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# Nutrient uptake, growth and yield performance of three tanier (*Xanthosoma* spp.) cultivars grown under intensive management[1]


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## ABSTRACT

**A study was conducted to determine the growth, nutrient uptake and yield performance of tanier cultivars Blanca del País, Kelly and Morada under intensive management. Tanier plants grown under field conditions were harvested for biomass production about every 30 days during the growing season. At each harvest, plants were separated into various plant parts to determine dry matter accumulation, N, P, K, Ca, Mg and Zn uptake and yield. Maximum uptake of nutrients was 307, 83, 417, 112, 68 and 1.4 kg/ha of N, P, K, Ca, Mg and Zn, respectively, for cultivar Blanca del País. Nutrient uptake by Kelly was considerably less than for Blanca del País and Morada. Overall, there were no significant differences in total dry matter production between cultivars Blanca del País and Morada whereas Kelly accumulated significantly less dry matter. Maximum yields ranged from 11,316 kg/ha in Kelly to 34,068 kg/ha in Morada.**

## RESUMEN

**Extracción de nutrimentos, crecimiento y rendimiento de tres cultivares de yautía (*Xanthosoma* spp.) bajo manejo intensivo**

**Se hizo un estudio para determinar el crecimiento, la extracción del suelo de varios nutrimentos y los rendimientos de los cultivares de yautía Blanca del País, Kelly y Morada. Se sembraron plantas de yautía en el campo y se consecharon aproximadamente cada 30 días. En cada cosecha**



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**se determinó la acumulación de materia seca en varios órganos de las plantas, la extracción de N, P, K, Ca, Mg y Zn y el rendimiento comercial. La extracción de nutrimentos fue 307, 83, 417, 112, 68 y 1.4 kg/ha de N, P, K, Ca, Mg y Zn, respectivamente, para el cultivar Blanca del País. La extracción de nutrimentos en el cultivar Kelly fue menor que en Blanca del País y Morada. En general, no hubo diferencias significativas en la materia seca total producida entre los cultivares Blanca del País y Morada, pero el cultivar Kelly acumuló significativamente menos materia seca. Los rendimientos más altos variaron desde 11,316 kg/ha en Kelly hasta 34,068 kg/ha en Morada.**

## INTRODUCTION

Tanier or new cocoyam (*Xanthosoma* spp.) is an important food staple in tropical countries. The crop, however, has received low research priority. Therefore, it has been classified by the National Academy of Sciences as a neglected food crop with promising economic potential (15).

Yield potential of tanier is seldom realized mainly because of lack of knowledge concerning diseases, proper management practices, and physiological determinants that may limit growth and development. On a world-wide basis, aroid (*Xanthosoma* and *Colocasia* spp.) yields range between 907 and 5,400 kg/ha, compared with averages of 8,700, 12,800 and 13,500 kg/ha for yams, sweet potato, and solanum potato, respectively (5, 13).

From 1950 to 1955 tanier production in Puerto Rico reached its highest level, averaging 25,000 metric tons per annum with about 5% of the production exported to the United States market. Production has steadily declined since then, with 13,000 metric tons produced in 1980 to the present lowest production of 4,900 metric tons (16, 17). In 1988-89 Puerto Rico imported 11,937 metric tons of tanier (17).

There are many factors responsible for the low yields and decreased production of taniers in Puerto Rico, but dry root rot has been considered the most important. This disease has been reported throughout the Caribbean Basin, where it is known as "burning," and in Africa, where it is referred to as the Apollo disease(11). In the field, the disease is often expressed in 4- to 5- month-old plants. Typical symptoms include reduced shoot growth, leaf chlorosis and premature senescence. The one time profuse root system suddenly becomes a fiber-like mass of dry roots, and plants can be easily pulled from the soil as a result of a marked deterioration of the root system.

The exact contribution of biotic or pathological elements to the dry root rot and the influence of environmental and agronomic factors have not been ascertained (2, 3, 10, 11 18). The disease, however, occurs predominantly in monocultures under poor or semi-intensive management where the crop often undergoes transient periods of water and nutritional stress.

