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## Nutrient Uptake by Taniers as Related to Stage of Growth and Effect of Age on Yields of the Morada Variety<sup>1, 2</sup>

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### ABSTRACT

Nutrient uptake by well fertilized taniers of the Morada variety was maximum near harvest time, averaging 125, 15, 156, 48 and 25 kg/ha for N, P, K, Mg and Ca, respectively. Uptake of N and K increased rapidly, but that of P slowly, from planting to harvest. Uptake of Mg and Ca increased steadily up to 5-6 months, after which it fluctuated considerably. Leaf weight increased rapidly during the first 6 months, then decreased and then remained fairly constant until harvest. Leaf lamina of well fertilized taniers contained about 3.2% N, 0.25% P<sub>2</sub>O<sub>5</sub>, 2.3% K and 1.3% Ca. In two other experiments yields increased from an average of 11,450 kg of tubers/ha 12 months after planting, when taniers are usually harvested, to 28,235 kg/ha 12 months later. Yield of corms, which can be used as pig feed, increased from 9,660 to 45,000 kg/ha over the same period.

### INTRODUCTION

Taniers or cocoyams (*Xanthosoma spp*), an important root crop of the humid tropics, can produce 20,000 kg of edible tubers/ha and a similar quantity of corms. Soldevila and Vicente-Chandler (5) have presented data with regard to the value of the corms as pig feed. Taniers are not severely attacked by insects, nematodes or viruses.

In Puerto Rico the effects of various cultural practices on yields has been studied by Abruña et al. (1) and by Silva and Irizarry (4). The productivity of different varieties of taniers was determined by Irizarry et al. (3). Abruña et al. (1) found that taniers growing on three Ultisols at Orocovis, Jayuya and Adjuntas responded to 110 kg of N/ha at all three locations, to 90 kg of P/ha at one location, and to 200 kg of K/ha at one location. The authors have found no reference to studies on the uptake of nutrients by taniers at various stages of growth.

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<sup>2</sup> 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, PR.

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Although taniers are usually harvested about 1 year after planting, the Morada variety (*X. nigrium*) can continue to grow for a longer period and the tubers and corms do not deteriorate if left unharvested in the field over rather long periods. No data are available on whether yields of this variety continue to increase beyond 1 year after planting.

The present study determined monthly growth and nutrient uptake by well-managed taniers of the Morada variety at three fertility levels at one location, and the effect of age at harvest on yields at two locations.

#### MATERIALS AND METHODS

The experiment on nutrient uptake was conducted at the Gurabo Substation starting May 1976. Elevation is about 80 m above sea level. Average minimum and maximum temperatures are 17.5 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 6 p/m of available P; 156 p/m of exchangeable K; 16.4 meq of exchangeable Ca; and 16.3 meq of exchangeable Mg/100 g of soil.

Two experiments were conducted on the effect of time after planting on yields. One was carried out near Aguas Buenas starting April 1976. Elevation is about 400 m above sea level. Average minimum and maximum temperatures are 17° and 29° C, respectively. Mean annual rainfall is about 1800 mm. The soil is Humatas clay (Typic Tropohumults) with a pH of 5.5 and 11 meq of exchangeable bases/ 100 g of soil.

The other was carried out near Yabucoa starting March 1976. Elevation is about 50 m above sea level. Average minimum and maximum temperatures are 18 and 31° C, respectively. The soil is Pandura clay loam (Typic Eutropepts) with a pH of 5.7 and 5.6 meq of exchangeable bases/ 100 g of soil. Mean annual rainfall is about 2500 mm.

At Gurabo the taniers were fertilized with 10-5-15-2 (N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, MgO). Rates were 0, 1,000 and 2,000 kg/ha/crop applied in three equal applications: 2, 6 and 9 months after planting. The soil was plowed and harrowed; the field was divided into three 15 × 45 m plots. Sections of corms, each weighing about 100 g were used for planting. During dry spells, 76 mm of water was applied with sprinklers every 2 weeks. Weeds were controlled by hoeing.

