Nutrient and Dry Matter Contents of Intensively Managed Cassava Grown on an Ultisol[1, 2]

Héber Irizarry and Edmundo Rivera[3]

ABSTRACT

Intensively managed, properly fertilized cassava grown on a typical Ultisol had a total of 204, 12, 222, 86, and 33 kg/ha of N, P, K, Ca, and Mg, respectively, at 10 months of age, and yielded 37.5 metric tons/ha of marketable roots. Leaf contents of about 4.3, 0.12, 1.8, 1.4, and 0.4% of N, P, K, Ca, and Mg, respectively, 6 months after planting indicated adequate fertilization.

INTRODUCTION

Root crops contribute a major share of the calories consumed by inhabitants of the humid tropics. From 60 to 80% of the calories consumed by the population of Africa are derived from these crops (4).

Cassava (*Manihot esculenta* Crantz) is one of the major food crops of the tropics. It is easily propagated from stem cuttings, tolerates periodic drought, is attacked by few insects or diseases of economic importance, and can produce large quantities of high calorie food per unit of land. Abruña et al. (2) found that cassava is highly tolerant to high soil acidity. Yields of cassava grown on a Corozal clay (Aquic Tropudults) were affected only when the soil pH dropped below 4.3 and the exchangeable Al increased above 60% saturation.

Relatively few fertilizer experiments have been conducted with cassava in Puerto Rico. Fox et al. (3) reported a significant response in yield by cassava of the Llanera cultivar grown on Humatas clay (Typic Tropohumults) to the application of 120 kg of N/ha, but found no response to N applications up to 200 kg/ha on Torres clay (Plinthic Palehumults). Samuels (6) tested various rates of N, P, and K with cassava growing on Corozal clay. He found a significant response in yield to applications of 49 kg of P and 93 kg of K/ha, but no response to N applications.

In Costa Rica, Oelsligle (5) determined total N, P, and K content and dry matter accumulation in the tops and roots of cassava plants grown at three fertilizer levels, none of which affected yields. Nutrient removal totaled 367, 41, and 213 kg/ha of N, P, and K, respectively. Average yields of fresh roots was 43 t/ha.

[1] Manuscript submitted to Editorial Board February 25, 1982.

[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, PR.

[3] Research Horticulturist and Agronomist, respectively, Agricultural Research Service, USDA, Río Piedras, PR.

The present study determined the monthly and total N, P, K, Ca, and Mg and the dry-matter contents and yields of cassava grown on a typical Ultisol of the humid region of Puerto Rico with adequate fertilization.

MATERIALS AND METHODS

The experiment was carried out on Corozal clay, at the Corozal Substation. The soil had a pH of 6.4 and contained 15 p/m of available P (Olsen method) and 0.94, 9.5, and 1.4 meq/100 g of soil of exchangeable K, Ca, and Mg, respectively.

The field was plowed and harrowed twice and divided into 7.4- × 3.7-m experimental plots, each surrounded by border rows and ditches. Stem cuttings of the Llanera cultivar were planted May 20, 1980, 0.92 apart in ridged rows spaced at 1.22 m, or about 9,000 plants/ha.

Fertilizer rates of 0, 500, and 1,000 kg/ha of 10-5-20-3 (N-P_2O_5-K_2O-MgO) were tested in a randomized complete block design with four replications. The fertilizer was divided into two equal applications 1 and 4 months after planting.

Starting 3 months after planting, and monthly thereafter, one randomly selected plant from each plot was uprooted, washed, and divided into leaf blades and petioles, stems, and roots. Weights of fresh and oven-dry plant parts were determined, and dried samples were ground, passed through a 20-mesh screen, and analyzed for N by the macro-Kjeldahl method; for P, colorimetrically; for K, by flame photometry; and for Ca and Mg, by the Versenate method after digestion in nitric-perchloric acid.

Ten months after planting, a 3.7 × 3.7 m area in each plot was harvested, and yields of marketable roots were determined.

RESULTS AND DISCUSSION

Similar yields, averaging 37.5 t/ha of marketable fresh roots were obtained with all three fertilizer levels. Also, examination of the data revealed no appreciable difference in uptake of the various nutrients at the different fertilizer levels. Values presented in this paper are averages of those obtained with the three fertilizer levels.

Contents of N and K were similar, increasing rapidly throughout the growth cycle (table 1, figure 1). Contents of Ca also increased with age, but at a much lower rate. Contents of P and Mg were low and leveled after about 7 months.

Dry matter in the stems, roots, and whole plant increased steadily with plant age (table 2, figure 2). Dry matter in the leaves declined sharply from 5 to 8 months after planting, and thereafter remained stable. Total dry matter in the plants 10 months after planting was 22,548 kg/ha; yield of edible fresh roots was 37.5 t/ha.

