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# Nutrient uptake and dry matter composition in the plant crop and first ratoon of the Grand Nain banana grown on an Ultisol[1, 2]

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## ABSTRACT

**Properly managed Grand Nain bananas grown on a red-acid Corozal clay (Aquic Tropudults) took up an average of 276, 23, 711, 152 and 54 kg/ha/crop of N, P, K, Ca and Mg, respectively, from planting throughout the first ratoon harvest. N, K and Ca uptakes steadily increased as the plants matured. P and Mg uptakes remained low. On the other hand, the N, P, K and Mg levels progressively decreased with age in all plant tissues, but the Ca level increased or remained constant. Dry matter composition also increased as the plants advanced in age, averaging, 27,447 kg/ha/crop at the time of harvest. At bunch harvest, about 52% of the total dry matter produced was removed from the field along with 123, 13, 263, 13 and 16 kg/ha of N, P, K, Ca and Mg, respectively. On the basis of the data obtained, a rational fertilization program is proposed for high yielding and good quality banana production on Ultisols. For optimum yields, the fertilizer applied must contain about 392, 64, 970 and 85 kg/ha of N, $P_2O_5$, $K_2O$ and MgO, respectively, in the plant crop and 266 kg/ha of N, 47 kg/ha of $P_2O_5$, 629 kg/ha of $K_2O$ and 58 kg/ha of MgO in the ratoon crop. These quantities are approximately equivalent to the nutrients in 3,250 and 2,200 kg/ha, respectively, of a 12-2-30-3 fertilizer.**

## RESUMEN

**Extracción de nutrimentos del suelo y composición de la materia seca en la plantilla y el primer retoño del banano Grand Nain en un Ultisol**

**Se determinó, mediante muestreos bimensuales, la extracción de nutrimentos y la producción de materia seca del banano Grand Nain sembrado en un suelo rojo y arcilloso de la Subestación de Corozal durante**

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[2]This paper covers work carried out cooperatively between the Agricultural Research Service-USDA, and the Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P. R.

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dos ciclos de producción. El ciclo de siembra a cosecha de la plantilla duró 12 meses y el del retoño 10 meses adicionales. La extracción total de N, K y Ca aumentó según las plantas crecían, mientras que P y Mg se mantuvieron bajos y poco variables todo el tiempo. Los niveles nutricionales de N, P, K y Mg disminuyeron en los diferentes tejidos del banano según las plantas se desarrollaban. Por el contrario, el nivel de Ca aumentó o se mantuvo constante según las plantas envejecían. Los niveles más altos de N, P, Ca y Mg se diagnosticaron en la lámina de la hoja, mientras que el valor más alto de K se detectó en el seudotallo en todos las edades de la planta. El consumo medio del banano Grand Nain fue de 276, 23, 711, 152 y 54 kg./ha. y cosecha de N, P, K, Ca y Mg, respectivamente. La acumulación y concentración de materia seca también aumentaron según las plantas se desarrollaban hasta llegar a una producción media de 27,447 kg./ha. y ciclo al tiempo de la cosecha. Un 52% de la materia seca total, la cual contenía 123, 13, 263, 13 y 16 kg./ha. de N, P, K, Ca y Mg, respectivamente, se sacó de la plantación al cosechar los racimos. Los restantes nutrimentos se trasladaron al hijuelo del retoño o devolvieron al suelo en los residuos de la cosecha. Los cálculos basados en estos datos, en la capacidad de los suelos Ultisol y Oxisol de la zona montañosa para suplir nutrimentos y en las pérdidas causadas por escorrentía y lixiviación cuando los nutrimentos se aplican como abonos señalan que para conseguir rendimientos óptimos hay que aplicar fertilizantes que suplan alrededor de 392, 64, 970 y 85 kg./ha. de N, $P_2O_5$, $K_2O$ y MgO, respectivamente, para la cosecha de plantilla y 226 kg./ha. de N, 47 kg./ha. de $P_2O_5$, 629 kg./ha. de $K_2O$ y 58 kg./ha. de MgO para los retoños. Estos nutrimentos los pueden suplir 3,250 kg./ha. de un abono 12-2-30-3, ó una fórmula similar, en la plantilla y 2,200 kg./ha. en los retoños. La plantilla debe abonarse a los 2, 5, 8 y 10 meses aproximadamente con 650, 812, 1,138 y 650 kg./ha., respectivamente. Debe empezarse a abonar el retoño en el apogeo de la cosecha de la plantilla, y debe repetirse cada 3 meses a razón de 730 kg./ha y aplicación.

## INTRODUCTION

Banana production in Puerto Rico is mainly in the interior highlands where the crop grows semi-abandoned under partial shade and intercropped with coffee. Under these conditions the yields are low and the fruits are of inferior quality. However, Puerto Rico has the climate, adequate soils, infrastructure, and easy access to U.S. market to develop a modern banana industry for the production of high economic yields and good fruit quality for local consumption and for export (6). Therefore, research efforts should be geared toward the development of effective crop management systems with emphasis on proper fertilization.

