caribbean food crops society

19

Nineteen Annual Meeting
August 1983
PUERTO RICO

Vol. XIX

NUTRIENT UPTAKE BY FIVE INTENSIVELY MANAGED TROPICAL FOOD CROPS[1/]

Héber Irizarry, José Vicente-Chandler and Edmundo Rivera

SUMMARY

There is little information available on the uptake of nutrients by well managed tropical food crops, particularly as related to stage of growth. The present studies were carried out to provide this information which is important as a basis for the fertilization of five important food crops of the tropics. Entire plants of these crops growing at adequate levels of fertility were dug up at intervals over an entire cropping season, divided into leaves, stems, fruits and roots, dried, weighed and analyzed for N, P, K, Ca and Mg.

With intensive management, taniers (*Xanthosoma* spp.), cassava (*Manihot esculenta*), pigeon peas (*Cajanus cajan*), plantains (*Musa acuminata* x *M. balbisiana*), and yams (*Dioscorea rotundata*) under humid tropical conditions yielded 4.2, 10.5, 2, 8.0 and 51.6 metric tons/ha of edible dry matter, respectively.

Maximum uptake of nutrients in kg/ha by the crops were: Taniers = N - 125, P - 15, K - 156, Ca - 25; Cassava = N - 204, P - 12, K - 222, Mg - 33, Ca - 86; Pigeon peas = N - 216, P - 12, K - 168, Mg - 19, Ca - 54; Plantains = N - 275, P - 24, K - 569, Mg - 48, Ca - 136 and Yams = N - 190, P - 25, K - 215, Mg - 90, Ca - 35.

Edible dry matter produced per kg of NPK used by the plant was 11.9, 24.0, 14.2, 9.2 and 5.1 for yams, cassava, taniers, plantains, and pigeon peas, respectively.

INTRODUCTION

Taniers, tannias or cocoyams (*Xanthosoma* spp.), cassava (*Manihot esculenta*), pigeon peas (*Cajanus cajan*), plantains (*Musa acuminata* x *M. balbisiana*) and yams *Dioscorea* sp.) are major food crops of the tropics, yet there is litte information

---

1/ This paper reports work carried out cooperatively by the Agricultural Research Service, USDA, and the Agricultural Experiment Station, College of Agricultural Sciences, Mayaguez Campus, University of Puerto Rico, Río Piedras, P. R.

on the quantity of their nutrient uptake. This information is important in estimating the fertilizer requirement of these crops.

No references are available on the uptake of nutrients by taniers, a root crop, although Spencer and Ahmad (9) have described the deficiency symptoms exhibited by these crops grown in sand culture in relation to tissue composition. Oelsligle (7), in Costa Rica, found that well fertilized cassava plants yielding 43 T of tubers/ha removed a total of 367, 41 and 213 kg/ha of N, P and K, respectively. Dalal (3), in Trinidad, reported that total contents of N, P, K, Ca and Mg in pigeon peas (a leguminous shrub) yielding 5,280 kg of mature green pods/ha, were 198, 17, 53, 43 and 31 kg/ha, respectively. Lugo-López and Abrams (5) rationalized that a crop of pigeon peas yielding 7,800 kg/ha of mature green pods could remove from the soil 60, 15, 20, 20 and 10 kg/ha of N, P, K, Ca and Mg, respectively. Walmsley (12) in Trinidad, found that a plantain field with 3,000 plants/ha removed 314, 35 and 689 kg/ha of N, P. and K, respectively. Samuels et al. (9) in Puerto Rico, found that total uptake by plantains at harvest was 332, 22, 1,713, 210 and 56 kg/ha of N, P, K, Ca and Mg, respectively. Sobulo (10) found that yams growing on an unfertilized soil extracted 205, 13 and 112 kg/ha of N, P and K, respectively, with yields of 26.9 T/ha. Obigbesan and Agboola (6) found that yams took up a total of 148, 18, 166, 4 and 11 kg/ha of N, P, K, Ca and Mg, respectively, with yields of 37.9 T/ha.

