and 336 kg/ha of N (treatments 7 and 8, table 4) significantly increased (at the 5% level) the average number of fruits per bunch from 33.49 (treatments 7 and 8, respectively, table 4). The broadcast treatments (9 and 10) also produced significant increases in the number of fruits per bunch when compared to the control (treatment 5).

There was no response to P applications to the soil for any of the measures studied. The lowest number of fruits per bunch was obtained with the combined treatment of 112 kg P/ha applied at planting and no-N (treatment 5).

The mean yield of this 10-month crop was 143,000 fruits/ha as compared to about 165,000 for the plant crop, a reduction of only 13%. The average commercial production for Puerto Rico is about 50,000 fruits/ha (3). For both crops, there was relatively little response to applied N and P fertilizers.

TABLE 4.—*Effects of N and P fertilization on yield of plantains, cf. Maricongo ratoon crop, growing in an Ultisol at the Corozal Substation, 1974*

| Treatment | N | P 1970 | P 1972 | Average bunch weight | Average fruits per bunch | Fruit yield | | Plants bearing a crop |
|---|---|---|---|---|---|---|---|---|
| *No.* | | *Kg/ha* | | *Kg* | *Number* | *Kg/ha* | *Number/ha* | *%* |
| 1 | 336 | 0 | 0 | 8.74 ab[2] | 39.10 ab | 31,333 ab | 140,230 ab | 92 |
| 2 | 336 | 179[1] | 0 | 11.21 a | 40.49 a | 40,209 a | 145,244 a | 92 |
| 3 | 336 | 1121[1] | 0 | 10.17 ab | 43.32 a | 36,478 ab | 155,042 a | 93 |
| 4 | 336 | 45 | 56 | 7.91 ab | 39.49 ab | 28,374 ab | 141,657 ab | 80 |
| 5 | 0 | 90 | 112 | 6.84 b | 33.49 b | 24,514 b | 120,139 b | 87 |
| 6 | 112 | 359 | 112 | 9.22 ab | 38.99 ab | 33,058 ab | 139,864 ab | 87 |
| 7 | 224 | 359 | 112 | 10.25 ab | 40.66 a | 36,766 ab | 145,839 a | 80 |
| 8 | 336 | 404 | 112 | 10.19 ab | 42.56 a | 36,552 ab | 152,653 a | 87 |
| 9 | 112[3] | 90 | 112 | 10.66 ab | 41.19 a | 38,223 ab | 147,754 a | 93 |
| 10 | 224[3] | 179 | 112 | 9.38 ab | 40.86 a | 33,639 ab | 146,563 a | 80 |

[1] P residual treatments.

[2] Values followed by one or more letters in common do not differ significantly at the 5% level.

[3] Broadcast N.

## RESUMEN

Dos cosechas consecutivas de plátano se recolectaron en un experimento sembrado en un suelo Ultisol que tiene una alta capacidad para la fijación del P. El estudio se diseñó para evaluar el comportamiento del plátano a varios niveles de N aplicados en franjas y al voleo, y además, para medir el efecto de aplicaciones de P al momento de sembrar, así como el efecto residual de aplicaciones anteriores. En las plantas que no recibieron aplicaciones de N se observaron carencias de N y Mg. Estas se verificaron por análisis de tejidos de las hojas. Los datos de rendimiento de la plantilla pueden resumirse como sigue: el peso de los racimos y el número y peso de las frutas del tercer gajo fue significativamente mayor en las plantas que recibieron N en franjas a razón de 224 kg./ha. que en las que no lo recibieron. No hubo diferencias en cuanto al número de frutas por racimo que puedan atribuirse a la aplicación de N en franjas o al voleo aun a los mismos niveles. El peso del racimo y de la fruta aumentaron cuando se incrementó la aplicación de P de O a 56 kg./ha. al momento de sembrar y con 179 kg./ha. de P residual (aplicado en 1970). La falta de P disminuyó el peso y el contenido de pulpa de las frutas en el tercer gajo. Los datos de la segunda cosecha, el retoño, revelan que las aplicaciones de N no afectaron el peso del racimo y que no se registraron respuestas a aplicaciones de P. La producción de la cosecha de retoño fue solamente 13% menor que la de la plantilla. En general, los datos indican que cuando se usan cultivares de alto potencial productivo, se usan siembras más densas, se siguen prácticas adecuadas de control de plagas y otras prácticas mejoradas de cultivo, incluyendo el abonamiento racional, es posible obtener altos niveles de producción en los suelos ácidos y de baja fertilidad inherente como lo son los Ultisols. De ambas cosechas, plantilla y retoño, se obtuvieron más de 300,000 frutas/ha.

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