Local research in banana nutrition has been limited. Santiago et al. (10) obtained 85 t/ha of marketable fruits from the plant and first ratoon harvests of the Grand Nain cultivar grown with drip irrigation, and fertilized with 495 and 990 kg/ha of N and $K_2O$, respectively, over a 22-month period. At present, the criteria used in banana fertilization are based on the recommendations developed for plantains. Irizarry et al. (5) conducted nutrient uptake studies with this crop and rationalized that plantains grown on red acid soils should be fertilized with about 338, 58, 780 and 100 kg/ha of N, $P_2O_5$, $K_2O$ and MgO, respectively, for optimum yields.

Shands (11) in Jamaica reported a significant increase in yield in the plant and first ratoon crop of the Valery banana with applications of 135, 90 and 336 kg/ha/year of N, $P_2O_5$ and $K_2O$, respectively. Lahav (8) reported that in Israel a 5-year old banana experiment responded to the applications of various rates of $K_2O$. Optimum yields of 40.2 t/ha/year of marketable fruits were obtained with the application of 758 kg/ha/year of $K_2O$.

Rodríguez-Gómez (9) conducted a series of banana experiments in Panama, Costa Rica and Honduras using various combinations of N, P, K and Mg. He obtained a maximum yield of 50 t/ha/year with the Grand Nain cultivar when he applied 1,080 kg/ha/year of $K_2O$, maintaining other nutrients in sufficient amounts. Garita and Jaramillo (4) studied the relationship between rates of $K_2O$ applied to the Giant Cavendish banana and yield. Optimum yields of 66.4 t/ha/year were reported with the application of 750 kg/ha/year of $K_2O$ combined with 35 kg/ha of $P_2O_5$ and 450 kg/ha of N. Nutrient values in the lamina of the third open leaf at the time of bunch shooting were 2.77% N, 3.04% K, 0.61% Ca and 0.33% Mg.

Twyford and Walmsley (12,13) studied on dry matter accumulation and nutrient uptake in the Robusta banana grown at various sites in the Windward Islands. The highest dry matter production was recorded at the Grenada site with 16 t/ha at the time of bunch harvest. Maximum nutrient uptakes for a plant crop with a population of 2,500 plants/ha were 448; 60; 1,457; 214 and 140 kg/ha of N, P, K, Ca and Mg, respectively. On this basis, they estimated that in order to obtain a yield averaging 50 t/ha/year from a similar field, the plant crop must be fertilized with about 5,000 kg/ha of a 9-9-35-5 (N, $P_2O_5$, $K_2O$ and MgO) fertilizer including losses from leaching and fixation. After considering the amount of nutrients removed from the field at harvest and those recycled to the soil from plant residues, the rate of fertilizer recommended for successive ratoon crops was adjusted to 630 kg/ha/year.

This study determined nutrient assimilation and dry matter composition at various stages of growth of the Grand Nain banana during two crop cycles. The data obtained were used to estimate total nutrient requirements, and to establish recommendations for the rational fertilization of bananas grown on red acid soils of the humid mountain region of Puerto Rico.

## MATERIALS AND METHODS

An experiment was planted 24 June 1982 at the Corozal Agricultural Substation. This substation is located in the north-central region of Puerto Rico about 200 m above sea level, where average minimum and maximum temperatures were about 19.5 and 30.5° C, respectively (fig. 1). Throughout the experiment the lowest temperatures were registered from November through April, averaging 18.4° C. The highest occurred

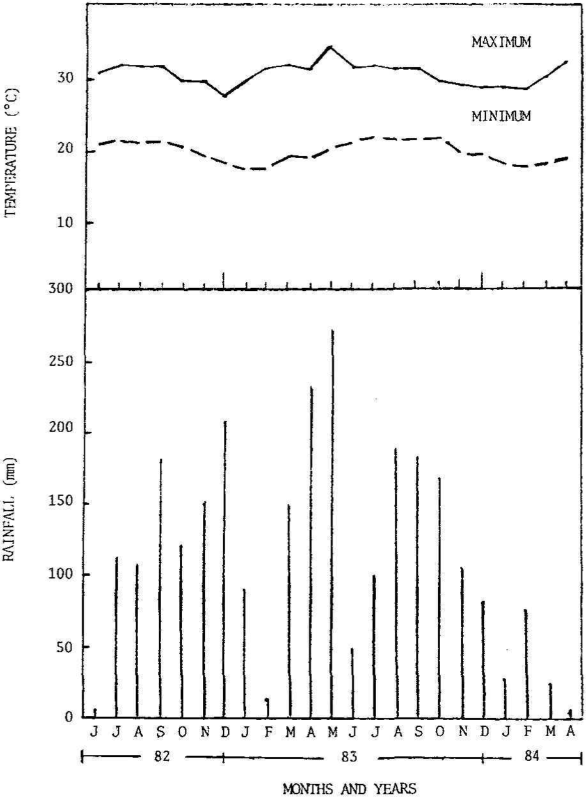


FIG. 1.—Average minimum and maximum temperatures, and monthly rainfall recorded at the Corozal Substation from 24 June 1982 to 24 April 1984.

from May to October, averaging 31.4° C. Mean monthly rainfall was 126 mm. January, February, March and June were the driest months, averaging only 55 mm (fig. 1). The rainfall deficit was compensated for with supplemental applications of overhead irrigation at the rate of 40 mm every 2 weeks.

