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ESTIMATE OF MACRONUTRIENTS UPTAKE BY ARRACACHA AT HARVEST[1]

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ABSTRACT. In Puerto Rico, arracacha or apio is a minor crop planted for its yellow-fleshed corm. The climatic requirements of this crop restrict its commercial production to high elevations where ultisols are common. Previous studies did not examine the amount of nutrients that must be supplied by the soil-fertilizer combination for optimum crop development and yield. The objective was to estimate arracacha's macronutrient uptake in a soil typically used for its production. The experiment was planted on a Humatas soil (Typic Tropohumults) under rain-fed conditions. Three levels of K fertilization were used (45, 90 and 135 kg/ha). Yield and plant fresh weight were recorded at harvest; then the plant parts were oven dried. The nutrient concentrations in the tissues were obtained to estimate nutrient uptake. Neither yield, plant parts fresh and dry weight nor nutrient concentrations in tissues were affected by the level of K fertilization. Fresh corm yield was 4.8 t/ha. On a dry weight basis, the crop harvest index was 0.81. Except for K, the nutrients were more concentrated in the leaf lamina. Uptake of N and K were the highest, whereas P and Ca uptake tended to be intermediate between the N-K group and Mg uptake. Nutrient harvest indexes exceeded 0.35.

INTRODUCTION

Arracacha (*Arracacia xanthorrhiza* Banc.) or apio is a minor crop throughout the Caribbean (Vietmeyer, 1986). In South America, arracacha is cultivated for its tuberous roots. In Puerto Rico, however, arracacha is planted for its yellow fleshed corm. The climatic requirements of this crop restrict its commercial production primarily to high elevations where ultisols are common. In the central mountains of Puerto Rico ultisols are characterized by low fertility and difficulty to work because of the slope and the stickiness and plasticity of the clay (USDA, 1978). In an Ultisol of the Humatas series, the tuber yield of arracacha was reported to increase with the level of N fertilization (del Valle et al., 1995). This trend was accompanied by a lack of response to P and K fertilization. Recently, Ortiz et al. (1997) indicated that nutrients concentration in arracacha plant parts varied with the level of N fertilization. These two studies focussed on the effect of fertilizer on yield and nutrient accumulation, but did not examine the amount of nutrients that must be supplied by the soil and fertilizer combination for optimum yield and crop development. An estimate of nutrient uptake is key to determine the amount of fertilizer that should be applied for optimum production. Thus, the objective of this study was to estimate arracacha's macronutrient uptake at harvest in a soil typically used for its production.

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MATERIALS AND METHODS

The experiment was planted in April 3, 1995 on a private farm located in the Barranquitas municipality in the central mountains of Puerto Rico. Elevation was 580 m. The traditional cultivar Criolla was used. The soil was a Humatas series (Typic Tropohumults, Clayey, kaolinitic, isohyperthermic), with a pH of 7.0. Soil chemical analyses revealed that available P was 7.9 mg/kg and exchangeable K was 0.7 $cmol_c$/kg. Exchangeable Ca and Mg were 11.5 and 0.4 $cmol_c$/kg, respectively. Particle analysis was 69% clay, 19% sand and 12% silt.

After emergence, plants were rogued to establish a stand equivalent to 11,961 plants per hectare. The experimental area was divided into nine 29.8-m^2 plots. There was a clean 1 m border with a ditch between plots. Three levels of K fertilization, 45, 90 and 135 kg/ha as potassium sulfate, were evaluated. All plots received the equivalent of 135 kg/ha of N, 90 kg/ha of P and 45 kg/ha of Mg. Nitrogen was provided as ammonium sulfate and P as triple superphosphate. Magnesium was provided as epsom salt. Total fertilizer was sidedressed in two equally divided portions at 64 and 112 days after planting. In the field, the experiment was laid out as a randomized complete block with three replications. Weeds were controlled by hand cultivation. Plants were rain-fed.

The experiment was harvested 267 days after planting. Prior to harvest, samples of five random plants per plot were pulled from the soil. The rest of the plants within the plot were harvested for yield. Sampled plants were cleaned and divided in leaf lamina, leaf petiole and corm then, fresh weight of the parts was recorded. After this procedure, the parts were oven-dried at 65° C to a constant weight, then ground for nutrient concentration analyses. The determination of N and P concentration in the tissues was made colorimetrically. Concentrations of K, Ca and Mg were determined by spectrophotometry. All chemical analyses followed the reference procedures for the Southern Region of the United States (Univ. of Georgia, 1992; Virginia Agric. Exp. Stn., 1992). Nutrient concentration was expressed as a percentage of the tissue dry weight. Data for nutrient concentration in tissues was analyzed as a 3 x 3 factorial arrangement of the level of K fertilization and plant part. Estimates of nutrient uptake were calculated by considering average concentration in tissues, tissue dry weight and stand, following the methodology described by Greenwood et al. (1979).