At harvest, 10 months after planting, the cassava plants contained 204, 12, 222, 86, and 33 kg/ha of N, P, K, Ca and Mg, respectively (table 1). The values for N and P were much lower than those reported by Oelsligle (5) for 10-month old cassava plants in Costa Rica, and the value for K was similar to that reported by Oelsligle. The Ca-supplying power of most soils is sufficient for optimum cassava production.

The nutrients contained in the cassava plants were equivalent to 204, 27, 267 and 55 kg/ha of N, P_2O_5, K_2O, and MgO, respectively, as expressed in commercial fertilizers (table 3). Long-term experiments conducted by

TABLE 1.—*Nutrient contents of cassava plants at different ages*

Months after planting	Nutrient				
	N	P	K	Ca	Mg
			kg/ha		
3	24	1	17	9	3
5	150	9	111	60	21
6	157	7	128	65	23
7	171	9	158	76	29
8	191	9	223	72	27
9	201	8	221	78	26
10	204	12	222	86	33

TABLE 2.—*Dry matter contents of various parts of cassava plants at different ages*

Months after planting	Plant part			
	Leaves	Stems	Roots	Whole plant
		kg/ha		
3	430	181	152	763
5	2,525	3,514	2,444	8,483
6	2,135	4,101	3,031	9,267
7	1,542	7,968	4,967	14,477
8	647	8,947	7,233	16,827
9	771	9,664	10,319	20,752
10	650	10,478	11,420	22,548

Abruña et al. (1) and Vicente-Chandler et al. (7) with tropical grasses growing in Ultisols and Oxisols indicated that those soils can supply about 80 kg/ha yearly of both N and K_2O, and about 20 kg/ha yearly of MgO. Those amounts are equivalent to 68 kg of N and K_2O, and 15 kg of MgO/ha over the 10-month cycle for cassava. It is assumed that no P is provided by the soil since it has no P-bearing minerals.

On the basis of the data on nutrient uptake, the nutrient-supplying power of the soil, and the assumption that the soil provides no P, optimum yields of cassava should be obtained by applying 136, 27, 199, and 40 kg/

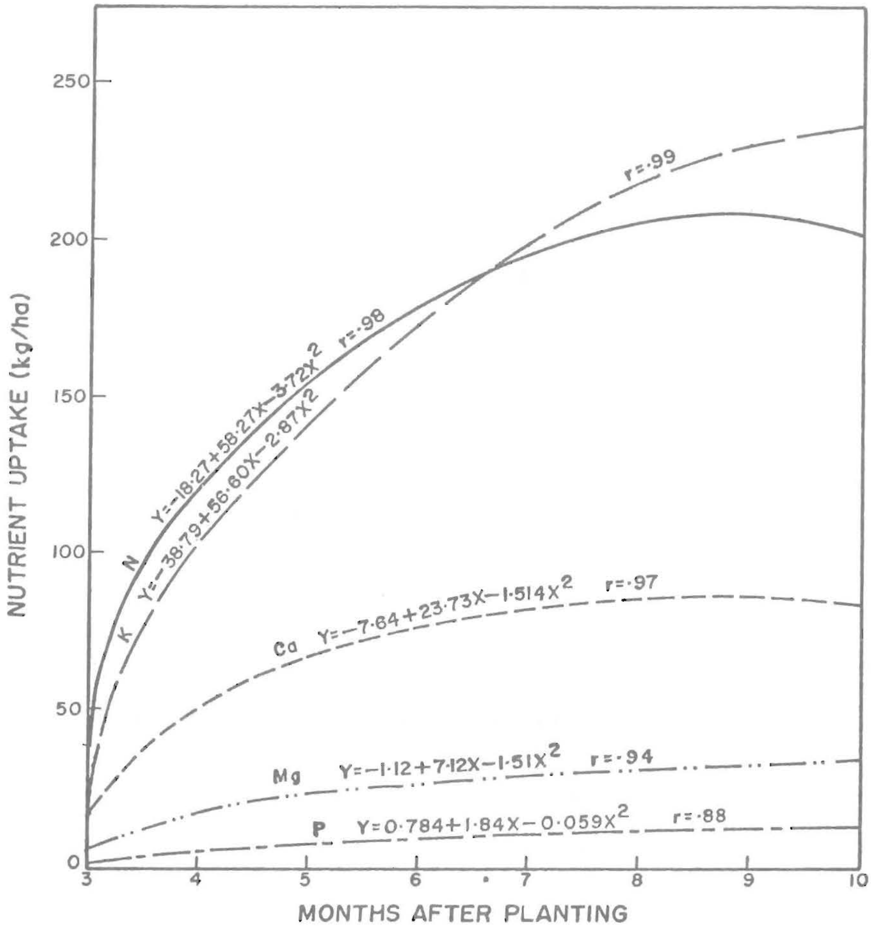

FIG. 1.—Nutrient contents of intensively managed cassava plants grown on a Corozal clay (Ultisol).

