Nutrient Uptake by Intensively Managed Plantains as Related to Stage of Growth at Two Locations[1,2]

Héber Irizarry, Fernando Abruña, José Rodríguez, and Nicolás Díaz[3]

ABSTRACT

Intensively managed, properly fertilized, high-yielding plantains growing on two soil types took up an average of 249, 21, 585, 60, and 147 kg/ha of N, P, K, Mg, and Ca, respectively. Uptake of all nutrients by the plants increased at varying rates up to harvest. Total dry matter production increased rapidly up to harvest. The corms, leaves and pseudostems stopped growing when the bunches emerged. A rational program for fertilization of both the plant and ratoon crops of plantains was developed from the data obtained: About 338, 58, 780 and 100 kg/ha of N, P_2O_5, K_2O, and MgO, respectively, must be applied as fertilizer to plantains to obtain near optimum yields. These amounts are approximately equivalent to those in 3,000 kg/ha of 10-2-25-3 commercial fertilizer.

INTRODUCTION

The response of plantains (*Musa acuminata* x *M. balbisiana*, AAB) to fertilization with N, P, K, Ca and Mg has been studied by several workers in Puerto Rico. Vicente-Chandler and Figarella (10) found that plantains growing on a Humatas clay (Typic Trophohumults) responded to applications of 224 kg of N/ha and 98 kg of P/ha but did not respond to applications of K, Ca, or Mg. On the same soil type, Caro-Costas et al. (3) reported that plantain yields were increased by applications of N, P, K and Mg at rates of 224, 98, 448 and 112 kg/ha, respectively. Del Valle et al. (4) reported an increase in bunch weight of plantains on Humatas clay from the application of 56 kg of P/ha. On this same soil, Samuels et al. (6) reported that plantains responded to the application of 122 kg of Mg/ha. Hernández-Medina and Lugo-López (5) found that on a Corozal clay (Aquic Tropudults) plantain yields increased from the application of 56 kg of Mg/ha. Samuels et al. (7) suggested the application of 168 kg of N/ha and 279 kg of K/ha for optimum production of plantains on a San Antón sandy clay (Cumulic Haplustolls) under irrigation.

Walmsley (11) in Trinidad found that a plantain field with 3,000 plants/ha removed 314, 35 and 689 kg/ha of N, P, and K, respectively. Samuels

[1] Manuscript submitted to Editorial Board May 9, 1980.

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

[3] Horticulturist and Soil Scientist, Agricultural Research, Science and Education Administration, USDA; Assistant Agronomist, Agricultural Experiment Station, University of Puerto Rico; and Research Technician, Agricultural Research, Science and Education Administration, USDA, Río Piedras, P.R., respectively.

et al. (8) in Puerto Rico found that total uptake by plantains at harvest was 332, 22, 1,713, 210 and 56 kg/ha of N, P, K, Ca and Mg, respectively. Since neither of these studies included fertility levels, it could not be determined whether the nutrient uptake values obtained represent optimum fertility levels.

This study determined growth and nutrient uptake of intensively managed plantains of a high yielding clone of the Maricongo cultivar at monthly intervals on two widely different soil types and at three fertilizer levels. These data were used as a basis for developing recommendations for the rational fertilization of intensively managed plantains.

MATERIALS AND METHODS

One experiment was conducted at the Gurabo Substation starting May 1976. Elevation is about 80 m above sea level. Minimum and maximum temperatures are 18.5 and 30.5° C, respectively. Average annual rainfall is about 1,450 mm. The soil is Mabi clay (Vertic Eutropepts) with a pH of 6.6 and containing 6 p/m of available P, 0.4 meq of exchangeable K, 16.4 meq of exchangeable Ca, and 16.3 meq of exchangeable Mg per 100 g of soil.

Another experiment was carried out at the Corozal Substation starting December 1976. Elevation is about 200 m above sea level. Average minimum and maximum temperatures are 19 and 30° C, respectively. Mean annual rainfall is 1,650 mm. The soil is Corozal clay (Aquic Tropudults) with a pH of 5.5 and containing 10 p/m of available P, 0.2 meq of exchangeable K, 9.1 meq of exchangeable Ca, and 1.9 meq of exchangeable Mg per 100 g of soil.

At Gurabo, the plantains were fertilized with a 10-5-15-2 fertilizer (N, P_2O_5, K_2O and MgO) containing 16 kg each of B_2O_3 and of ZnO per short ton. Rates of 0, 1,350 and 2,700 kg/ha crop were tested, divided in four equal applications at 2, 5, 9 and 10 months after planting.

At Corozal, the plantains were fertilized with 10-5-20-4 containing 16 kg each of B_2O_3 and of ZnO per short ton. Rates of 0, 2,000 and 4,000 kg/ha/crop were tested divided in four equal applications 1, 4, 7 and 10 months after planting.

At both locations, the soil was plowed and harrowed twice. Each field was divided into three 15- × 45-m plots with 235 plants per plot spaced at 1.7 × 1.7 m. The plots, corresponding to the three fertilizer levels mentioned above, were separated by ditches 45 cm wide and 60 cm deep to prevent fertilizer from washing from one plot to another. Corms from a high yielding Maricongo clone were used as planting material.