In this investigation we determined nutrient uptake by intensively managed taniers, cassava, pigeon peas, yams and plantains that were grown with near optimum fertilization under humid tropical conditions in Puerto Rico.

MATERIALS AND METHODS

The experiments with cassava, pigeon peas, yams, and plantains were conducted at the Corozal Substation. Elevation is about 200 m above sea level. Average minimum and maximum temperatures are 19 and 30°C, respectively, and mean annual rainfall is 1,650 mm. The soil is Corozal clay (Aquic Tropudults) with a pH of 5.5 and containing 10 ppm of available P (Olsen method), 81 ppm of exchangeable K, 9.1 me of exchangeable Ca and 1.9 me of exchangeable Mg/100 g of soil.

The experiment with taniers was conducted at the Gurabo Substation. Elevation is about 80 m above sea level. Minimum and maximum temperatures are 17.5 and 30.5°C, respectively, and mean annual rainfall is 1,450 mm. The soil is Mabí clay (Vertic Eutropepts) with a pH of 6.6 and containing 6 ppm of available P, 156 ppm of exchangeable K, 16.4 me of exchangeable Ca and 16.3 me of exchangeable Mg/100 g of soil.

In all experiments, the soil was plowed and harrowed twice. Insects, diseases and weeds were controlled by following recommendations of the Puerto Rico Agricultural Experiment Station (1). During dry spells, 7.5 cm of water were applied every two weeks by sprinkler irrigation. Border rows and ditches surrounded all plots. All plots were limed to pH 5.5.

In all experiments, the indicated numbers of plants were dug at the specified intervals, divided into various sections as described later, and green and oven dry weights determined. We estimated, based on studies of the root system of these crops by Rivera et al. (8), that only about one third of total roots were recovered. Dry samples were ground, passed through a 20-mesh screen and analyzed for N by the macrokjeldahl method. After digestion with perchloric acid, P was determined colorimetrically, K by flame photometry and CA and Mg by the Versenate method (Cheng and Bray (2).

The experiment with taniers was started in May 1976: sections of corms weighing about 100 g were planted at 0.7 x 0.7 m in 15 x 45 m plots. A total of 100, 25, 125, and 12 kg/ha of N, P, K, and Mg, respectively, were applied divided into 3 equal applications at 2, 6 and 9 months after planting. Sixteen randomly selected plants were dug at monthly intervals, starting 3 months after planting. The plants were divided into corms, tubers, petioles, leaves and roots.

The experiment with pigeon peas was started in July 1980; seed of the determinate line 147, developed by the Puerto Rico Experiment Station, were planted every 30 cm in rows 90 cm apart. Plot size was 2,7 x 7.2 m and there were 6 replications. A total of 45, 22, and 37, kg/ha of N, P, and K, respectively, was applied 2 weeks after planting. Two randomly selected plants were uprooted from each plot (12 plants in all) every two weeks, starting 7 weeks after planting. The plants were divided into: leaf blades and petioles, stems, blossoms, pods, and roots.

The experiment with cassava was started in May 1980; stem cuttings of the Llanera cultivar were planted at 0.9 m spacing in ridges 1.2 meters apart. There were 4 replications and plot size was 3.6 x 7.2 m. A total of 50, 12, 83, and 9 kg/ha of N, P, K, and Mg, respectively, was applied in 2 equal applications 30 and 120 days after planting. Starting 60 days after planting, and monthly thereafter, one randomly selected plant from each plot (four plants in all) was uprooted, and divided into leaf blade and petioles, stems, and roots.

Irizarry et al. (4) started the experiment with plantains in December 1976; suckers were planted at 2 x 2 m in 15 x 15 m plots. A total of 200, 48, 332, and 48 kg/ha of N, P, K, and Mg, respectively, was applied divided in four equal applications 1, 4, 7 and 10 months after planting. Six randomly selected plants were dug monthly starting 4 months after planting, and divided into corms, pseudostems, leaf sheaths, petioles, bunches, and roots.