Sixteen randomly selected plants were dug up at monthly intervals in each plot, starting 3 months after planting, and continuing until final harvest at 12 months. The plants were divided into corms, tubers, petioles, leaves and roots. However, only about 30% of the roots were recovered. Green and oven-dry weights of all sections were determined. The dry samples were ground, passed through a 20 mesh screen, and analyzed for N,P,K, Ca and Mg. Nitrogen was determined by the Kjeldahl macro-

method, P colorimetrically, K by flame photometry, and Ca and Mg by the Versenate method.

At Aguas Buenas and Yabucoa, the taniers were planted in well prepared soil at  $1.0 \times 0.7$  m. Sections of corms, each weighing about 100 g, were used for planting. Weeds were controlled by hoeing. The taniers received 600 kg of 10-5-15 fertilizer/ha 3, 8 and 13 months after planting. Sixteen randomly selected plants were harvested at 2-month interval, starting 12 months after planting, and weight of tubers and corms were determined.

Quality of the tubers harvested 24 months after planting was evaluated by 12 tasters at the Food Technology Laboratory of the Puerto Rico Agricultural Experiment Station. The tubers were boiled for 45 minutes and evaluated on a scale of 1 to 5, ranging from poor to excellent.

## RESULTS AND DISCUSSION

### NUTRIENT UPTAKE

The medium level of fertilization (1,000 kg/ha) was near optimum for the taniers, producing about 15,000 kg of tubers/ha. Thus the following discussions are limited to results obtained with this level of fertilization.

Figure 1 shows that uptake of N and K increased rapidly from 3 months after planting until harvest. Phosphorus uptake was low, increasing slowly throughout the crop cycle. Magnesium and Ca uptake increased steadily up to 4-6 months, then fluctuated considerably thereafter. Calcium and Mg were not significantly correlated with age of the plants. As shown later, about a third of the Mg and almost half of the Ca taken up by taniers was contained in the leaves and petioles.

Figure 2 shows that the plants increased rapidly in dry weight from 3 months after planting to harvest. Growth of corms and tubers increased steadily from 3 months after planting to harvest. Leaf weight (including petioles) increased steadily during the first 6 months, then decreased and remained fairly constant until harvest. Many new leaves were produced during the first month and few older leaves were lost. Later, the older leaves deteriorated at about the same rate that new ones were produced and only 4-6 active leaves were maintained per plant.

Maximum uptake of nutrients, which occurred near harvest time, was as follows: N, 125; P, 15; K, 156, Mg, 48 and Ca, 25 kg/ha. Uptake of Mg probably exceeded that needed for maximum production (luxury uptake). Exchangeable Mg in the soil was high and Mg content of the plant parts in the unfertilized plots was also high. Furthermore, Mg levels in the leaf laminae averaged about 0.90% as compared with 0.25% in other experiments by Abruña et al. (1), in which taniers produced high yields.

Fertilizer recommendations for taniers can be computed as shown in table 1. Nutrient uptake for nearly optimum yields was 125, 37, 187, and 40 kg/ha of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and MgO, respectively. Experiments by Vicente Chandler et al. (6) and Abruña et al. (2) have shown that the soils