Soil insects and nematodes, and foliar diseases as well as weeds were well controlled with acceptable methods.

Six randomly selected plants were dug up monthly in each plot at both locations starting 3–4 months after planting and continuing until the mature bunches were harvested. The plants were divided into roots, corms, pseudostems, bunches, and leaves (lamina, midribs and petioles). Only a part of the roots (probably 30%) were recovered and analyzed. Green- and oven-dry weights of all sections were determined, and dried samples from each were ground, passed through a 20 mesh screen and analyzed for N, P, K, Ca and Mg. 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 medium level of fertilization was near optimum for plantains at both locations, since yields were higher than those at the low fertilization rate and not further increased by the high rate. For this reason, we will limit all discussions in this paper to results obtained with the medium fertilizer level.

At the medium fertilizer level, 86,400 plaintains (26 metric ton/ha) were produced at Gurabo and 113,000 plantains (33 metric ton/ha) at Corozal. Although plantain yields were about 23% higher at Corozal, total dry matter produced was about the same at both locations, averaging 30,200 kg/ha.

The planting-to-harvest cycle lasted about 16 months at Corozal but only 12 months at Gurabo. The faster growth and earlier production at Gurabo may be explained by less cloudiness, more uniform levels of moisture, and rather heavy soil at this location as compared with the more porous soil at the steeper Corozal location.

Figure 1 shows that at Gurabo, uptake of N, K and Ca, steadily increased throughout the crop cycle. Magnesium uptake increased rapidly until about 8 months, after which it remained fairly constant. Phosphorus uptake was low, increasing slowly throughout the crop cycle.

Figure 2 shows that at Corozal nutrient uptake increased throughout the crop cycle. Nitrogen, K and Ca uptake increased steadily until about 3 months before harvest, after which the rate decreased somewhat. Uptake of Mg and P was much lower, increasing slowly throughout the crop cycle. Plants took up much less Mg at Corozal than at Gurabo.

Figure 3 shows that at Gurabo total weight of the plants increased rapidly from planting to harvesting. Growth of the corms and pseudostems stopped after about 10 months, when the bunches started to increase rapidly in weight. Leaf growth remained rather constant after about the first 6 months.

Figure 4 shows that at Corozal total weight of the plants also increased from planting to harvesting but at a somewhat slower rate than those at

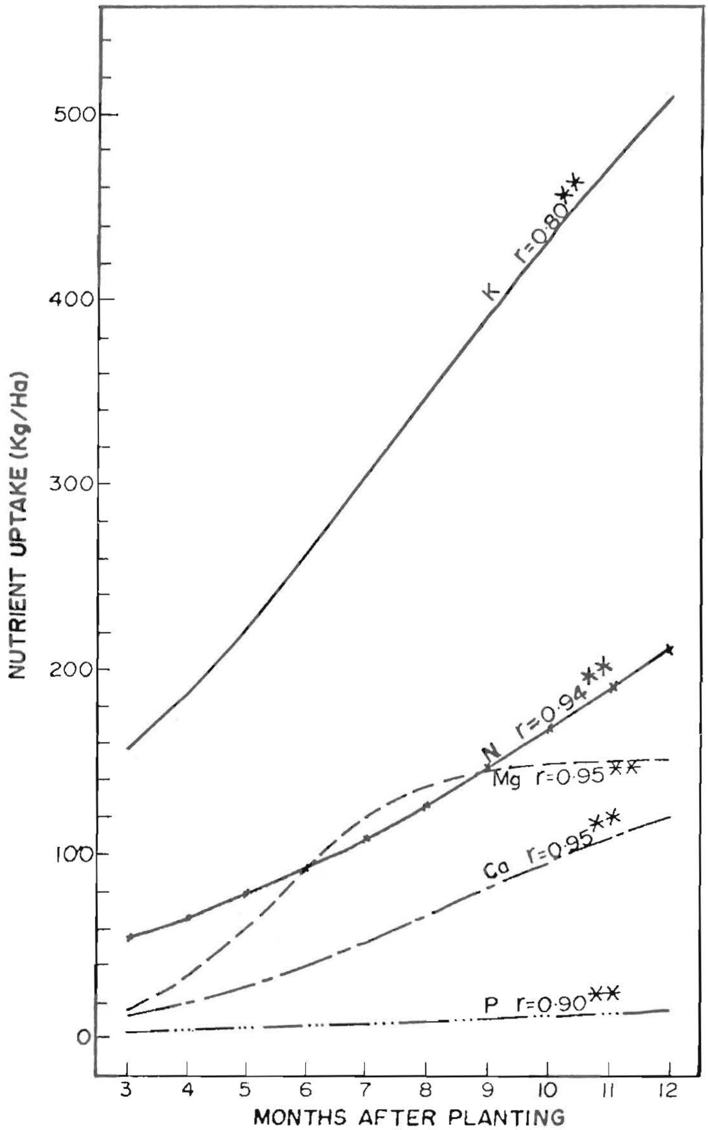

FIG. 1.—Uptake of nutrients by intensively managed plantains at Gurabo as estimated by fitting to the data an equation of the type $Y = \frac{A}{1 + Be^{-CX}}$.