The soil is a Corozal clay (Aquic Tropudults, clayey, mixed isohyperthermic). Soil pH was 5.2 and contained 5.1 p/m of available P (Bray Method II) and 0.5, 3.0 and 9.0 meq of exchangeable K, Mg and Ca/100 g of soil, respectively. Prior to planting, the soil was plowed and harrowed twice to a depth of about 25 cm.

Grand Nain banana plants of uniform age and size, and regenerated through tissue culture, were spaced in the field in a double-row planting system of 1.8 by 1.8 by 3.1 m. This corresponded to a density of about 2,250 plants/ha. The field was divided into blocks of 14.6 by 27.4 m. The blocks were subdivided into 3 plots with 30 plants each and separated by ditches 30 cm wide by 46 cm deep. Frequent suckering allowed the development of only one "follower"/stump.

Weed growth was chemically suppressed, and the corm weevil (*Cosmopolites sordidus*), nematodes, and the yellow sigatoka (*Mycosphaerella musicola*) were controlled by the appropriate cultural practices recommended for the control of pests and diseases in plantains and bananas (7).

Three fertilizer treatments were arranged in a randomized complete block design with 3 replications. The treatments consisted in the application of 0, 1,340 and 2,680 kg/ha/crop of a 10-5-30-3 (N, $P_2O_5$, $K_2O$, MgO) fertilizer supplemented with 23 kg/t of minor elements. The fertilizer was divided into equal portions and applied at planting time and at intervals of 3 months thereafter. At the end of the first ratoon harvest (24 April 1984) the plants grown on the medium and high fertility plots had received a total of 2,680 and 5,360 kg/ha, respectively, of the complete fertilizer.

At the third, fifth, seventh, ninth, eleventh and twelfth months after planting, and every 2 months thereafter, 6 plants from each treatment were dug up and dissected into roots, corms, pseudostems, leaves and bunches. The leaves were further sub-divided into lamina, midrib and petiole, and the mature-green fruits separated into pulp and peel. A total of 11 sampling dates were performed throughout the plant crop and first ratoon cycles. The bunches were considered marketable when the fruits reached 3/4 full.

Green and oven-dry weights of all plant parts were determined, and samples from each were ground, sifted through a 20-mesh screen and analyzed for N, P, K, Ca and Mg. Total nutrient uptakes were calculated on the basis of the dry matter weight and the nutrient concentration data.

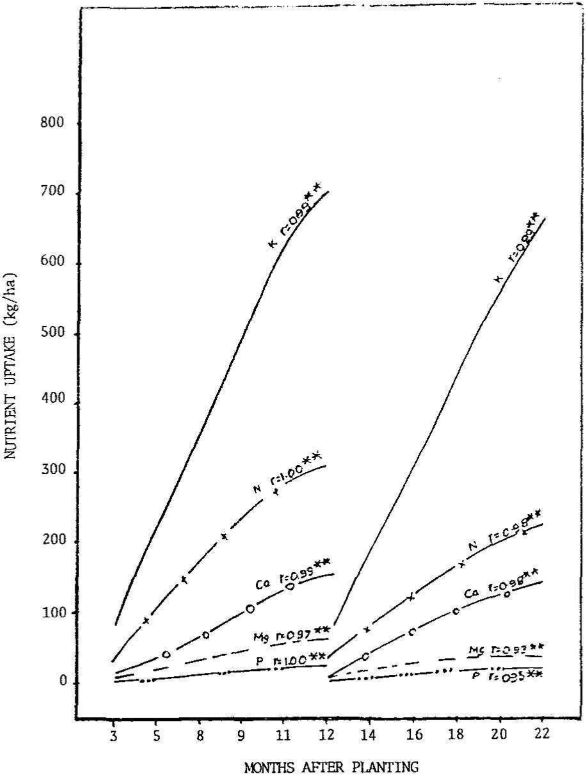


FIG. 2.—Nutrient uptake by the Grand Nain banana from planting throughout the harvest of the plant and first ratoon crops. An equation of the type $Y=A+BX+CX^2$ was fitted to the actual data.

Nitrogen was determined by the macro-Kjeldahl method; P colorimetrically; K, by flame photometry; and Ca and Mg by the Versenate method after digestion with nitric-perchloric acid.

## RESULTS AND DISCUSSION

The experiment lasted 22 months. The plant crop planting-to-harvest cycle was completed in 12 months, and the first ratoon terminated 10 months later. During that period, two high-yielding crops were obtained.

