Deficiency Symptoms in Nutrient Pot Experiments with Cassava*

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INTRODUCTION

Cassava (*Manihot utilissima* Pohl) is an economic plant of which the center of origin in generally believed to be Brazil (6) and which has been used by indigenous residents of South America, Central America, and the Caribbean Islands since pre-columbian (4) times.

Cassava is widely used as a human food (10, 11) as well as for starch (3) and animal food (1, 5); secondary products include dextrins, alcohol, extenders, mucilages, and sizing.

Because it requires little care in planting and harvesting, and only two or three weedings per crop, it lends itself to small holder and peasant farming. It is highly drought resistant, suffers from no major diseases, and is infrequently bothered by insects. Through mechanization (7), large acreages can be planted efficiently and effectively.

Although widely grown in the West Indies for food and in Jamaica for laundry starch, little is known of its fertility requirements aside from the work in Brazil (8, 9). Because of the great potential of cassava in Caribbean agriculture and a lack of knowledge of its basic mineral nutrition, research was begun at the Federal Experiment Station, U. S. Department of Agriculture, Kingshill, St. Croix U. S. Virgin Islands, to determine the fundamental mineral nutrition requirements of cassava. This paper reports on the mineral-deficiency sympton phase of the research.

PROCEDURE

The cassava-deficiency studies were started on August 2, 1964 and harvested November 5, 1964, using the "Fowl Fat" variety of cassava.

All deficiencies were developed on plants grown in direct sunlight in sand culture using five-gallon, self-draining, glazed stone crocks filled with nutrient-free white quartz sand. First experiments in the

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partial shade provided by Saran cloth were not successful as the plants were etiolated and further work was carried out in full sunlight. The differential nutrient solutions used in this experiment are shown in Table 1. They were applied at the rate of two liters per crock twice a week to each of three replications. In between feedings, the sand was kept moist with de-ionized water. Cuttings about 6 inches long were planted, three per pot, and reduced to the one best plant when growth had begun. Measurements were made of growth at eight weeks; weights and color slides of the tops of the cassava were taken of each deficiency group when plants were harvested. Harvesting took place at twelve weeks due to technical reasons, and thus no root weights are available.

RESULTS

Growth and Yields

The effect of the various deficiency treatments on growth and yields is given in table 2. Both height and weight of plant were reduced drastically when nitrogen was omitted from the nutrient solution. Sligh reductions in height and yield were realized (Table 2) with the minus phosphorus and minus manganese theatments. All other deficiency treatments failed to reduce plant height or weight as compared to the complete treatment.

Internodal length (Table 2) was reduced greatly by the minus nitrogen treatment. Minus potassium and minus calcium treatments produced some reduction in the 3 to 4 internode growth, but not in the 7 to 8 internode.

PLANT ANALYSES

The results of the chemical analyses of the cassava plant grown under the various treatments are given in tables 3 and 4.

The nutrient content for a given element varies in the different parts of the cassava plant. Using the complete treatment as a guide, the leaf was highest in nitrogen content as compared to the petiole and stem; the stem was highest in phosphorus and potassium content; the petiole was highest in calcium and magnesium.

Considering the sensitivity to the deficiency nutrient treatments, the portion of the plant highest in a given element may not necessarily be most sensitive. Table 4 shows the relative percentage decreases or increases in nutrient content of the various parts of the cassava plant grown under various deficiency treatments as compared to the complete treatments. The leaf did not appear to be suitable for detection of any of the mineral deficiencies. The petiole showed lowest relative values for nitrogen, calcium, and magnesium; the stem was lowest for phosphorus and potassium. Cours *et al.* (2) reported the stem was more sensitive to a potassium deficiency than leaf or petiole. No tissue appeared to be especially sensitive to nitrogen deficiency in this study despite marked differences in growth. In fact the stem showed a slightly higher N content in the minus-nitrogen treatment as compared to the complete. This may be due to nitrogen accumulation caused by the poor growth of the plant. A similar high value was observed for potassium in the leaf (tables 3 and 4).