Gurabo. Growth of the corms and the pseudostems stopped after about 14 months when the bunches started to increase rapidly in weight. Leaf growth increased until 12 months and then decreased somewhat after 14 months since they were affected by the leaf-spot disease.

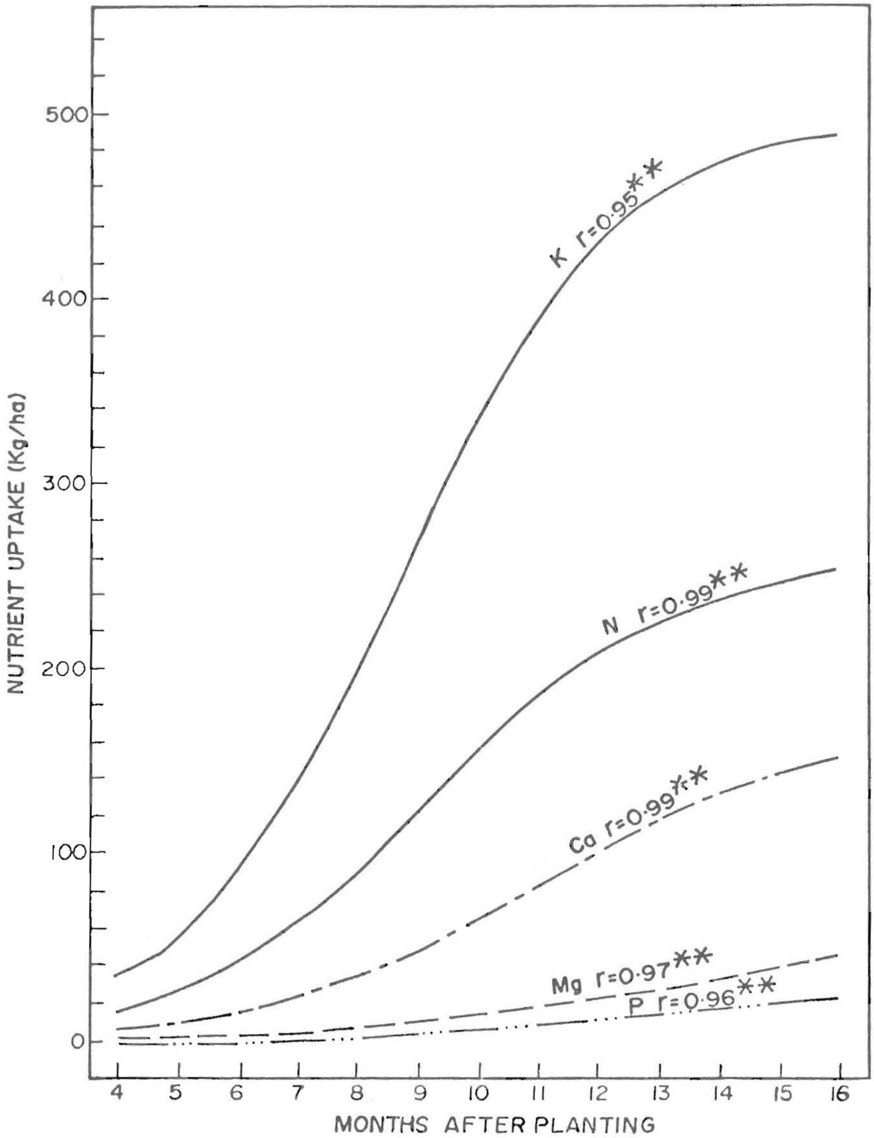

FIG. 2.—Uptake of nutrients by intensively managed plantains at Corozal by fitting to the data an equation of the type $Y = \frac{A}{1 + Be^{-CX}}$.

Table 1 shows that maximum nutrient uptake, which occurred at harvest at both Corozal and Gurabo, was similar except that the plants at Gurabo took up about 3 times more Mg. This was clearly a case of "luxury" uptake beyond plant needs for maximum production, as was