There were no significant yield differences among fertilizer treatments, nor between the plant and first ratoon crops. Average marketable yields were 55,485 kg/ha/fertilizer treatment and crop, equivalent to about 3,045 boxes[4] of fruits/ha.

Nutrient uptake was consistently higher in all plants receiving fertilizer; however, the differences in uptake between the second (medium) and third (high) fertilizer treatments were not appreciable. Therefore, this paper presents data and discusses results obtained with the application of the medium fertilizer treatment; 1,340 kg/ha/crop or a total of 2,680 kg/ha in 22 months.

Figure 2 shows that banana nutrient uptakes followed similar patterns in both crop cycles. Nitrogen, K and Ca uptakes steadily increased as the plant matured. Phosphorus and Mg uptakes remained low throughout the crop cycle, but the latter increased with age until the plants reached the bunch shooting stage. Thereafter it remained constant.

Figure 3 shows that total dry matter accumulation consistently increased with plant age in both crop cycles. Root dry matter production was always low and fairly constant throughout the plant cycles. Leaf, pseudostem and corm dry matter accumulation also increased with time until the bananas reached the bunch-shooting stage, at about 9 months in the plant crop, and 18 months later in the ratoon crop. Thereafter, dry matter accumulation stabilized and shifted the build-up to the bunches at a rapid rate. Total dry matter composition was about 9% higher in the plant crop than in the first ratoon, 28,767 and 26,127 kg/ha, respectively. At harvest, dry matter in the mature bunches was about the same for both plant cycles, averaging 14,239 kg/ha or 52% of the dry matter produced in the whole plant. In this aspect, bananas seem to be more efficient than plantains. Irizarry et al. (5) reported that about 44% of the total dry matter produced in plantains was accumulated in the mature green bunches.

Table 1 summarizes the maximum nutrient uptakes recorded after the completion of the plant crop and first ratoon harvests, and the average for both crops. Nutrient uptake was higher in the plant crop than in the ratoon, especially N and Mg with a 22 and 38% increase, respectively.

[4]One box = 18.2 kg.

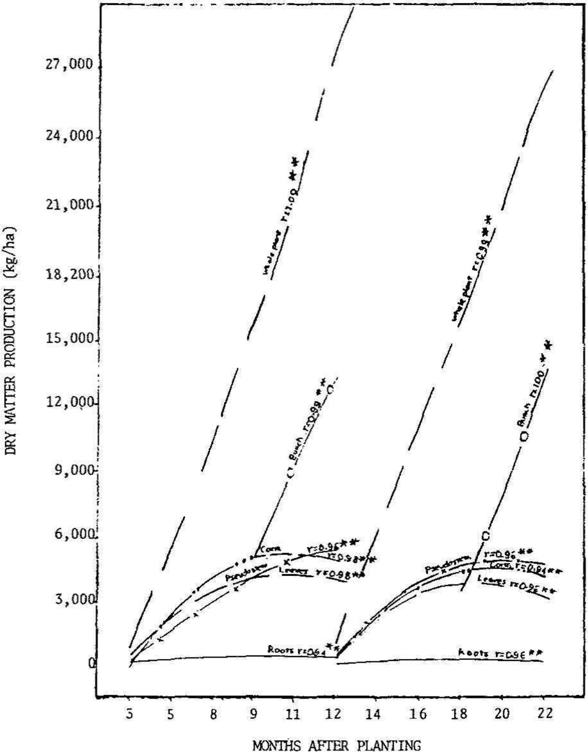


FIG. 3.—Dry matter accumulation in the whole plant and parts of the Grand Nain banana from planting throughout the harvest of the plant and first ratoon crops. An equation of the type $Y=A+BX+CX^2$ was fitted to the actual data.

TABLE 1.—*Amount of nutrients taken up by the Grand Nain banana plants grown on an Ultisol during the plant and first ratoon crops (kg/ha)*

| Nutrient | Plant crop | First ratoon crop | Average |
|---|---|---|---|
| N | 310 | 241 | 276 |
| P | 24 | 22 | 23 |
| K | 726 | 695 | 711 |
| Ca | 157 | 147 | 152 |
| Mg | 66 | 41 | 54 |

Average N, P, Ca and Mg uptakes were 276, 23, 152 and 54 kg/ha/crop, respectively. These quantities were very similar to those reported in plantains grown on an Ultisol by Irizarry et al. (5). However, the banana plants took up 711 kg/ha/crop of K, or 20% more than plantains.