Higher tanier yields require the support of an updated and tested package of agronomic practices. On the basis of the assumption that dry root rot is the result of a combined interaction of biotic, environmental and agronomic factors, an integrated approach must be followed to gather enough reliable information on the joint effects.

The objective of this study was to determine the growth, nutrient uptake and yield performance of three tanier cultivars grown under intensive management as an initial effort to develop a package of agronomic practices for improved monoculture tanier production.

## MATERIALS AND METHODS

An experiment was conducted at the Isabela Research Farm of the Tropical Agriculture Research Station in a well drained Oxisol (Typic Eutostrox) with a pH of 5.4, bulk density of 1.4, 2.0% organic carbon, and 8.3 c mol (+)/kg of soil of exchangeable bases. Soil nitrate and ammonium at 0 to 15 cm depth were 8.1 and 14.9 $\mu$g/g of soil, respectively. Average monthly rainfall, class A pan evaporation, and air mean temperature throughout the 16-month experimental period were 3.9 mm, 4.6 mm and 24.4°C, respectively. The experimental area was subsoiled to a depth of about 0.46 m and dolomitic limestone was broadcast at the rate of 1,340 kg/ha and then incorporated with a roto-tiller.

Excised corm buds with fresh weights of about 16 g were planted in jiffy pots with Pro-Mix growing medium in a screenhouse. The three tanier cultivars used for the experiment were Blanca del País (*Xanthosoma caracu*), Kelly and Morada (*Xanthosoma violaceum*). Kelly produces yellow-fleshed cormels and is considered an early type cultivar with highest yields obtained at about 8 months after planting. Blanca del País produces white-fleshed, and Morada, purple-fleshed, cormels and they attain maximum yields at about 12 and 14 months after planting, respectively.

On 6 July 1989, plants at the one-leaf stage were transplanted to the field with cultivars as the main plots and replicated seven times. The main plots were split to accommodate 14 biomass harvests. Each subplot contained 20 plants spaced .91 x .46 m apart, from which the inner six were sampled. Plots were drip-irrigated when the soil water tension, measured with tensiometers at a depth of 15 cm, exceeded 20 Kpa. Fertigation was supplied about every 2 weeks at the rate of 6.0 and 7.9 kg/ha of N and K, respectively, using potassium nitrate and urea as nutrient sources. Each plant received 3.5 g of granular P provided as triple superphosphate at planting time.

Plant and biomass measurements were collected at 35, 68, 98, 131, 161, 195, 223, 251, 285, 313, 342, 377, 417, and 460 days after planting

(DAP) except for cultivar Kelly, for which the last biomass harvest was made 377 DAP.

At each harvest, leaves were cut at the midrib - petiole intersection. We then harvested each of the plants in the subplots by digging an area of 0.42 square meters around each plant to a depth of 30.5 cm. Because of the labor and carefulness required during the root sampling operation, only two of the six plants were used for that purpose. Plants were then pulled from the soil, washed, and separated into leaves, petioles, corm, cormels, roots, and suckers. Samples were dried at 70°C to constant weight for dry matter determination. The dry samples were ground to pass a 1.0-mil mesh screen and analyzed for N, P, K, Ca, Mg and Zn. Nitrogen was determined by the micro Kjeldahl procedure (14), P by the molybdovanadophosphoric acid method (8), and K, Ca, Mg and Zn by atomic absorption spectrophotometry (4).

We determined best fit curves and mean comparisons by using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS) program package (19). Only coefficients significant at $P \leq 0.05$ were retained in the models.

## RESULTS AND DISCUSSION

### Nutrient uptake

Figure 1 A-F shows that uptake of all nutrients steadily increased from planting until late in the growing season. The amounts of N, P, K, Ca, Mg and Zn taken up by cultivars Blanca del País and Morada were very similar and significantly greater than for Kelly, which is an early type cultivar that accumulates less dry matter.