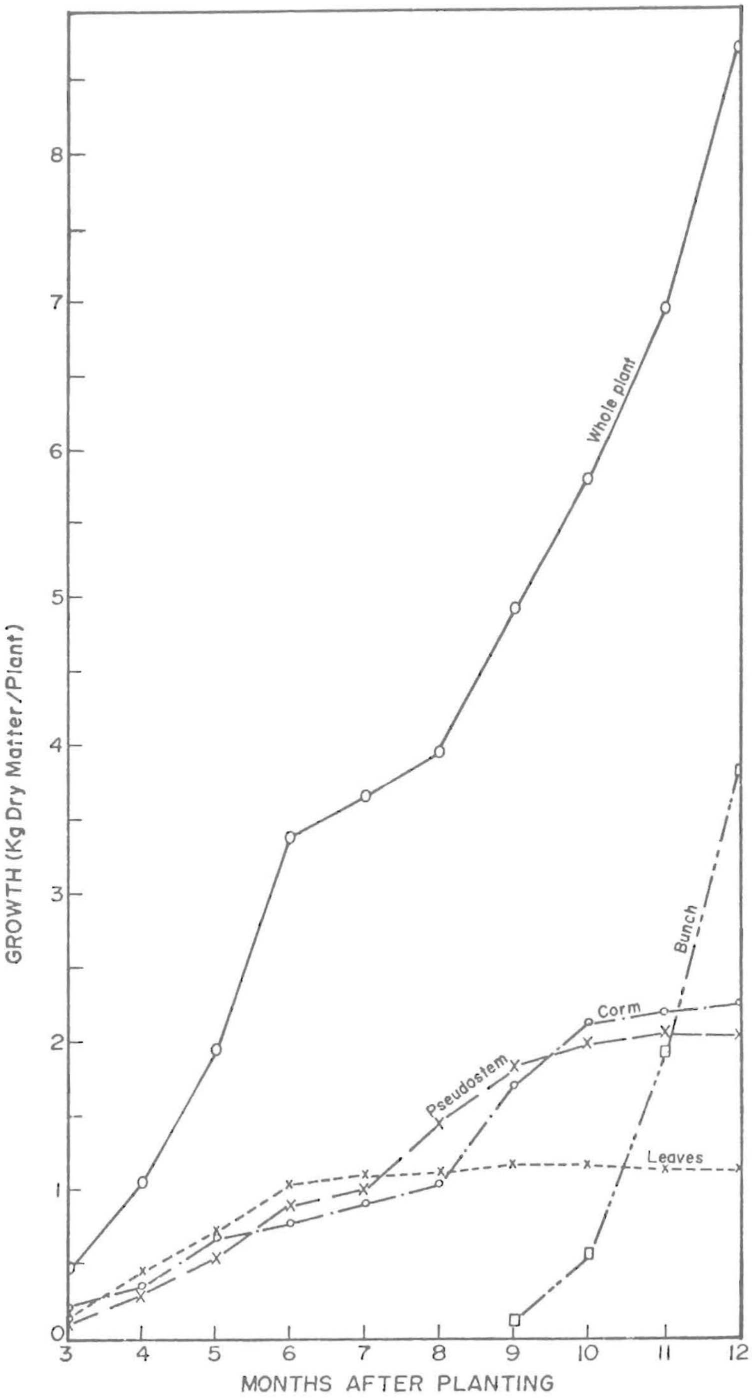

FIG. 3.—Monthly growth of different parts of the plantain plants at Gurabo.