The experiment with yams was planted in June, 1981. Pre-germinated tuber sections weighing about 200 g each were planted 60 cm apart in rows 90 cm apart. A total of 224, 112, 448 and 67 kg/ha of N, P, K, and Mg, respectively, were applied in two equal applications 2 and 5 months after planting. Starting 2 months after planting and monthly, thereafter, eight plants were dug up and divided into leaf blades and petioles, vines and tubers.

RESULTS AND DISCUSSION

Nutrient Uptake

Rate of N uptake by cassava and pigeon peas was high during the early stages of growth and decreased with approaching maturity (Fig. 1). Uptake of N increased throughout the crop cycle of taniers and yams. Plantains used little N until about 6 months after planting, thereafter N was used at a faster rate.

Rate of K uptake by the various crops followed a pattern similar to that of N uptake (Fig. 2).

Maximum N uptake was lowest for taniers (125 kg/ha) highest for plantains (275 kg/ha) and intermediate for cassava, yams and pigeon peas (Table 1). Uptake of P was similar for cassava, taniers and pigeon peas at 12-15 kg/ha compared to 22-24 kg/ha for yams and plantains. Uptake of K was relatively low for taniers and pigeon peas (about 160 kg/ha) higher with cassava and yams and very high for plantains (569 kg/ha). Uptake of Mg was low for pigeon peas (19 kg/ha), moderate for cassava and yams and high for plantains (48 kg/ha). Uptake of Ca varied from 25 kg/ha for taniers to 136 kg/ha for plantains.

Growth Rate and Yields

Pigeon peas and yam had the fastest early growth rate and sustained this rapid rate until the crop was harvested. (Fig. 3). Cassava grew very slowly during the first 3 months and then maintained a rapid rate of growth until the crop was harvested about 10 months after planting. Taniers exhibited a moderate rate of growth throughout their life cycle. Plantains grew slowly during the first 4 months, developed at a moderate rate during about the next 4 months, and then grew at a fast rate until the crop was harvested.

Figures 4, 5, 6, 7 and 8 show monthly growth of the various parts of the tanier, pigeon pea, cassava, plantain and yam plants.

Yields were 15, 37,5, 8, 33 and 51.6 metric tons/ha for taniers, cassava, pigeon peas, plantains and yams, respectively.

Overall, average monthly total dry matter production in kg/ha for the different crops was: Taniers: 880, Plantains: 2,010, Cassava and yam: 2,250 and pigeon peas: 2,420.

The following tabulation shows yields of edible dry matter produced by four of the tropical food crops with the described intensive management as compared to corn with comparable management in the United States:

	Edible dry matter (kg/ha)	Edible dry matter Produced/month (kg/ha)
Taniers (12 months)	4,200	350
Plantains (15 months)	8,000	533
Cassava (10 months)	10,500	1,050
Yam (8 months)	18,000	2,250
Corn (4 months)	8,000	2,000

Yam produced highest yields of edible dry matter followed by cassava, corn and plantains, but on a monthly bases, yams produced more dible dry matter than did any of the other crops.

Efficiency of Fertilizer Use

The following tabulation shows the relative efficiencies of the tropical crops studied in using either (NPK) or N alone to produce edible dry matter:

Crop	Kg of edible dry matter produced/kg of	
	NPK	N
Yams	41.9	94.7
Cassava	24.0	51.4
Taniers	14.2	33.6
Plantains	9.2	29.1
Pigeon peas	5.1	9.3

Yams were most and pigeos peas least, efficient, in the use of either N, P and K or N alone, to produce edible dry matter.

The data presented provide a rational basis for fertilization of the four crops studied and show their relative efficiencies in the use of nutrients.

LITERATURE CITED

1. Anonymous, 1980. Control de Plagas de Importancia Económica en Puerto Rico, College of Agricultural Sciences, Mayaguez Campus, University of Puerto Rico.

2. Cheng, R. L, and Bray, R. H., 1951. Determination of calcium and magnesium in soil and plant material, Soil Sci. 72: 49-58.

3. Dalal, R. C., 1980. Nutrient element concentration and dry matter production by field grown pigeon peas (Cajanus cajan (L.) Millsp.) Trop. Agric. 57(2) 107-12.