ha of N, P_2O_5, K_2O, and MgO, respectively. However, Vicente-Chandler et al. (7) reported that about 50% of the N, 20% of the P_2O_5, and 25% of the K_2O and MgO applied as fertilizer is lost. On the basis of those losses, cassava must be fertilized with 272, 32, 249, and 50 kg/ha of N, P_2O_5, K_2O, and MgO, respectively, roughly equivalent to 2,000 kg/ha of 14-2-13-3 commercial fertilizer to produce near maximum yields. The fertilizer should be applied in two equal applications, 2 and 6 months after planting.

The data in table 4 indicate that 52, 5, 110, 8, and 9 kg/ha of N, P, K,

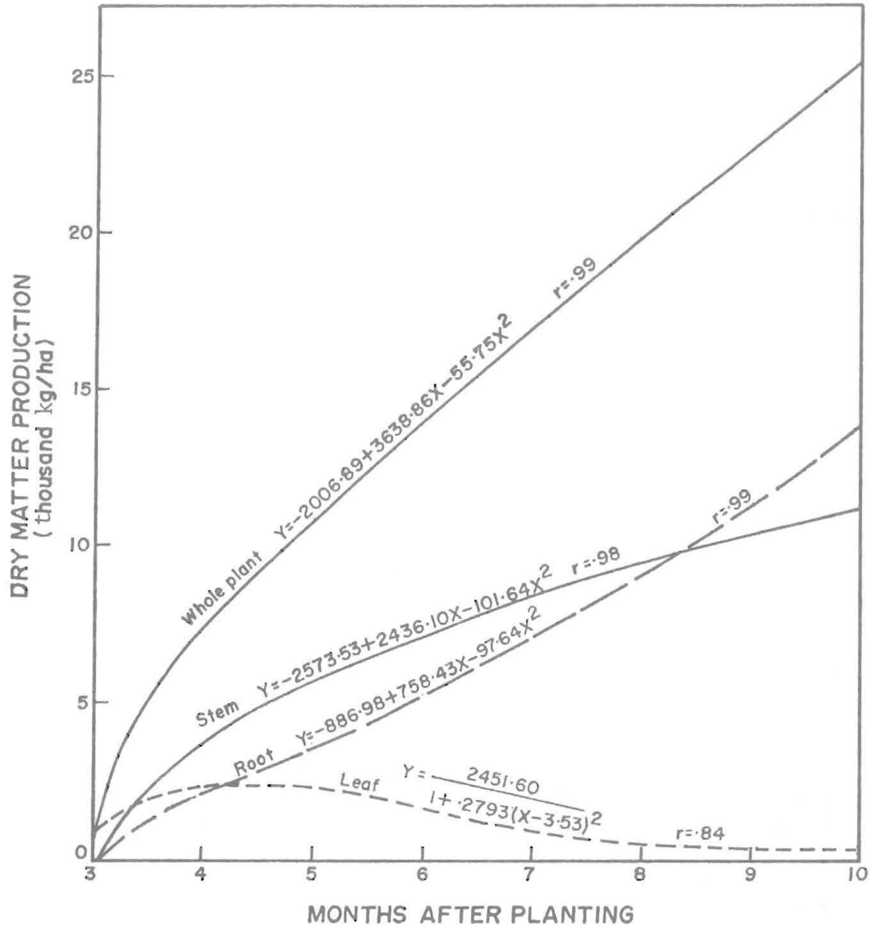

FIG. 2.—Rates of growth by intensively managed cassava plants grown on a Corozal clay (Ultisol).

Ca, and Mg, respectively, amounts contained in 11,420 kg/ha of dry matter, were removed from the field in the marketable roots. The other nutrients extracted by the plant are returned to the soil as plant residues and can help reduce fertilizer needs of subsequent crops.

The data in table 5 indicate the changes in nutrient content of different parts of cassava with age of the plants. Nutrient content was considerably higher in the leaves than in the other plant parts at all ages. During the last 3 months, the N and K content of the leaves increased, whereas Ca and Mg decreased, precisely when the amount of dry matter in the leaves decreased (fig. 2, table 2). Phosphorus content remained fairly constant. Contents of 4.3, 0.12, 1.8, 1.4, and 0.4% of N, P, K, Ca, and Mg, respectively, in the leaves about 6 months after planting indicated that fertilization was adequate.