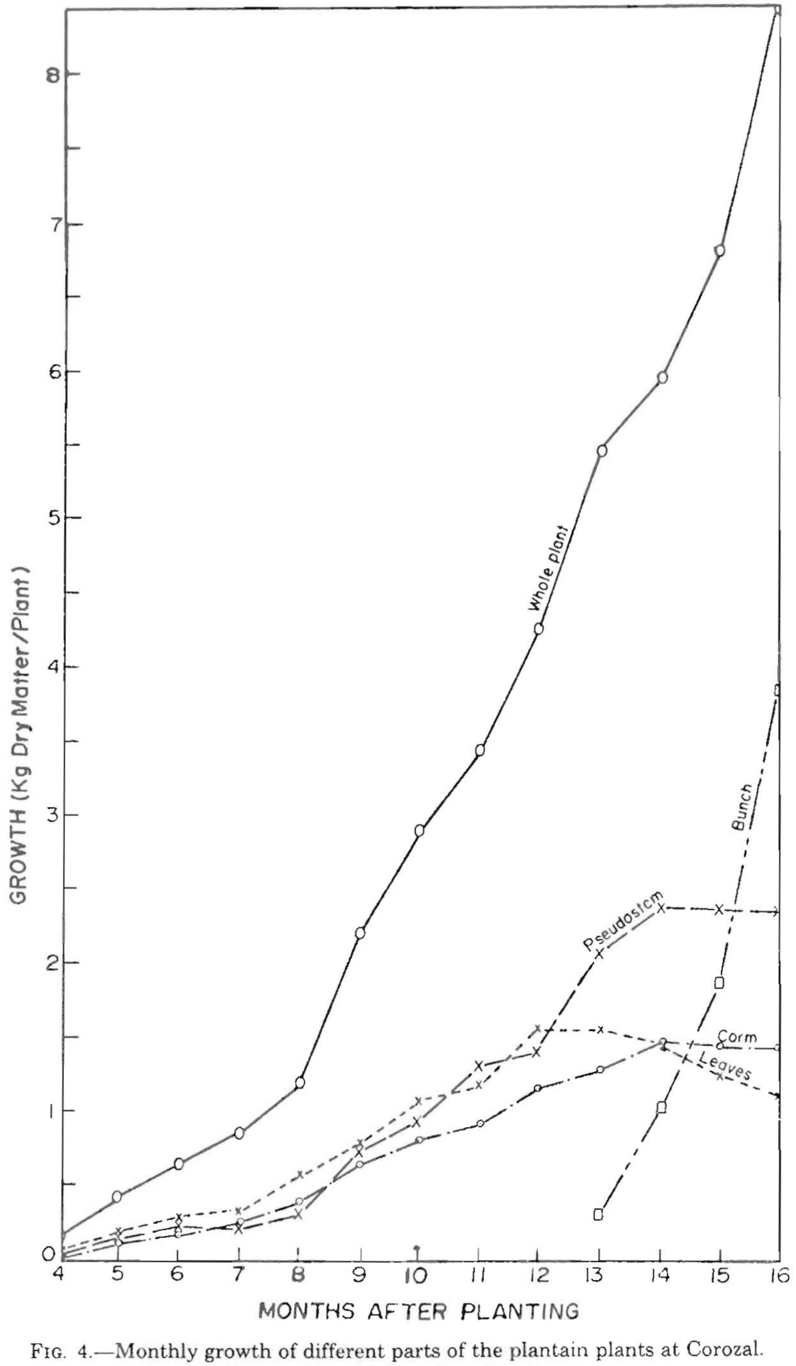

FIG. 4.—Monthly growth of different parts of the plantain plants at Corozal.

indicated by a) exchangeable Mg in the soil and Mg levels in plants were high, even those in the unfertilzed plots; b) Mg applications increased Mg uptake but did not increase yields; and c) Mg levels in the leaf laminas averaged 0.90% as compared with 0.30 of those at Corozal, yet yields were higher at Corozal. Our data agreed with those of Vicente-Chandler and Figarella (10), Caro-Costas et al. (3), Hernández Medina and Lugo-López (5), who have shown that 0.30% of Mg in the leaf laminas is associated with high yields and that heavier Mg applications increase Mg content in the leaves but do not further increase yields.

Table 2 shows how fertilizer recommendations for the plant crop of plantains might be rationalized. Uptake of nutrients for near optimum yields of plantains averaged 249, 48, 705 and 100 kg/ha of N, P_2O_5, K_2O and MgO, respectively, equivalent to the nutrients in about 2,500 kg/ha of a 10-2-28-4 fertilizer. The data on nutients supplied by the soil are based on the results of many experiments by Vicente-Chandler et al. (9) and Abruña et al. (1, 2) and show that most soils in the humid mountain region, where plantains are generally grown, can provide, on a long term basis, about 80 kg/ha yearly of both N and K_2O and at least 20 kg/ha of MgO. We assumed that the soils provided no P on a long term basis, since they have almost no P-bearing minerals. Therefore, for high plantain yields fertilizers must provide 169, 48, 625, and 80kg/ha of N, P_2O_5, K_2O, and MgO, respectively. We further assumed, on the basis of the

TABLE 1.—*Maximum uptake of nutrients by plantains receiving near optimum fertilization (kg/ha)*

Nutrient	Corozal	Gurabo	Average
N	275	223	249
P	24	18	21
K	569	601	585
Mg	48	156[1]	102(60)[2]
Ca	136	158	147

[1] Uptake at Gurabo was much in excess of the plantain needs, as discussed in text.

[2] In all following discussion it is assumed that 60 kg of Mg/ha is near to optimum for plantains.

TABLE 2.—*Computation of the fertilizer needs of the plant crop of plantains (kg/ha)*

Nutrient	Uptake by plantains (from table 1)	Supplied by soil[1]	Supplied as fertilizer	Applied as fertilizer[2]
N	249	80	169	338
P_2O_5	48	0	48	58
K_2O	705	80	625	780
MgO	100	20	80	100

[1] See text for details.

[2] Assuming losses of 50% N; 20% P_2O_5; and 25% K_2O and MgO.

results of several experiments by Vicente-Chandler et al. (9), that 50% of the fertilizer N, 20% of the P_2O_5, and 25% of the K_2O and MgO are lost. Therefore, about 338, 58, 780 and 100 kg/ha of N, P_2O_5, K_2O, and MgO, respectively, must be applied as fertilizer to plantains to obtain near optimum yields. These amounts are approximately equivalent to those in 3,000 kg/ha of 10-2-25-3 commercial fertilizer. The corms used as planting material (3,500/kg of corms/ha) contained only 3.5, 0.9, 4.3 and 3.4 kg/ha of N, P_2O_5, and K_2O and MgO, respectively, and their contribution of nutrients was, therefore, insignificant as compared with the plants' needs.

Plantains in the mountain region require about 16 months to produce a crop and should be fertilized at about 2, 6, 9 and 12 months after planting. Those at low elevations, which produce a crop in only about 13 months, should be fertilized at about 2, 5, 8, 11 months after planting. Data in figures 1 and 2 show that nutrient uptake over these successive 3-month intervals was about 15, 25, 35 and 25% of total uptake, respectively. Therefore, about 500, 700, 1,000 and 800 kg/ha of 10-2-25-3 fertilizer should be applied at these corresponding intervals after planting.

Table 3 shows that 88, 10, 229 and 13 kg/ha of N, P, K and Mg, respectively, were contained in the bunches that were harvested. However, the rest of the plants, which remain in the field, contain large quantities of nutrients (161, 11, 356 and 35 kg/ha of N, P, K and Mg, respectively) that are gradually released during a 3-4 month period and contribute to the nutrient requirements of the ratoon crop.