4. Irizarry, H., Abruña, F., Rodríguez, J., and Díaz, N. 1981. Nutrient uptake by intensively managed plantains as related to stage of growth at two locations. J. Agr. Univ. P.R. 65(4): 331-45.

5. Lugo-López, M. A. and R. Abrams, 1981. High yields of nonfertilized protein-rich pigeon peas on tropical soils of low inherent fertility of Puerto Rico. An explanation of a paradox, J. Agr. Univ. P.R. 65(1): 21-28.

6. Obigbesan, S. O. and Agboola, A. A., 1978. Uptake and distribution of nutrients by yams (Dioscorea spp).in Western Nigeria Exptl Agriculture 14:349-355.

7. Oelsligle, D. C., 1975. Accumulation of dry matter, nitrogen, phosphorus and potassium in cassava (Manihot esculenta, Crantz). Instituto Interamericano de Ciencias Agrícolas, Turrialba (Costa Rica) 25(1): 85-87.

8. Rivera, E., Silva, S., and Vicente-Chandler, J., 1982. Distribution of Pigeon Peas, Cassava, Coffee and Grass Roots in an Ultisol. In Press. J. Agr. Univ. of P.R.

9. Samuels, G., A. Beale, and S. Torres, 1978. Nutrient content of the plantain (Musa AAB group) during growth and fruit production, J. Agr. Univ. P.R. 62(2): 178-85.

10. Sobulo, R. A., 1972. Studies in white yam (Dioscorea rotundata) II. Changes in nutrient content with age. Trop. Agric. 8:107-115.

11. Spencer, J. A., and Ahmad, N., 1967. Plant nutrient deficiencies and related tissues composition of Tannia, Proc. of Int. Symp. Trop. Root Crops 1:61-67.

12. Walmsley, D., 1974. Mineral nutrition of two plantain (Musa AAB group) cultivars of the French and Horn types. Proc. Caribbean Food Crops Society 12th Annual Meeting. Jamaica, W. I. 141-47.

Table 1 - Maximum uptake of nutrients by five tropical food crops grown with intensive management

Nutrient	Taniers	Cassava	Plantains	Yams	Pigeon Peas
	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
N	125 (54)[1/]	204 (52)	275 (88)	190 (134)	216 (101)
P	15 (5)	12 (5)	24 (10)	25 (22)	12 (3)
K	156 (85)	222 (110)	569 (229)	215 (160)	168 (54)
Mg	--	33 (9)	48 (15)	35 (25)	19 (3)
Ca	25 (6)	86 (8)	136 (13)	90 (18)	54 (6)

1/ Numbers in parenthesis show nutrient content in the marketable product.

Fig. 1.- Uptake of nitrogen by five intensively managed tropical food crops.