After the first few months, the roots enlarged rapidly as they began to store carbohydrates, and their N, P, Ca, and Mg contents decreased, whereas their K content increased (table 5).

TABLE 3.—*Computations of fertilizer required by the cassava plant to produce near-maximum yields*

Nutrient	Total content of cassava plants	Released by the soil[1]	To be supplied from fertilizer	To be applied as commercial fertilizer[2]
		kg/ha		
N	204	68	136	272
P_2O_5	27	0	27	32
K_2O	267	68	199	249
MgO	55	15	40	50

[1] See text for details.

[2] Assuming losses of 50% N, 20% P_2O_5, and 25% K_2O and MgO from the fertilizer applied.

TABLE 4.—*Contents of dry matter and nutrients in different parts of the cassava plant*

Plant part	Nutrient					Dry matter
	N	P	K	Ca	Mg	
				kg/ha		
Leaves	34	2	15	6	2	650
Stems	118	5	97	72	22	10,478
Total plant residue	152	7	112	78	24	11,128
Roots (storage)	52	5	110	8	9	11,420
Total	204	12	222	86	33	22,548

RESUMEN

Los contenidos de los nutrimentos nitrógeno, fósforo, potasio, calcio y magnesio por la cultivar de yuca Llanera se determinó en un suelo Corozal arcilloso (Ultisol) a tres niveles de fertilidad. La mitad del abono se aplicó un mes después de la siembra, y el remanente 3 meses más tarde. Los tratamientos se compararon con un diseño de cuatro bloques completos.

Mensualmente, comenzando 3 meses después de la siembra, se cosechó una planta de cada parcela. Esta se dividió en hojas, tallos y raíces, determinándose los pesos verde y seco, y analizándose cada parte para distintos nutrimentos.

Los tres niveles de fertilidad no afectaron la producción de raíces

TABLE 5.—*Nutrient content of leaves, stems, and roots of cassava plants at different ages*

Age of plants	Leaves					Stems					Roots				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg	N	P	K	Ca	Mg
mo								%							
3	4.35	0.13	2.60	1.38	0.43	1.79	0.15	2.43	1.35	0.40	1.49	0.11	1.05	0.35	0.14
5	4.21	0.12	1.81	1.37	0.35	0.91	0.08	1.28	0.62	0.23	0.75	0.11	0.94	0.19	0.14
6	4.25	0.11	1.84	1.36	0.36	0.89	0.06	1.27	0.63	0.23	0.70	0.05	0.98	0.15	0.11
7	4.19	0.14	1.82	1.52	0.42	1.09	0.06	1.08	0.66	0.22	0.71	0.06	0.99	0.11	0.10
8	4.71	0.12	2.71	1.02	0.31	1.09	0.05	1.10	0.65	0.18	0.68	0.06	1.36	0.11	0.10
9	4.97	0.13	2.32	1.18	0.28	1.12	0.05	1.08	0.72	0.16	0.56	0.04	1.24	0.10	0.07
10	5.19	0.15	2.33	0.90	0.29	1.13	0.05	1.05	0.63	0.20	0.52	0.04	1.14	0.07	0.07

comerciales, que fue de 37.5 toneladas métricas/ha a los 10 meses de la siembra.

Las plantas llegaron a contener un máximo de 204, 12, 222, 86, y 33 kg/ha de nitrógeno, fósforo, potasio, calcio y magnesio, respectivamente.

Los contenidos de nitrógeno y potasio fueron altos, el de calcio intermedio y los de fósforo y magnesio bajos, durante todo el ciclo de crecimiento.

El contenido de materia seca en los tallos y raíces aumentó con la edad de las plantas, pero el de las hojas bajó señalamente después de los 6 meses, estabilizándose luego de los 8 meses. El contenido de nutrimentos fue siempre mayor en las hojas todo el tiempo.

Cálculos basados en el contenido de nutrimentos en la yuca, la cantidad de los mismos disponibles en suelos Ultisols típicos en Puerto Rico y las pérdidas de nutrimentos aplicados como abono, demuestran que para obtener rendimientos aproximadamente máximos de la yuca es necesario aplicar 272, 32, 249, y 50 kg/ha de N, P_2O_5, K_2O, y MgO, respectivamente, equivalentes a alrededor de 2,000 kg/ha de un abono comercial 14-2-13-3. Este abono debe aplicarse en dos partes iguales 2 y 6 meses después de la siembra. Los contenidos de 4.3, 0.12, 1.8, 1.4, y 0.4% de nitrógeno, fósforo, potasio, calcio y magnesio, respectivamente, en las hojas de yuca indicaron un nivel adecuado de abonamiento.

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