The maximum uptake of nutrients for all cultivars (table 1) was considerably greater than values reported previously for Morada (20). In that study, maximum uptake values for N, P, K, Ca and Mg were 54, 79, 66, 74, and 9% smaller, respectively, than the values herein reported for the same cultivar. Higher nutrient contents in this study can be attributed to the utilization of a drip irrigation system which allowed for optimum soil moisture conditions and fertigation schedules that promoted vigorous growth and consequently greater production of dry matter by

TABLE 1. *Maximum uptake of various nutrients near the end of the growing season in three tanier cultivars (kg/ha).*

| Cultivar | N | P | K | Ca | Mg | Zn |
|---|---|---|---|---|---|---|
| Blanca del País | 307 | 83 | 417 | 112 | 68 | 1.4 |
| Morada | 272 | 73 | 454 | 98 | 53 | 1.3 |
| Kelly | 145 | 40 | 220 | 63 | 33 | 0.5 |

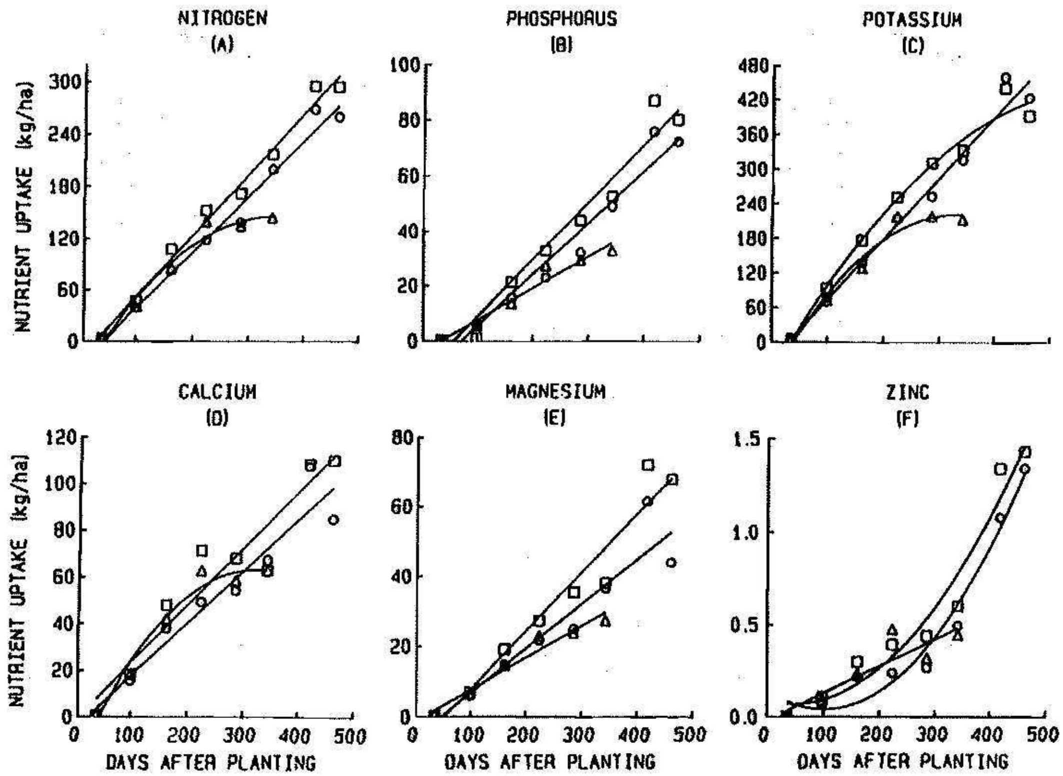


FIG. 1.—Nutrient content of three tanier vultivars as influenced by plant age. Blanca del País = (■), Kelly = (▲), Morada = (●).

all cultivars. It has been reported that the irrigation efficiency provided by a drip system is 80% compared to only 60% for sprinkle and 40% for furrow irrigation systems (7). Periodic fertigation schedules provide plants with a small but constant nutrient supply in the root zone. The constant nutrient supply is particularly important in tanier production in contrast with the common practice of applying all of the fertilizer requirement early in the season and, therefore, making it susceptible to runoff or leaching losses after heavy rains.