RESULTS AND DISCUSSION

Neither yield, nor plant parts fresh and dry weight were affected by level of K fertilization. Arracacha's lack of response to K fertilization has been reported previously by del Valle et al. (1995). Average yield was 4.8 t/ha which was relatively low compared to the reported by del Valle et al. (1995). This experiment was under rain fed conditions thus, reduction in yield can be attributed in part to more than 40% reduction in average precipitation in the experimental area.

The corm was the heaviest of the plant parts in terms of both fresh and dry weight (Table 1). On a fresh weight basis, the corm/plant weight ratio was 0.61. On a dry weight basis, the

harvest index (fraction of the plant that is economically important) was 0.81. This harvest index is higher than that of upland taro planted in similar conditions (Ortiz, C.E., unpublished data).

Table 1. Average plant fresh and dry weight and corm/plant weight ratio of arracacha harvested 267 days after planting.

Basis	Plant part			Total	Corm/Plant Ratio
	Lamina	Petiole	Corm		
Fresh weight (g/plant)	78.6	116.0	303.6	498.2	0.61
Dry weight (g/plant)	9.8	8.6	76.5	94.9	0.81[1/]
Humidity (%)	87	92	75		

[1/] Corm/plant ratio is equivalent to the harvest index.

As for yield, the level of K fertilization had no effect on the nutrient concentration in the plant parts. Plant part, however, was a significant source of variation for nutrient concentration. Except for K, the nutrients were significantly more concentrated in the leaf lamina than in the petiole, whereas concentration in the petiole was significantly higher than in the corm (Table 2). Potassium was more concentrated in petioles than in laminas and corms. The results of this study coincided with those previously reported by Ortiz et al. (1997). These researchers found that nutrients concentration tended to be higher in the leaf lamina.

Table 2. Nutrient concentration in arracacha plant parts harvested 267 days after planting.

Plant Part	Nutrient				
	N	P	K	Ca	Mg
	% of dry weight				
Lamina	3.45	0.61	3.67	1.64	0.18
Petiole	0.96	0.52	5.12	0.96	0.04
Corm	0.46	0.30	2.52	0.20	0.03
$LSD_{0.05}$	0.07	0.04	0.25	0.28	0.01

In this study the estimate of K uptake (32.03 kg/ha) was relatively high compared to other nutrients (Table 3). This result may be associated to availability of K as a consequence of treatments. Since the K level of fertilization treatment did not increase yield, its uptake value may be the result of luxury consumption. Uptake of N and K were the highest, whereas P and Ca uptake tended to be intermediate between the N-K group and Mg uptake (Table 3).

Similar mineral uptake patterns have been reported for tanier and yams (Goenaga and Chardon, 1993; Irrizarry et al., 1995).

Table 3. Estimate of nutrients uptake and harvest index of nutrient (HIN) of arracacha harvested at 267 days after planting.

Plant Part	Nutrient				
	N	P	K	Ca	Mg
Lamina (kg/ha)	4.04	0.72	3.77	1.92	0.21
Petiole (kg/ha)	0.99	0.53	5.26	0.99	0.04
Corm (kg/ha)	4.21	2.75	23.00	1.83	0.27
Total (kg/ha)	9.24	4.00	32.03	4.74	0.52
HIN	0.45	0.69	0.72	0.39	0.52

Arracacha's biomass production per unit of area depends on plant population, use of fertilizer and other management practices. In absence of supplemental irrigation, rainfall plays an important role in crop development and dry weight accumulation. Since nutrient uptake depends on total dry weight, the uptake values obtained in this study are a gross estimate of the amount of nutrients that the soil or soil-fertilizer combination has to supply for approximately 5t of fresh corms. An additional amount of nutrient may be needed to supply the accumulation of minerals in the roots, which may account from 2 to 3% of the plant dry weight.

Russell (1988) defined the harvest index of a nutrient as the fraction of the nutrient taken up by the crop which is present in the economically important part of the plant. Nutrient harvest indexes for P, K and Mg exceeded 0.50 (Table 3). These results indicate that less than half of theses nutrients can be recycled into the soil after harvest. Additional information on the dynamics of mineral release and its interaction with nutrient uptake is necessary for the enhancement of fertilization practices for arracacha and for other specialty tubers.

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