Table 4 shows nutrient computations, based on previous discussion in this paper, from which we estimated the fertilizer needs of the ratoon crop of plantains. According to these calculations, the ratoon crop, if intensively managed, requires 144, 34, 353, and 43 kg/ha of N, P_2O_5, K_2O and MgO, respectively, applied as fertilizer. These amounts are approximately equivalent to the nutrients in 1,500 kg/ha of 10-2-25-3 fertilizer.

TABLE 3.—*Average quantities of nutrients in different parts of well fertilized plantain plants when harvested at Gurabo and Corozal*

Plant part	N	P	K	Mg[1]	Ca	Dry matter
		kg/ha				
Roots	3	1	19	2	3	400
Corm	44	3	123	13	14	6,200
Pseudostem	46	3	129	7	47	6,500
Leaves	68	4	85	13	68	3,800
Total residues	161	11	356	35	132	16,900
Bunch	88	10	229	13	15	13,300
Total	249	21	585	48	147	30,200

[1] Corozal only; uptake at Gurabo was much in excess of the plantain needs, as discussed in text.

About 9 months are required from harvest of the plant crop to harvest of the ratoon crop. The suckers can probably obtain the required nutrients for the first 3 months of growth from the mother plant. At this time, 700 kg/ha of 10-2-25-3 fertilizer should be appled for plant growth and an additional 800 kg/ha at 6 months to provide the nutrients required for development of the bunches.

Thus, although plantains have heavy fertilizer requirements for the plant crop, as a result of nutrients in residues of the plant crop, the ratoon crop needs half as much fertilizer to yield 30,000 kg/ha of dry matter.

Table 5 shows nutrient content of the laminas of plantain leaves (third from the top) 7 months after planting, associated with the production of high yields in experiments by Vicente-Chandler and Figarella (10) (experiment No. 1); Caro-Costas et al. (3) (experiment No. 2); this paper's experiments at Corozal and Gurabo (experiments No. 3 and 4); and in two recently concluded unpublished experiments (experiments No. 5 and 6). Nutrient content of the leaves associated with high yields in the four experiments at Orocovis and Corozal (on Ultisols and Oxisols in the humid mountain region where most plantains are grown) are remarkably similar. Values of 3.2–3.9% for N, 0.17–0.20 for P, 3.0–3.6 for K, 0.3 for

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

Item	Nutrient Source	N	P_2O_5	K_2O	MgO
1.	In crop residues (from table 3)	161	25	429	58
2.	Available from crop residues (assuming losses of 40% N and 20% of the other nutrients)	97	20	343	46
3.	Supplied by soil (see text)	80	0	80	20
4.	Required by plantains (table 2)	249	48	705	100
5.	Total available (items 2 + 3)	177	20	423	66
6.	Supplied by fertilizer (items 4 − 5)	72	28	282	34
7.	Applied at fertilizer[1]	144	34	353	43

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

TABLE 5.—*Nutrient content of plantain leaf laminas (third leaf, 7 months after planting) associated with the production of high yields in 6 different experiments (percent)*[1]

	Experiment No. 1 Orocovis	Experiment No. 2 Orocovis	Experiment No. 3 Corozal	Experiment No. 4 Gurabo	Experiment No. 5 Corozal	Experiment No. 6 Gurabo
N	3.9	3.9	3.7	2.5	3.2	3.1
P	0.2	0.2	0.17	0.13	0.19	0.18
K	3.3	3.6	3.6	2.4	3.0	2.4
Mg	0.3	0.3	0.3	0.9	0.3	0.6
Ca	0.6	0.6	0.7	0.8	0.8	1.0

[1] Data obtained from (3), (10), and Irizarry's unpublished data.

Mg, and 0.6–0.8 for Ca indicate near optimum nutrition for high production of plantains.

Values for N in experiment No. 4 at Gurabo are somewhat low, and K levels were considerably lower in both experiments at Gurabo, possibly because of the high levels of soil Mg and poorer drainage, both of which tend to reduce K uptake. Calcium and P levels were similar at the two locations. The higher Mg levels at Gurabo were explained previously as "luxury" uptake beyond the plants' needs, resulting from high Mg levels in the soil. Potassium levels were not increased by heavier applications of fertilizer that contained both K and Mg.

Table 6 shows monthly changes in composition of various plant parts in the experiment at Corozal. Nitrogen and K contents of all plant parts decreased as plants aged. Potassium content was very high in all plant parts during the early stages of growth, exceeding 8% in the pseudostems and leaf petioles. Phosphorus content in all plant parts was low at all times, tending to decrease as plants aged except that of corms and leaf laminas. Calcium content of the corms tended to decrease slightly with age but Ca content was similar and remained constant in the roots and pseudostems throughout the growth cycle. On the other hand, Ca content of the leaf laminas, leaf petioles, and midribs increased as plant aged and Ca content of the bunches decreased sharply after their emergence. Magnesium content of most plant parts varied throughout the growth cycle with no discernible overall trend, except that it decreased sharply in the bunches after emergence and decreased in the pseudostems as plants aged. Dry matter content of the corms remained rather constant but that of the pseudostems and roots increased slightly as plants aged. However, dry matter content of the leaf petioles and midribs, and particularly that of the leaf laminas and bunches, increased as plants aged.