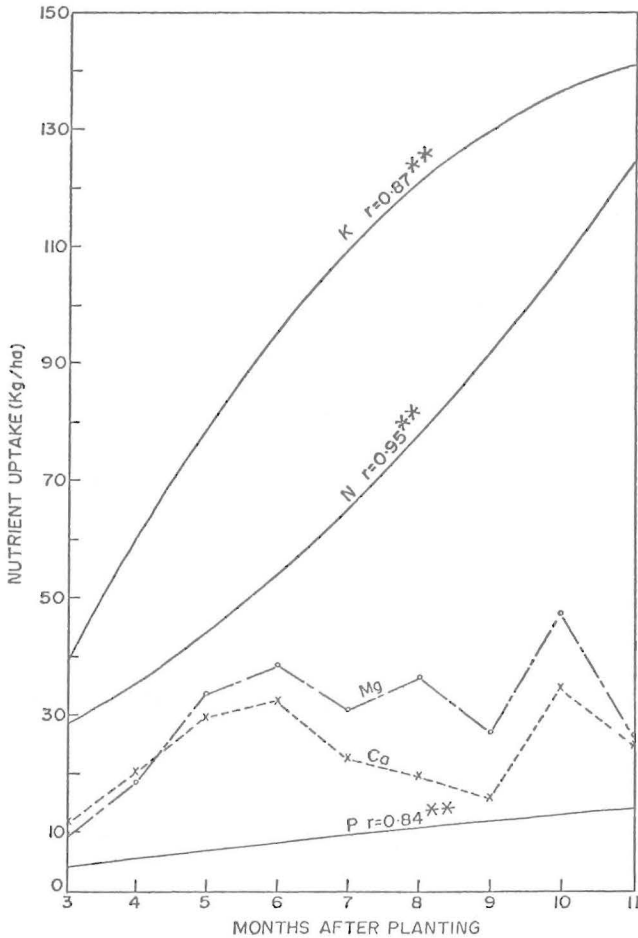


FIG. 1.—Monthly uptake of nutrients by intensively managed taniers. For K— $Y = A + BX + CX^2$ ; for N— $Y = \frac{A}{1 + Be^{-CX}}$ ; for P— $Y = A + BX$ .

generally planted to taniers can provide on a long-term basis, about 80 kg/ha yearly of both N and K<sub>2</sub>O, and 20 kg of MgO. It is assumed that the soil has no P other than that applied as fertilizer, since these soils have no P-bearing minerals. Thus fertilizers for high tanier yields would

have to provide 45, 37, 107 and 20 kg/ha of N,  $P_2O_5$ ,  $K_2O$  and MgO, respectively. On the assumption that 50% of the fertilizer N, 20% of the P, and 25% of the  $K_2O$  and MgO are lost, as shown by the experiments reported by Vicente-Chandler et al. (6), about 90, 46, 143 and 24 kg/ha of N,  $P_2O_5$ ,  $K_2O$  and MgO, respectively, must be applied as fertilizer to taniers to obtain near optimum yields. This is roughly equivalent to 1,000 kg/ha of the available commercial fertilizer mixture 10-5-15-3. Taniers should receive this fertilizer in two equal applications about 2 and 6 months after

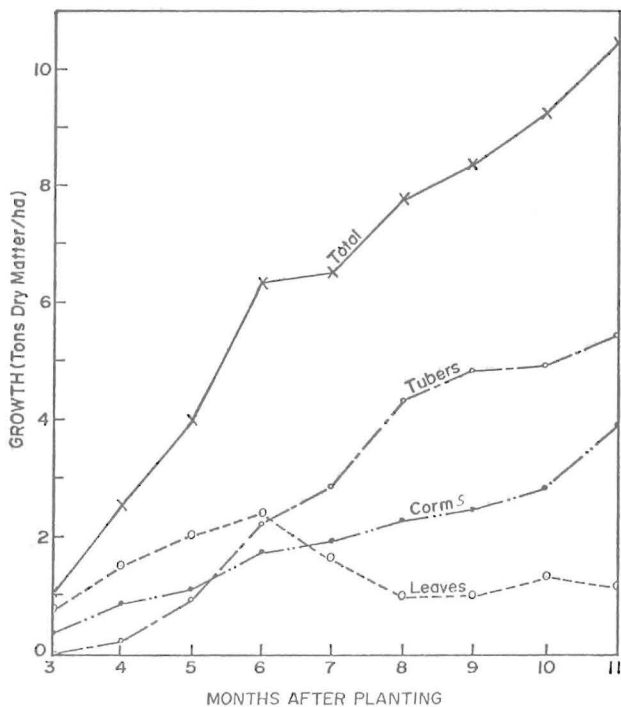


FIG. 2.—Monthly growth of different parts of the tanier plants.

planting, and an additional application of 500 kg should be made at 12 months, if harvest of the Morada variety is to be delayed in line with results discussed later in this paper.

Table 2 shows that 100, 12.5, 121, and 31 kg/ha of N, P, K and Mg, respectively, were contained in the corms and tubers, both of which are harvested and removed from the field. The leaves, petioles, and roots which remain in the field as residues, contain 25, 2.5, 35 and 17 kg/ha of N, P, K and Mg, respectively.