Table 2 shows the steps followed in developing a rational fertilizer program for bananas on the basis of the uptake data. In terms of fertilizers, the nutrient uptake averaged 276, 53, 856 and 88 kg/ha/crop of N, $P_2O_5$, $K_2O$ and MgO, respectively. According to Abruña-Rodríguez et al. (1) and Vicente-Chandler et al. (15), on a long term basis, most Ultisols and Oxisols of the humid mountain region of Puerto Rico can provide about 80 kg/ha/year of N and $K_2O$, and 20 kg/ha/year of MgO. Since these soils lack a P-bearing parent rock, we assumed that their P supplying power is negligible. Therefore, to sustain a high yielding banana crop on these soils the plants must receive 196, 53, 776 and 68 kg/ha of N, $P_2O_5$, $K_2O$ and MgO, respectively, from fertilizers. However, Vicente-Chandler et al. (15) have appraised the losses of fertilizer from run-off experiments on highlands as 50% for N, 20% for $P_2O_5$ and 25% for $K_2O$ and MgO. Therefore, we estimate that in order for the banana plants to receive the proper amount of nutrients, the fertilizer applied must contain about 392, 64, 970 and 85 kg/ha of N, $P_2O_5$, $K_2O$ and MgO, respectively. These quantities are approximately equivalent to 3,250 kg/ha of a 12-2-30-3 commercial fertilizer.

Under Corozal conditions the bananas took 12 months to complete the plant crop cycle and a total of 22 months to produce two crops. On the

TABLE 2.—*Estimate of fertilizer requirements for the production of high yields in the plant crop of bananas grown on an Ultisol (kg/ha)*

| Nutrient | Uptaken by bananas | Supplied by soil | Supplied from fertilizer | Applied as fertilizer[1] |
|---|---|---|---|---|
| N | 276 | 80 | 196 | 392 |
| $P_2O_5$ | 53 | 0 | 53 | 64 |
| $K_2O$ | 856 | 80 | 776 | 970 |
| MgO | 88 | 20 | 68 | 85 |

[1] Assuming losses of 50% N, 20% $P_2O_5$, and 25% $K_2O$ and MgO.

basis of the data obtained from the bi-monthly nutrient uptakes, and dry matter distribution and accumulation (fig. 2 and 3), bananas should be fertilized about 2, 5, 8 and 10 months after planting, and every 3 months thereafter. The fertilizer applied to the plant crop should be distributed in portions of 20, 25, 35 and 20%, respectively. It is of primary importance that about 80% of the total fertilizer be applied before the flowering peak.

Table 3 shows that of the total nutrients taken up by the banana plants during the plant crop 123, 13, 263, 13 and 16 kg/ha of N, P, K, Ca and Mg, respectively, were removed in the bunches at harvest time. On the other hand, about 153 kg/ha of N, 10 kg/ha of P, 448 kg/ha of K, 139 kg/ha of Ca and 38 kg/ha of Mg initially taken up in the plant crop were either diverted toward the ratoon sucker or returned to the soil in 13,209 kg/ha of dry plant residues. However, no immediate residual effect in terms of yield was detected in the first ratoon crop. Yields were about the same for both harvests, averaging 28.4 kg/bunch and yielding 55,485 kg/ha of marketable fruits. Perhaps the heavy surface compaction of the Corozal soil, the steepness of the terrain, excessive run-off and leaching, or the need for additional weathering for the mineralization of the banana residues contributed to the lack of yield response of the first ratoon to residual nutrients. Talleyrand et al. (12), working with crop rotations on Oxisols and Ultisols, could not detect an effect of residual N on yields of subsequent crops.

Table 4 shows the steps followed in calculating the fertilizer recommended for the ratoon crop. Apparently the only immediate measurable effect of the plant crop residual nutrients on successive crops occurred at the beginning of the ratoon cycle. Amounts of nutrients equivalent to 76, 14, 286 and 25 kg/ha of N, $P_2O_5$, $K_2O$ and MgO, respectively, were estimated to be remobilized from the mother plant to the ratoon sucker at the completion of the plant crop cycle. These quantities corresponded to 31, 4, 77 and 6 kg/ha of N, P, K and Mg, respectively, found in the

TABLE 3.—*Nutrients and dry matter accumulated in different parts of the Grand Nain banana at the completion of the plant crop cycle*

| Plant part | N | P | K | Ca | Mg | Dry matter |
|---|---|---|---|---|---|---|
| | | | *kg/ha* | | | |
| Roots | 3 | 0.2 | 15 | 2 | 1 | 308 |
| Corm | 32 | 2 | 140 | 12 | 7 | 4,410 |
| Pseudostem | 46 | 4 | 199 | 60 | 17 | 4,938 |
| Leaf lamina, midrib and petioles | 72 | 4 | 94 | 65 | 13 | 3,553 |
| Total in plant residues | 153 | 10 | 448 | 139 | 38 | 13,209 |
| Bunch | 123 | 13 | 263 | 13 | 16 | 14,239 |
| Grand Total | 276 | 23 | 711 | 152 | 54 | 27,448 |