Nutrient content of the leaf laminas, the tissues most generally used as an index of the nutrient status of the plant, deserves special attention. Nitrogen content decreased during the last 4 months and K content decreased after the first 9 months. Phosphorus and Mg content varied somewhat throughout the growth cycle with no consistent trends. Calcium content increased during the last 3 months before harvest. Most changes in leaf composition were caused by aging, since plantains produce no new leaves after bunches appear at about 4 months before harvest.

RESUMEN

El crecimiento mensual y el contenido de distintos nutrimentos se determinaron en plataneros cultivados intensivamente en las subestaciones de Corozal y Gurabo.

Las plantas tardaron aproximadamente 12 meses en cosecharse en

TABLE 6.—*Percent nutrient content on a dry-weight basis of different parts of the plantain plant over an entire crop cycle at Corozal brush*

Months after planting	N	P	K	Ca	Mg	Dry Matter	N	P	K	Ca	Mg	Dry Matter
			Corms						*Pseudostem*			
4	1.33	.06	4.25	.43	.18	12.0	1.66	.11	8.25	.71	.24	4.7
5	1.08	.07	3.88	.52	.16	11.3	1.74	.12	7.76	.74	.27	4.0
6	.95	.06	4.65	.52	.18	12.3	1.62	.14	8.64	.84	.24	.40
7	1.01	.06	2.62	.53	.15	11.7	1.65	.11	6.67	.83	.25	3.3
8	1.00	.04	1.53	.43	.17	11.3	1.38	.05	4.93	.79	.23	3.7
9	1.06	.06	3.79	.40	.13	9.2	1.29	.08	6.02	.74	.16	4.1
10	.83	.06	2.56	.30	.18	10.2	1.11	.10	4.85	.81	.18	3.4
11	.76	.06	2.37	.32	.12	12.0	.91	.04	3.38	.80	.14	4.5
12	.85	.04	1.98	.34	.14	12.2	.90	.05	3.10	.75	.08	5.1
13	.75	.06	1.67	.18	.11	12.5	.49	.06	2.17	.47	.09	6.0
14	.95	.05	2.41	.24	.14	12.7	.51	.05	2.11	.62	.10	5.1
15	.82	.07	2.16	.23	.19	13.7	.64	.07	1.71	.66	.10	6.1
16	.76	.05	1.45	.25	.22	11.3	.71	.05	1.42	.81	.09	6.1
Month after planting	N	P	K	Ca	Mg	Dry matter	N	P	K	Ca	Mg	Dry matter
			Leaf lamina						*Leaf petioles and midribs*			
4	3.62	.17	4.74	.75	.28	12.3	1.43	.10	8.84	.87	.31	7.0
5	3.61	.19	3.97	.71	.31	14.7	1.31	.09	7.27	.96	.24	8.0
6	3.67	.18	3.77	.67	.32	15.3	1.12	.09	6.24	.83	.28	7.7
7	3.71	.17	3.61	.73	.31	14.3	1.18	.06	4.76	1.08	.22	7.0
8	3.76	.11	3.66	.73	.21	16.0	.95	.05	2.41	1.16	.13	7.3
9	3.91	.17	3.73	.65	.22	16.7	1.15	.08	5.33	1.03	.16	7.0
10	3.45	.15	2.93	.79	.25	16.4	.75	.06	3.42	1.14	.15	8.0
11	3.19	.10	2.55	.89	.23	17.4	.63	.04	2.49	.88	.15	9.6
12	3.52	.11	2.26	.94	.19	16.9	.56	.03	1.70	1.10	.13	9.5
13	2.97	.14	1.99	.86	.23	18.6	.41	.05	1.78	.99	.15	9.8
14	2.67	.11	2.41	1.09	.18	20.5	.55	.02	1.49	1.42	.19	9.8
15	2.83	.16	2.07	1.24	.24	20.4	.56	.05	1.44	1.64	.25	10.3
16	2.61	.14	2.07	1.47	.33	22.5	.60	.05	1.75	2.44	.23	11.6

Month after planting	N	P	K	Ca	Mg	Dry matter	N	P	K	Ca	Mg	Dry matter
			Roots						*Bunches*			
4	1.57	.14	6.93	.61	.30	5.0						
5	1.43	.12	6.49	.73	.29	4.7						
6	1.43	.07	7.13	.78	.23	5.7						
7	1.55	.10	7.00	.62	.28	6.0						
8	1.56	.07	5.81	.54	.26	6.3						
9	1.30	.07	5.75	.61	.25	6.7						
10	1.04	.08	4.74	.70	.26	6.7						
11	.89	.04	3.91	.67	.27	7.3						
12	.87	.05	3.66	.65	.25	8.2						
13	.77	.06	4.63	.48	.22	9.1	2.61	.15	4.34	.34	.35	7.3
14	.85	.04	4.01	.63	.24	8.1	.75	.07	1.43	.05	.10	20.6
15	.76	.06	3.35	.65	.29	8.5	.81	.07	1.71	.09	.10	25.3
16	.78	.05	3.37	.74	.33	7.9	.72	.09	1.74	.09	.10	30.3

Gurabo, y 16 en Corozal. Produjeron 23% más plátanos en Corozal, pero el peso total de materia seca en las plantas fue igual en ambos lugares.