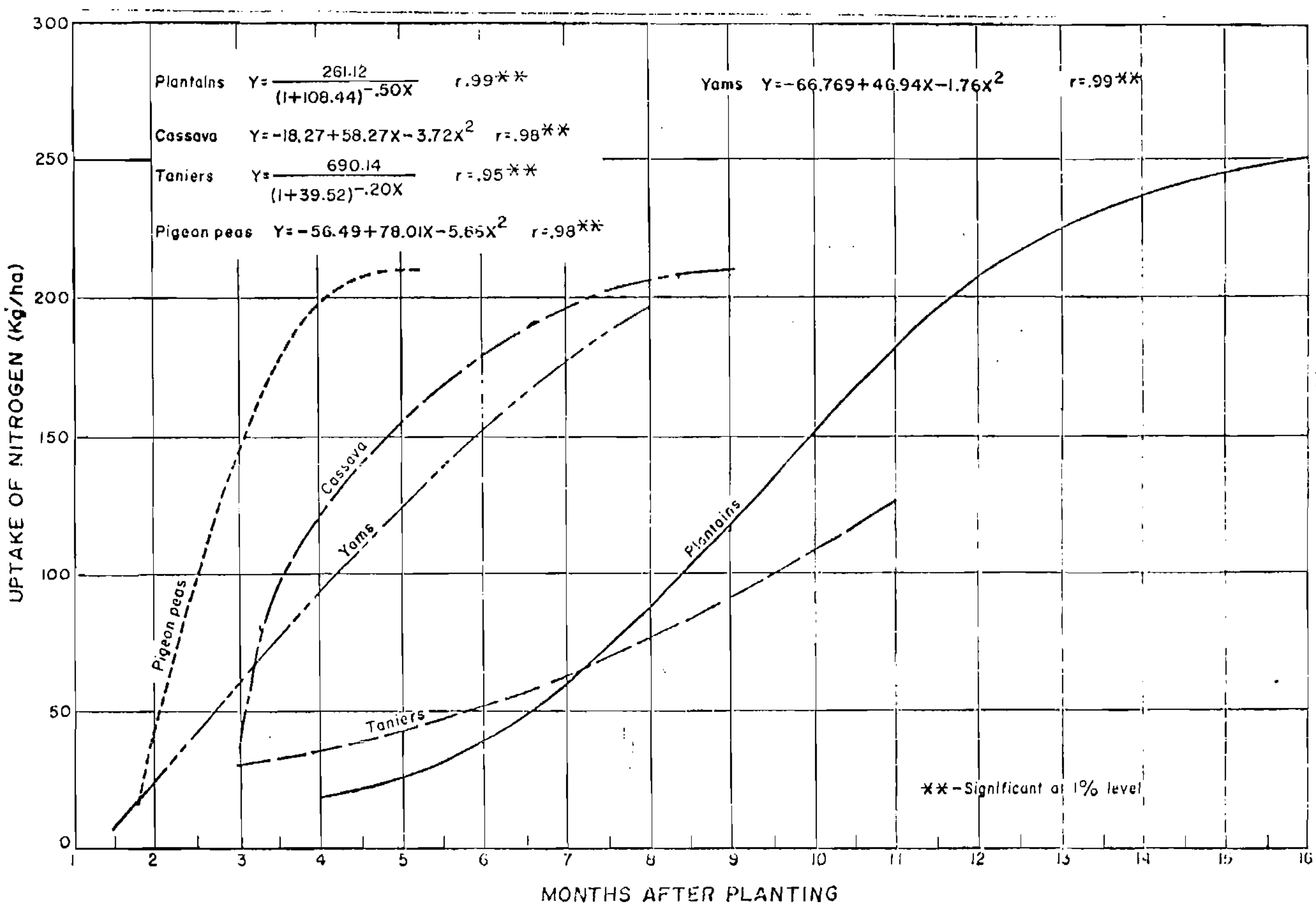

Fig. 2.- Uptake of potassium by five intensively managed tropical food crops.