Visual Defficiency Symptoms

The deficiency symptoms described herein for cassava were developed under the experimental conditions and intensity of symptoms will probably be different in the field. However, the deficiency pattern will be the same, and thus the descriptions given should be useful in identifying nutrient deficiencies in field grown cassava. Visual deficiency symptoms were displayed in all treatments except minus phosphorus despite the fact that severe growth reduction was obtained only with the minus-nitrogen treatment and mild growth reductions with phosphorus and manganese.

Nitrogen

The leaf became lighter green in color in the earlier stages of the deficiency and plant growth was very poor in both height and size of leaves (see figure 1). In the later stages, where the deficiency was severe, there was almost a complete loss of green color giving a bright yellow color to the leaf. The oldest leaves were affected first.

Phosphorus

There were no signs of chlorosis in the leaf. Plant growth was only slightly reduced.

Potassium

The oldest leaves showed their symptoms first which began as a bronzing or purpling of the leaf. As symptoms became more severe, there was a marginal chlorosis. The minor influence on growth and high-leaf potassium values indicate that only a mild potassium deficiency was produced.

Calcium

There was a scorching of the leaf tip and the new leaves.

Magnesium

Chlorosis began on the older leaves first, as yellowing of the margin and tips of the leaf, and extended inward.

Sulphur

The leaves showed a lighter green color quite similar to a mild nitrogen deficiency. The leaf size was also reduced

Iron

The younger leaves displayed an interveinal chlorosis quite early in growth. Plant growth was not limited.

Manganese

All leaves showed an interveinal chlorosis. The chlorosis produced was similar to that for iron, but the background was more chlorotic; almost a pale green. The leaves were reduced in size.

Boron

The young leaves were slightly chlorotic and reduced in size; plants were dwarfed in their initial stages of growth.

SUMMARY

Cassava (*Manihot utilissima* Pohl) was grown in sand culture using nutrient solutions to develop deficiencies of nitrogen, phosphorus, potassium, magnesium, calcium, sulfur, iron, manganese and boron. The results were as follows:

1. Both height and weight of plant were severely reduced when nitrogen was omitted from the nutrient solution.
2. Plant analyses revealed that for the complete treatment the leaf was highest in nitrogen; the stem was highest in phosphorus and potassium; the petiole was highest in calcium and magnesium.
3. The leaf did no appear to be sensitive enough for detection of mineral deficiencies. The petiole showed lowest values for nitrogen, calcium, and magnesium; the stem was lowest for phosphorus and potassium.
4. Visual deficiency symptoms of lighter green color and poor growth were obtained for nitrogen deficiencies. Potassium deficiency was characterized by first a bronzing or purpling of the leaf followed by a marginal chlorosis. No visual symptoms were obtained for phosphorus deficiency.
5. Deficiency symptoms are also described for calcium, magnesium, sulfur, iron, manganese, and boron.

RESUMEN

A plantas de yuca (*Manihot utilissima* Pohl) cultivadas en arena se les suministraron soluciones nutritivas para inducir carencias de nitrógeno, fósforo, potasio, magnesio, calcio, azufre, hierro, manganeso y boro. Se obtuvieron los siguientes resultados:

1. La omisión de nitrógeno disminuó severamente la altura y el peso de las plantas.
2. Los análisis indican que los valores más elevados de nitrógeno foliar se obtuvieron con la solución nutritiva completa, mientras que

el tallo contenía los más elevados en fósforo y potasio; y el pecíolo los de calcio y magnesio.

3. Al parecer las hojas de estas plantas no eran suficientemente sensitivas para mostrar síntomas carenciales. El pecíolo arrojó los valores más bajos para nitrógeno, calcio y magnesio; y el tallo los más bajos para fósforo y potasio.

4. La carencia de nitrógeno se manifestó con un color verde claro y crecimiento pobre. Lo de potasio por un bronceado o una coloración purpúrea iniciales de las hojas seguidos por una clorosis de los bordes. El fósforo no mostró síntomas visuales.