Table 3 shows that nutrient content of the leaf laminas did not vary

appreciably with age. Taniers continually produce new leaves while the older ones deteriorate. After about the first 6 months of growth, the plants have only 4-6 healthy active leaves. Percent nutrient levels in the leaf laminas of the high-yielding taniers averaged about N, 3.2; P, 0.25; K, 2.3; Ca, 1.3; and Mg, 0.9. The very high Mg levels probably represent

TABLE 1.—*Computation of the fertilizer needs of taniers (kg/ha)*

Nutrient	Uptake by taniers	Supplied by soil	To be supplied from fertilizer	To be applied as fertilizer <sup>1</sup>
N	125	80	45	90
P <sub>2</sub> O <sub>5</sub>	37	0	37	46
K <sub>2</sub> O	187	80	107	143
MgO	40 <sup>2</sup>	20	20	24

<sup>1</sup> Assuming following losses of applied fertilizer nutrients: N = 50%, P<sub>2</sub>O<sub>5</sub> = 20%, K<sub>2</sub>O and MgO = 25%.

<sup>2</sup> Reduced from maximum uptake which is considered to be "luxury consumption" as discussed in text.

TABLE 2.—*Average quantity of the various nutrients contained in different parts of the tanier plants near harvest (kg/ha)*

Plant part	Dry matter	N	P	K	Mg	Ca
Petioles	650	6	1.2	19	7	5
Leaves	500	17	1.2	10	8	6
Roots	150	2	0.1	6	2	1
Total residues	1,300	25	2.5	35	17	12
Tuber	5,400	54	4.5	85	14	6
Corms	3,900	46	8.0	36	17	7
Total	10,600	125	15	156	48	25

TABLE 3.—*Monthly percent nutrient content of leaf laminas of taniers (third leaf from top)*

Months after planting	N	P	K	Ca	Mg <sup>1</sup>
3	3.3	0.35	2.3	1.7	1.1
4	3.1	0.26	2.2	1.2	0.9
5	2.9	0.27	1.9	1.4	1.1
6	2.0	0.21	2.2	1.5	0.9
7	3.1	0.23	2.3	1.3	0.9
8	3.7	0.18	1.9	1.4	1.1
9	3.8	0.21	1.7	1.8	1.2
10	3.7	0.25	2.0	1.8	1.2
11	3.4	0.22	2.1	1.1	0.6
12	3.6	0.24	2.1	1.1	0.7

<sup>1</sup> Considered to represent "luxury uptake" as discussed in text.

luxury consumption as discussed previously. Data from other experiments indicate that Mg levels of about 0.3% are close to optimum for taniers.

## EFFECT OF AGE ON YIELDS

Table 4 shows that yields of tubers at both Yabucoa and Aguas Buenas decreased slightly from 12 to 16 months after planting, when some of the tubers sprouted and were therefore counted as corms; then yields more than doubled during the next 8 months. Yields of tubers increased from an average of 11,450 kg/ha 12 months after planting, when taniers are usually harvested, to 28,235 kg/ha 12 months later (fig. 3). Yields of corms, which can be used to feed pigs, increased steadily from 9,660 kg/ha 12 months after planting to 45,080 kg/ha 12 months later.

Yields of marketable tubers obtained in these experiments harvested at 24, rather than the customary 12 months after planting were 4 times

TABLE 4.—*Effect of time after planting on yield (kg/ha) of well managed taniers of the Morada variety at two locations*

Time after planting	Tubers at Yabucoa	Tubers at Aguas Buenas	Average yields of tubers	Corms at Yabucoa
<i>Mo</i>				
12	10,100	12,800	11,450	9,660
14	7,820	9,240	8,530	11,850
16	9,430	10,800	10,115	14,950
18	11,730	15,380	13,555	20,700
20	18,630	22,320	20,475	26,200
22	17,070	21,360	19,251	35,420
24	25,990	30,480	28,235	45,080

higher than average yields for the island, and higher than any others reported.

The following tabulation shows the results of two quality evaluations by 12 trained tasters at the Food Technology Laboratory of the Puerto Rico Agricultural Experiment Station of tanier tubers harvested 24 months after planting (fig. 3) and boiled for 55 minutes.