The concentrations of nutrients in the leaf laminas did not vary appreciably among cultivars and, hence, they are presented in table 2 as the average for all cultivars. Nitrogen and potassium concentrations in leaf lamina remained high during the first 98 DAP and then declined, whereas P, Ca, Mg and Zn concentration increased toward the end of the growing season.

A total of 644 kg/ha of potassium nitrate and 220 kg/ha of urea were supplied to cultivars Blanca del País and Morada through the drip irrigation system during the growing season. These quantities supplied 185 and 232 kg/ha of N and K, respectively. Kelly received 149 and 198 kg/ha of N and K, respectively. Although these amounts are considerably

TABLE 2. *Average percentage nutrient content in leaf laminas of three tanier cultivars.*

| Days after planting | N | P | K | Ca | Mg | Zn |
|---|---|---|---|---|---|---|
| 35 | 5.1 | 0.37 | 4.4 | 1.2 | 0.41 | 0.0042 |
| 98 | 4.2 | 0.44 | 4.2 | 1.7 | 0.39 | 0.0054 |
| 161 | 3.9 | 0.42 | 3.3 | 2.0 | 0.38 | 0.0054 |
| 223 | 3.8 | 0.36 | 2.9 | 1.8 | 0.36 | 0.0036 |
| 285 | 3.8 | 0.42 | 3.0 | 2.2 | 0.40 | 0.0040 |
| 342 | 3.8 | 0.42 | 2.6 | 2.4 | 0.45 | 0.0040 |
| 417 | 3.3 | 0.38 | 2.8 | 2.1 | 0.45 | 0.0051 |
| 460 | 3.5 | 0.37 | 2.7 | 2.1 | 0.45 | 0.0063 |

greater than those used by Vicente-Chandler et al. (20), their application resulted in greater production of dry matter and higher yields.

## Dry matter production

Table 3 presents the results of statistical analyses (LSD values) to determine significant cultivar effects within biomass harvests for dry matter production of various plant parts. Figure 2 A-F presents data representative of these dry matter values.

TABLE 3. *Summary of protected LSD values for statistical comparison of dry weight of various plant parts at each biomass harvest in figure 2.*

| Days after planting | Dry weight (kg/ha) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Total | Leaves | Roots | Petioles | Corms | Cormels | Suckers |
| | LSD[a] | | | | | | |
| 35 | 31 | 14 | NS | 7 | 6 | – | – |
| 68 | 156 | 111 | 29 | 58 | 24 | – | – |
| 98 | NS[b] | NS | NS | NS | NS | NS | – |
| 131 | NS | 156 | NS | NS | 281 | 265 | – |
| 161 | 984 | 260 | 118 | 459 | 273 | NS | – |
| 195 | 1757 | 472 | NS | 786 | 662 | NS | – |
| 223 | NS | 422 | NS | 761 | 873 | NS | – |
| 251 | 2206 | 331 | NS | 735 | 573 | 1196 | NS |
| 285 | 2042 | 199 | NS | 347 | 585 | 1350 | NS |
| 313 | 1501 | 235 | NS | 680 | 986 | 1257 | NS |
| 342 | 3084 | 147 | NS | 759 | 1464 | 1635 | 156 |
| 377 | 4606 | 487 | NS | 833 | 3098 | 1718 | 556 |
| 417 | NS | NS | NS | NS | NS | 343 | NS |
| 460 | NS | NS | NS | NS | NS | NS | NS |

[a]Protected LSD, significant at the 0.05 probability level.
[b]NS = no significant difference.