5. También se describen los síntomas carenciales para calcio, magnesio, azufre, hierro, manganeso y boro.

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TABLE 1.—*Composition of nutrient solution used*

	Partial volume - molecular concentration of									Parts per million of				
Treatments	$Ca(NO_3)_2$	$MgSO_4$	KH_2PO_4	$CaCl_2$	NaH_2NO_4	$NaNO_3$	K_2SO_4	KNO_3	$Mg(NO_3)_2$	Fe Seque-strene	H_3BO_3	$MnSO_4$	$ZnSO_4$	$CuSO_4$
Complete	0.009	0.0045	0.0045							5	0.5	0.5	0.05	0.02
Minus N		.0045	.0045	0.009						5	.5	.5	.05	.02
Minus K	.009	.0045			0.0045					5	.5	.5	.05	.02
Minus P	.009	.0045					0.0023			5	.5	.5	.05	.02
Minus Ca		.0045	.0045		.0045			0.0045		5	.5	.5	.05	.02
Minus Mg	.009		.0045			.0045				5	.5	.5	.05	.02
Minus S	.009		.0045						0.0023	5	.5	.5	.05	.02
Minus Fe	.009	.0025	.0045							—	.5	.5	.05	.02
Minus B	.009	.0025	.0045							5	—	.5	.05	.02
Minus Mn	.009	.0025	.0045							5	.5	—	.05	.02

1. Chloride instead of the sulfate of the indicated element was used.

TABLE 2.—*Height, green weight of above ground portion, and internodal lengths of cassava plants grown under varying deficiency treatments*

Treatment	Above ground portion after 12 weeks		Internodal lenght 1/ after 8 weeks	
	Height In.	Weight Gm.	3-4 node In.	7-8 node In.
Minus N	9	8	0.6	1.0
Minus P	28	23	2.4	2.0
Minus K	38	34	1.7	2.3
Minus Ca	32	32	1.8	2.5
Minus Mg	40	44	2.8	2.8
Minus S	46	43	2.0	3.4
Minus Fe	40	39	2.0	2.3
Minus Mn	29	22	2.8	3.3
Minus B	33	32	2.7	3.5
Complete	32	29	2.6	2.5

1. Counting from growing point to the base.

TABLE 3.—*Mineral analyses of stem, leaf, and petiole from cassava plants grown under varying deficiency treatments.*

Treatment	Nutrient content of various portion of the cassava plant, percent dry weight basis				
	N	P	K	Ca	Mg
	LEAF				
Minus N	2.62	—	—	—	—
Minus P	—	0.20	—	—	—
Minus K	—	—	1.34	—	—
Minus Ca	—	—	—	1.83	—
Minus Mg	—	—	—	—	0.48
Complete	2.80	.25	1.27	2.23	.55
	PETIOLE				
Minus N	0.78	—	—	—	—
Minus P	—	.10	—	—	—
Minus K	—	—	1.18	—	—
Minus Ca	—	—	—	1.75	—
Minus Mg	—	—	—	—	.43
Complete	.86	.24	1.56	5.86	1.23
	STEM				
Minus N	.70	—	—	—	—
Minus P	—	.10	—	—	—
Minus K	—	—	1.07	—	—
Minus Ca	—	—	—	.37	—
Minus Mg	—	—	—	—	.09
Complete	.60	.36	1.92	.88	.17

TABLE 4.—*Relative percentage decrease or increase in nutrient content of various parts of the cassava plant grown under various deficiency treatments.*

		Relative decrease or increase for				
Treatment	Part of Plant	N	P	K	Ca	Mg
Minus element	Leaf	94	80	105	82	87
Complete		100	100	100	100	100
Minus element	Petiole	90	42	76	30	35
Complete		100	100	100	100	100
Minus element	Stem	117	28	56	42	53
Complete		100	100	100	100	100

Figure 1.