En Gurabo, el contenido total de nitrógeno, potasio y calcio aumentó a lo largo del ciclo de siembra a cosecha, el de magnesio aumentó rápidamente hasta 8 meses, manteniéndose luego aproximadamente estable y el de fósforo aumentó lentamente.

En Corozal, el contenido total de nitrógeno, potasio y calcio aumentó rápidamente hasta 3 meses antes de la cosecha, aumentando luego más lentamente. Los contenidos de magnesio y fósforo fueron bajos y aumentaron lentamente a lo largo del ciclo de siembra a cosecha.

El peso de las plantas en Corozal y Gurabo aumentó desde la siembra hasta la cosecha. El crecimiento de los cormos, seudotallos y hojas cesó cuando se produjeron los racimos. La cantidad de hojas se mantuvo más o menos constante o bajó ligeramente después de los primeros 6 meses en Gurabo y después de los 12 meses en Corozal.

En promedio, las plantas utilizaron un máximo de 249, 21, 585 y 60 kg/ha de N, P, K y Mg, respectivamente. Cálculos basados en estos datos, en la disponibilidad de nutrimentos en los suelos típicos en los que se siembra el plátano y en pérdidas de los aplicados como abono, señalan que deben aplicarse alrededor de 3,000 kg/ha de un fertilizante de análisis 10-2-25-3 ó similar en la cosecha de plantilla. El abono debe aplicarse a los 2, 6, 9 y 12 meses después de la siembra en zonas de medianía y a los 2, 5, 8 y 11 meses en la zona de bajura. De acuerdo con los datos obtenidos en relación a su utilización por las plantas, deben aplicarse 500, 700, 1,000 y 800 kg/ha de abono a los intervalos señalados, respectivamente.

Cálculos similares para la cosecha de retoño, tomando en cuenta los nutrimentos en los residuos de la cosecha de plantilla, señalan que al retoño debe aplicársele 1,500 kg/ha de abono 10-2-25-3. El retoño debe abonarse con 700 kg/ha 3 meses después de la cosecha de plantilla y 800 kg 3 meses más tarde.

Se presentan datos señalando que la lámina de la tercera hoja de arriba hacia abajo 7 meses después de la siembra debe contener las siguientes cantidades de nutrimentos para la producción óptima: N = 3.2 − 3.9, P = .17 − .20, K = 3.0 − 3.6, Mg = .3, Ca = .6 − .8%.

Se presentan curvas de crecimiento para cada una de las partes de la planta. Asimismo, se presentan curvas señalando la cantidad de nutrimentos utilizados mensualmente por la planta durante un ciclo completo de producción.

LITERATURE CITED

1. Abruña, F., 1979. Potassium supplying power of the major upland Inceptisols of Puerto Rico, J. Agri. Univ. P.R. 64 (1): 9–28.

2. ——, Vicente-Chandler, J., Figarella, J., and Silva, S., 1976. Potassium supplying power of the major Ultisols and Oxisols of Puerto Rico, J. Agri. Univ. P.R. 60 (1): 45–60.
3. Caro-Costas, R., Abruña, F., and Vicente-Chandler, J. 1964. Response to fertilization of strip-cultivated plantains growing on a steep latosol in the humid mountain region of Puerto Rico, J. Agri. Univ. P.R. 48 (4): 312–17.
4. Del Valle, R., Scott, T.W., Rodríguez, J., and Lugo-López, M. A., 1978. Response of plantain to banded and broadcast N and to P applications at planting and to residual P on an Ultisol, J. Agri. Univ. P.R. 62 (1): 29–39.
5. Hernández-Medina, E., and Lugo-López, M. A., 1969. Effect of minor nutrient elements and magnesium upon the growth, development and yields of plantains J. Agri. Univ. P.R. 53 (1): 33–40.
6. Samuels, G., Hernández, E., and Torres, S., 1975. Response of plantain to magnesium fertilizer in an Ultisol, J. Agri. Univ. P.R. 59 (3): 233–35.
7. ——, Orengo-Santiago, E., and Beale, A., 1978. Influence of fertilizers on the production of plantains with irrigation, J. Agri. Univ. P.R. 62 (1): 1–9.
8. ——, Beale, A., and Torres, S. 1978. Nutrient content of the plantain (*Musa*, AAB group) during growth and fruit production, J. Agri. Univ. P.R. 62 (2): 178–85.
9. Vicente-Chandler, J., Abruña, F. Caro-Costas, R., Figarella, J., Silva, S., and Pearson, R. W., 1974. Intensive grassland management in the humid tropics of Puerto Rico, Agri. Exp. Stn., Univ. P.R., Bull. 233.
10. —— and Figarella, J., 1962. Experiments on plantain production with conservation of the mountain region of Puerto Rico, J. Agri. Univ. P.R. 46 (3): 226–36.
11. Walmsley, D., 1974. Mineral nutrition of two plantain (*Musa*, AAB group) cultivars of the French and Horn type, Proc. Caribbean Food Crops Soc. 12th Annu. Meet., Jamaica, W.I. 141–47.