TABLE 4.—*Computation of fertilizer needs for the ratoon crop of bananas (kg/ha)*

| Item | Nutrient source | N | $P_2O_5$ | $K_2O$ | MgO |
|---|---|---|---|---|---|
| 1 | Available in crop residues | 153 | 23 | 540 | 63 |
| 2 | Net remobilization from the plant | 76 | 14 | 286 | 25 |
| 3 | Supplied by the soil in 10 months | 67 | 0 | 67 | 17 |
| 4 | Required by bananas | 276 | 53 | 856 | 88 |
| 5 | Total available (items 2 + 3) | 143 | 14 | 353 | 42 |
| 6 | Supplied by fertilizers (item 4 – 5) | 133 | 39 | 503 | 46 |
| 7 | Applied as fertilizers[1] | 266 | 47 | 629 | 58 |

[1] Assuming losses of 50% N, 20% $P_2O_5$, and 25% $K_2O$ and MgO.

first sampling of the ratoon sucker, and 45 kg/ha of N, 2 kg/ha of P, 160 kg/ha of K and 9 kg/ha of Mg recorded from both the mother corm and the root system at the time of the plant crop harvest. Since the sucker continued connected to the mother corm after harvest, we assumed that nutrients in these plant repositories are readily available to the ratoon crop. The nutrient uptakes reported herein for the young ratoon sucker were very similar to those found in the plant crop 3 months after planting.

According to these computations, and on the basis of previous discussions in the text, the ratoon crop, if intensively managed for optimum yield, will require 266, 47, 629 and 58 kg/ha of N, $P_2O_5$, $K_2O$ and MgO, respectively. These quantities are approximately equivalent to the nutrients in 2,200 kg/ha of a 12-2-30-3 fertilizer. The fertilizer should be applied at the rate of 730 kg/ha every 3 months.

Table 5 shows the bimonthly changes that occurred in the nutrients and dry-matter concentrations in the various parts of the banana plant. Nutrient levels tended to be higher in all sampled tissues of the plant crop than in the first ratoon. The highest N and P levels were detected in the leaf lamina, whereas the greatest K level occurred in the pseudostem and roots. These nutrient concentrations progressively decreased in all plant organs as the plants matured. The higher Ca levels were detected in the leaf lamina, midrib and petiole, and the pseudostem. As the banana plants advanced in age, the Ca concentration increased in these organs, and remained more or less stable in other plant parts after the first sampling date. The higher Mg levels were also detected in the leaf lamina, midrib and petiole, and the pseudostem during the early stages of plant growth. Thereafter, it remained stable or decreased in all plant organs as the plants matured. According to García et al. (3), the reduction of K and the increase in Ca concentrations in the leaf as the plants advanced in age may be caused by the gradual replacement of

TABLE 5.—*Nutrient and dry matter concentrations in different tissues of the Grand Nain banana plant during various stages of growth of the plant and first ratoon crops*

| Months after planting | Leaf lamina | | | | | | Leaf midrib and petiole | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | DM | N | P | K | Ca | Mg | DM |
| | % | | | | | | % | | | | | |
| | *Plant crop* | | | | | | | | | | | |
| 3 | 4.78 | .28 | 4.26 | .88 | .63 | 14.7 | 2.00 | .17 | 9.0 | 1.48 | .43 | 5.9 |
| 5 | 3.94 | .18 | 3.70 | .73 | .41 | 13.1 | 1.30 | .10 | 5.54 | 1.16 | .31 | 6.6 |
| 7 | 3.39 | .17 | 3.50 | .70 | .41 | 16.3 | .83 | .07 | 3.41 | 1.37 | .34 | 9.8 |
| 9 | 3.14 | .14 | 3.15 | .75 | .46 | 17.6 | .99 | .06 | 2.93 | 1.38 | .32 | 8.1 |
| 11 | 2.83 | .13 | 2.81 | 1.09 | .36 | 19.0 | .94 | .06 | 2.69 | 2.25 | .41 | 8.7 |
| 12 | 2.67 | .13 | 2.40 | 1.37 | .42 | 20.9 | .85 | .06 | .94 | 2.72 | .42 | 10.2 |
| | *Ratoon crop* | | | | | | | | | | | |
| 12 | 3.71 | .23 | 4.17 | .74 | .41 | 18.9 | 1.03 | .13 | 4.14 | .86 | .27 | 9.2 |
| 14 | 3.55 | .22 | 3.38 | .77 | .34 | 13.4 | .89 | .12 | 4.06 | 1.26 | .24 | 8.9 |
| 16 | 3.27 | .19 | 3.44 | .70 | .36 | 16.6 | .86 | .10 | 3.58 | 1.39 | .31 | 9.4 |
| 18 | 2.93 | .17 | 2.86 | .93 | .30 | 20.4 | .62 | .09 | 2.75 | 1.66 | .29 | 9.9 |
| 20 | 2.79 | .17 | 2.60 | 1.06 | .26 | 21.5 | .63 | .06 | 2.12 | 1.74 | .18 | 11.4 |
| 22 | 2.64 | .16 | 2.63 | 1.22 | .24 | 22.1 | .68 | .06 | 2.31 | 2.79 | .20 | 11.2 |