Overall, there were no significant differences in total dry matter production between cultivars Blanca del País and Morada (fig. 2A). Cultivar Kelly accumulated significantly less dry matter, especially during late stages of growth. All cultivars were characterized by low rates of total dry matter production during the first 98 DAP (fig. 2A). At this date, leaves and petioles accounted for more than 70% of the total dry matter produced in all cultivars (fig. 2B,C). After 98 DAP, total dry matter increased almost linearly until about 223 DAP as a result of increased rates of dry matter accumulation in all plant components (fig. 2A-F). Thereafter, the increase in total dry matter was mainly the result of corm and cormel growth (fig. 2E, F).

Cormel development was initiated at 98 DAP in all cultivars; however, the rates of cormel dry matter accumulation varied between cultivars (fig. 2F). These rates remained high until 285, 342, and 417 DAP, for cultivars Kelly, Blanca del País and Morada, respectively. Results published elsewhere by the senior author (6) showed that leaf area indices in this study were higher than those reported in the literature for tanier (9) and may explain why cormel and corm dry matter accumulation continued until late stages of growth (fig. 2E, F).

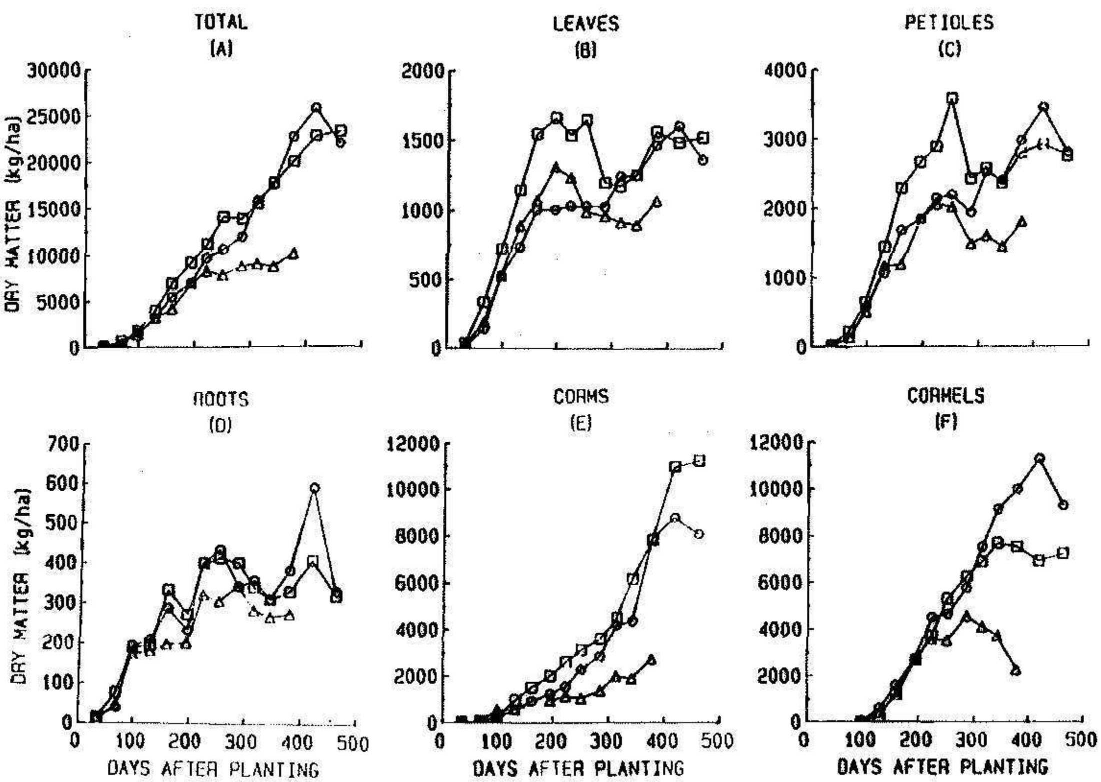


FIG. 2.—Accumulation of dry matter in three tanier cultivars as influenced by plant age. Data for cultivar Blanca del País = (■), Kelly = (▲), Morada = (●).