	<i>Rating</i> <sup>4</sup>	
	<i>First test</i>	<i>Second test</i>
Appearance	3.9	3.2
Taste	4.0	3.2
General quality	3.8	3.6

<sup>4</sup> On a scale of 1-5 ranging from poor to excellent.

The texture was considered typical of boiled taniers in general by 75% of the testers in both tests.

These results show that under many conditions, yields of the Morada variety can be greatly increased by harvesting about 2 years after planting rather than at 1 year as is customary. This practice is feasible only if the taniers are healthy and growing vigorously at the end of the first year. If



FIG. 3.—Corm and tubers of the Morada variety of taniers harvested 24 months after planting. The six tubers weighed 3 kg; the corm, 5 kg.

the ground is not well shaded the tubers will sprout (eventually becoming corms) and have little commercial value. This may occur if many leaves are destroyed by fungi. Weeding, allowing light to reach the soil, can also stimulate the tubers to sprout and should therefore be avoided after about 8 months after planting. The crop must be harvested whenever many tubers start to sprout. If taniers are to grow for an additional year,



they should receive about 500 kg/ha of 10-5-15-3 fertilizer near the end of the first year.

#### RESUMEN

El crecimiento y la utilización de varios nutrimentos por la yautía en distintas etapas de crecimiento se determinó en un experimento en Gurabo, y el efecto del intervalo entre siembra y cosecha en la producción de la variedad Morada en experimentos en Yabucoa y Aguas Buenas.

La utilización del nitrógeno y del potasio aumentó rápidamente y la del fósforo lentamente hasta la cosecha. La utilización del magnesio y del calcio aumentó hasta los 5 ó 6 meses después de la siembra y luego fluctuó de un mes a otro.

El crecimiento de los cormos y tubérculos aumentó rápidamente durante todo el ciclo hasta la cosecha, pero el de las hojas (incluyendo los pecíolos) aumentó sólo durante los primeros 6 meses, reduciéndose luego y entonces manteniéndose más o menos constante hasta la cosecha.

Las yautía utilizó un máximo de 125, 15, 156, 48 y 25 kg/ha de nitrógeno, fósforo, potasio, magnesio y calcio, respectivamente. La utilización de magnesio se consideró excesiva porque el suelo contenía mucho magnesio en forma asimilable.

A base de los datos sobre cantidades de nutrimentos disponibles en los suelos y las pérdidas de los que se aplican como fertilizantes, se calcula que la yautía debe recibir 500 kg/ha de abono 10-5-15-3 aplicado 2 y 6 meses después de la siembra y una aplicación adicional a los 12 meses si se va a posponer la recolección de la variedad Morada más allá de un año, lo cual es factible en muchos casos.

No hubo cambios apreciables en la composición de la lámina de la hoja desde 3 meses después de la siembra hasta la cosecha. La yautía produce nuevas hojas constantemente a la vez que las viejas se deterioran de tal manera que en un momento dado después de los primeros meses, cada planta cuenta con sólo 4 ó 6 hojas activas.

Los siguientes porcentajes de nutrimentos en la lámina de la hoja parecen ser indicativos de un buen abonamiento de la yautía: N-3.2, P-0.25, K-2.3, Ca-1.3 y Mg-0.3.

En experimentos realizados en Yabucoa y Aguas Buenas, el rendimiento de la variedad Morada aumentó desde un promedio de 11,450 kg de tubérculos y 9,660 kg de cormos/ha 12 meses después de la siembra a 28,235 kg de tubérculos y 45,080 kg de cormos/ha 12 meses más tarde, o sea 24 meses después de la siembra. Estos resultados señalan que, aunque todas las variedades de yautía usualmente se cosechan alrededor de 12 meses después de la siembra, la variedad Morada, bajo ciertas condiciones, puede continuar creciendo y aumen-

tando su producción hasta por un año más con pocos costos adicionales. Sin embargo, debe cosecharse cuando se observe que una cantidad apreciable de tubérculos empiezan a brotar y desarrollar hojas.

Dos catas realizadas científicamente por 12 personas señalaron que la calidad de los tubérculos cosechados 24 meses después de la siembra fue entre "moderadamente buena y muy buena" en cuanto a apariencia, sabor y calidad general. La textura se consideró típica de yautías hervidas por el 70% de los catadores.

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