| Months after planting | Pseudostem | | | | | | Corm | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | DM | N | P | K | Ca | Mg | DM |
| | % | | | | | | % | | | | | |
| | *Plant crop* | | | | | | | | | | | |
| 3 | 2.49 | .23 | 10.00 | .97 | .52 | 3.7 | 1.84 | .19 | 5.13 | .93 | .49 | 7.6 |
| 5 | 2.36 | .19 | 8.05 | .80 | .39 | 3.5 | 1.28 | .08 | 3.39 | .53 | .20 | 9.4 |
| 7 | 1.46 | .15 | 5.12 | .70 | .34 | 3.0 | .95 | .06 | 2.57 | .28 | .19 | 15.2 |
| 9 | 1.31 | .09 | 4.46 | .87 | .43 | 4.9 | .97 | .06 | 2.50 | .32 | .17 | 15.2 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | 1.16 | .09 | 4.12 | .91 | .39 | 5.1 | .96 | .05 | 2.31 | .33 | .14 | 12.4 |
| 12 | 1.08 | .08 | 4.06 | 1.16 | .42 | 5.8 | .92 | .04 | 2.29 | .31 | .17 | 13.3 |
| | | | | | | *Ratoon crop* | | | | | | |
| 12 | 1.60 | .26 | 6.55 | .79 | .48 | 4.1 | .70 | .14 | 22.3 | .20 | .15 | 16.9 |
| 14 | 1.74 | .22 | 6.94 | .82 | .32 | 4.0 | .72 | .12 | 2.14 | .21 | .16 | 16.2 |
| 16 | 1.22 | .18 | 5.22 | .91 | .33 | 4.4 | .73 | .09 | 2.20 | .23 | .11 | 14.6 |
| 18 | .96 | .13 | 3.82 | .87 | .25 | 4.9 | .66 | .06 | 2.20 | .20 | .15 | 15.7 |
| 20 | .81 | .08 | 3.68 | .87 | .22 | 5.1 | .56 | .06 | 2.08 | .25 | .13 | 14.6 |
| 22 | .76 | .07 | 3.50 | 1.06 | .25 | 5.4 | .54 | .06 | 1.90 | .27 | .15 | 11.9 |

| Months after planting | Root | | | | | | Bunch | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | DM | N | P | K | Ca | Mg | DM |
| | % | | | | | | % | | | | | |
| | | | | | | *Plant crop* | | | | | | |
| 3 | 1.79 | .12 | 7.41 | .76 | .35 | 5.1 | | | | | | |
| 5 | 1.59 | .08 | 5.81 | .79 | .42 | 5.1 | | | | | | |
| 7 | 1.27 | .07 | 5.91 | .68 | .42 | 6.0 | | | | | | |
| 9 | 1.21 | .07 | 5.26 | .65 | .34 | 7.3 | 1.81 | .14 | 3.17 | .38 | .28 | 10.3 |
| 11 | .91 | .06 | 4.72 | .67 | .34 | 6.4 | .83 | .10 | 1.72 | 0.5 | .10 | 18.5 |
| 12 | .89 | .05 | 4.94 | .72 | .33 | 6.9 | .99 | .11 | 2.78 | .09 | .12 | 20.6 |
| | | | | | | *Ratoon crop* | | | | | | |
| 12 | .90 | .23 | 6.94 | .96 | .34 | 7.4 | | | | | | |
| 14 | .93 | .10 | 5.72 | .73 | .24 | 6.4 | | | | | | |
| 16 | .96 | .07 | 4.79 | .65 | .30 | 7.5 | | | | | | |
| 18 | .95 | .08 | 4.88 | .67 | .24 | 8.2 | 1.31 | .12 | 2.97 | .32 | .18 | 10.1 |
| 20 | .94 | .07 | 4.76 | .75 | .26 | 8.4 | .88 | .07 | 1.68 | .04 | .10 | 18.0 |
| 22 | .89 | .07 | 4.31 | .74 | .24 | 9.8 | .97 | .12 | 2.67 | .10 | .13 | 20.2 |

TABLE 6.—*Percentage nutrient concentration in the leaf lamina of 7-month old Grand Nain plants as compared to those reported elsewhere for bananas of approximately the same age and associated with near-optimum yield*

| Nutrient | Source | | | |
|---|---|---|---|---|
| | From table 5[1] | Rodríguez-Gómez (9) | Shand (11) | WINBAN (2) |
| N | 3.33 | 2.58 | 2.80 | 2.70–3.00 |
| P | 0.18 | 0.17 | 0.24 | 0.17–0.21 |
| K | 3.47 | 3.35 | 4.20 | 3.20–3.80 |
| Ca | 0.70 | 0.60 | 0.98 | 0.50–1.00 |
| Mg | 0.38 | 0.25 | 0.27 | 0.24–0.34 |

[1]Average for the plant and first ratoon crops.

K by Ca in bananas growing on red acid Oxisols. Rather than competition, however, it seems that since $Ca^{++}$ is an immobile ion, once it gets into a specific tissue, no remobilization within the plant occurs.