Cultivar Kelly initiated sucker development at 251 DAP whereas Blanca del País and Morada did so at 342 and 417 DAP, respectively (data not shown). The maximum total number of suckers per plant were 4.0 at 377 DAP, 1.8 at 460 DAP, and 0.16 at 460 DAP, respectively, for cultivars Kelly, Blanca del País and Morada. It should be noted that under normal cultural practices, cultivar Kelly would be harvested at about 285 DAP. Extending the growing season beyond this point reduces commercial yields as a result of cormel sprouting.

## Yield performance

Table 4 gives FLSD values to determine significant cultivar effects within harvests for cormel number and yield. Cormels were considered marketable only if they weighed more than 130 g.

Table 5 shows that all cultivars commenced to produce excellent yields at 223 DAP. At this time, yields ranged from 10,130 kg/ha in Kelly to 14,032 kg/ha in Morada. Maximum yields ranged from 11,316 kg/ha at 285 DAP in Kelly to 34,068 kg/ha at 417 DAP in Morada. The maximum number of cormels ranged from 66,552 in Kelly to 92,456 cormels/ha in Morada (table 5).

The yields obtained in this investigation represent conservative values since only cormels that weighed more than 130 g were considered marketable. Still, these yields were up to three times greater than those previously reported (1, 13, 20) and demonstrate that a successful and profitable tanier crop can be grown if proper agronomic and management practices are implemented.

Assuming that a farmer can obtain similar yields following the cultural practices used in this study and a farm gate price of 88 cents per

TABLE 4. *Summary of protected LSD values for statistical comparison of cormel number (No./ha) and marketable cormel yield (kg/ha) at each day after planting shown in table 5.*

| Days after planting | Cormel number | Marketable yield |
|---|---|---|
| | LSD[a] | |
| 223 | NS[b] | NS |
| 251 | NS | 4987 |
| 285 | NS | 5133 |
| 313 | 12850 | 4521 |
| 342 | 20563 | 7008 |
| 377 | 15354 | 7304 |
| 417 | 22349 | NS |
| 460 | NS | NS |

[a]Protected LSD, significant at the 0.05 probability level.
[b]NS = no significant difference.

TALBE 5. *Number of commercial cormels (No./ha) and marketable yield (kg/ha) of three intensively managed tanier cultivars at various days after planting.*

| Days after planting | Cultivar | | | | | |
|---|---|---|---|---|---|---|
| | Blanca del País | | Morada | | Kelly | |
| | Cormel No. | Yield | Cormel No. | Yield | Cormel No. | Yield |
| 223 | 65,756 | 11,796[a] | 78,508 | 14,032 | 62,567 | 10,130 |
| 251 | 63,763 | 15,399 | 62,966 | 13,259 | 44,235 | 8,971 |
| 285 | 63,364 | 17,778 | 66,752 | 15,920 | 46,627 | 11,316 |
| 313 | 63,763 | 20,448 | 75,718 | 21,667 | 45,032 | 11,174 |
| 342 | 68,147 | 22,648 | 91,659 | 25,692 | 34,273 | 10,114 |
| 377 | 62,169 | 23,401 | 90,464 | 30,339 | 22,317 | 6,683 |
| 417 | 59,778 | 22,181 | 92,456 | 34,068 | – | – |
| 460 | 63,763 | 22,142 | 89,268 | 28,674 | – | – |

[a]Cormels were considered marketable when they attained a weight of 130 g or more.

kilogram of cormels, the above-mentioned yields will result in gross profits ranging from $9,958 to $29,980 per hectare. These earnings would justify the cost of the initial investment and the installation of a drip irrigation system.

Careful examination of root samples at each biomass harvest showed a vigorous radical system and total absence of dry root rot in all cultivars. These results suggest that the incidence of this disease is related to the agronomic management of the crop.

It is acknowledged, however, that the experimental area did not have a previous history of dry root rot and, therefore, a cause and effect relationship between crop management and dry root rot incidence cannot be established definitely. This relationship should be studied further since, in many instances, tanier crops planted in fields without a history of dry root rot are often affected by the disease.

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