Contrary to the nutrient levels, dry matter concentrations were somewhat higher in the ratoon than in the plant crop, and always increased as the plants matured (table 5). The leaf lamina, corm and the bunch were the major accumulators of dry matter throughout the crop cycles.

Nutrient concentrations in the leaf lamina, the tissue generally used for the diagnosis of deficiency symptoms in the banana plant, deserves special attention (table 5). In this experiment, the N level was high during the early stage of growth of the plant crop. Thereafter, the K/N ratio was maintained close to 1 in both crop cycles. This is less than the critical value of 1.6 proposed by García et al. (3) to assure maximum economic yields in Oxisols, and yet a yield of 55,485 kg/ha/crop was obtained. Other nutrient relationships involving Ca were affected by the age of the plants at the time of sampling. At the stage of bunch-shooting in both crop cycles, the Ca/Mg, K/Ca and K/Mg ratios averaged 2.2, 3.6 and 7.9, respectively. However, at the time of bunch-harvest the Ca/Mg ratio had increased to 3.9, the K/Ca value had decreased to 2.0, and the K/Mg remained unchanged.

Table 6 compares the nutrient levels obtained in the leaf lamina of 7-month old banana plants with those reported in other growing areas. Except for N, other nutrient levels compared favorably with those established elsewhere as optimum for a well nourished banana plant. The values in the third fully open leaf ranged 0.17 to 0.24% for P, 3.20 to 4.20% for K, 0.50 to 1.00% for Ca, and 0.24 to 0.38% for Mg. Nitrogen acceptable values ranged from 2.60 to 3.00%.

## LITERATURE CITED

1. Abruña, F., J. Vicente-Chandler, J. Figarella and S. Silva, 1976. Potassium supplying power of the major Ultisols and Oxisols of Puerto Rico. *J. Agric. Univ. P. R.* 60 (1): 45-60.
2. Anonymous, 1981. Guide to the interpretation of banana leaf analysis. WINBAN Research and Development Div., Castries, St. Lucia, W.I.
3. García, R., R. Guijano and B. Díaz, 1980. Changes in the nutritional status of banana due to the effect of potassium, on red soils in Cuba, their relations with yield and with the control of fertilizing. *Potash Rev.* 10: 1-7.
4. Garita, R. C. and R. C. Jaramillo, 1984. Respuesta del cultivar Cavendish Gigante (*Musa* AAA) a dosis crecientes de potasio en un suelo de la vertiente del Caribe de Costa Rica. Informe mensual #66, UPEB, Panamá, 50-55.
5. Irizarry, H., F. Abruña, J. Rodríguez and N. Díaz, 1981. Nutrient uptake by intensively managed plantains as related to stage of growth at two locations. *J. Agric. Univ. P. R.* 65 (4): 331-45.
6. —— and J. Vicente-Chandler, 1984. Perspectivas para la producción de guineos para la exportación. Revista del Colegio de Agrónomos de Puerto Rico. (Núm. enero-marzo) 13-15.
7. —— and R. Montalvo-Zapata, 1986. Conjunto tecnológico para la producción de plátanos y guineos. Pbl. 97, 2nda. ed., Esta. Exp. Agric., Univ. P. R.
8. Lahav, E., 1978. The value of the K/Ca + Mg ratio for determination of the nutritional status of the banana sucker. *Fruits* 33 (1): 3-6.
9. Rodríguez-Gómez, M., 1980. Estudios preliminares sobre la nutrición con potasio de los bananales en América Central. *Fruits* 35 (5): 283-91.
10. Santiago, M. A., H. Irizarry and D. J. Pool, 1985. Experimentación con aplicaciones de nitrógeno y potasa vía riego por goteo en el banano Grand Nain en Puerto Rico. Proc. ACORBAT, 7th Meet. (Sept. 23-27), San José, Costa Rica.
11. Shand, C. R., 1975. Effect of varying levels of fertilizer on the growth and yield of Valery bananas. Annu. Rep.-Res. and Dev. Dep., Banana Board, Jamaica 11-14.
12. Talleyrand, H., R. Pérez-Escolar, M. A. Lugo-López and T. W. Scott, 1977. Utilization of N from crop residues in Oxisols and Ultisols. *J. Agric. Univ. P. R.* 61 (4): 450-55.
13. Twyford, I. T. and D. Walmsley, 1973. The mineral composition of the Robusta banana plant. I. Methods and plant growth studies. *Plant Soil* 39: 227-43.
14. —— and ——, 1974. The mineral composition of the Robusta banana plant. II. The concentration of mineral constituents. III. Uptake and distribution of mineral constituents. IV. The application of fertilizers for high yields. *Plant Soil* 41: 459-508.
15. Vicente-Chandler, J., F. Abruña, R. Caro-Costas, J. Figarella, S. Silva and R. W. Pearson, 1974. Intensive grassland management in the humid tropics of Puerto Rico. Bull. 233, Agric. Exp. Stn., Univ. P. R.