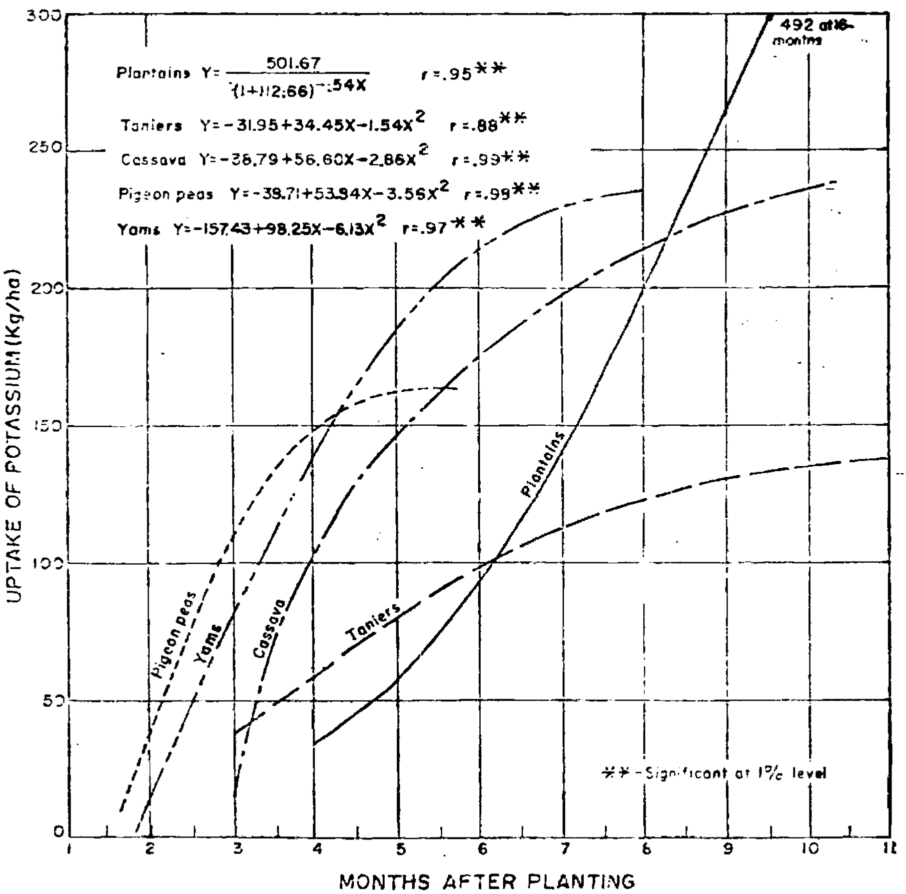

Fig. 5.- Growth rate of five intensively managed tropical food crops.

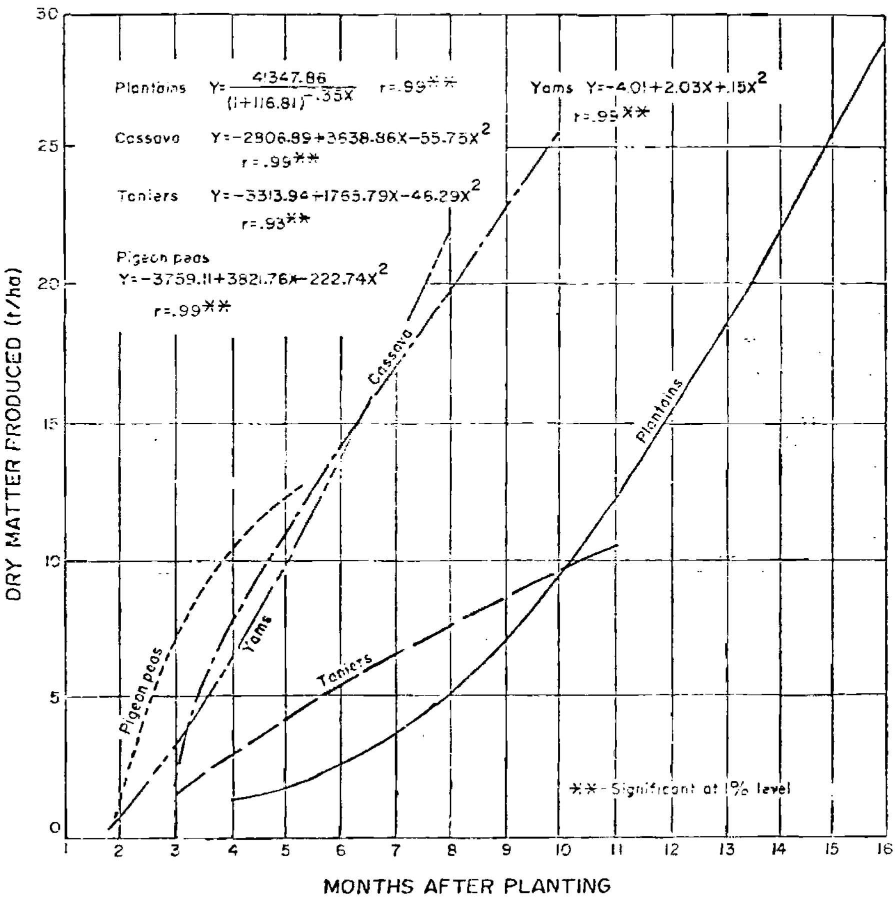

Fig. 4.- Growth rate of different parts of the tanier plant.

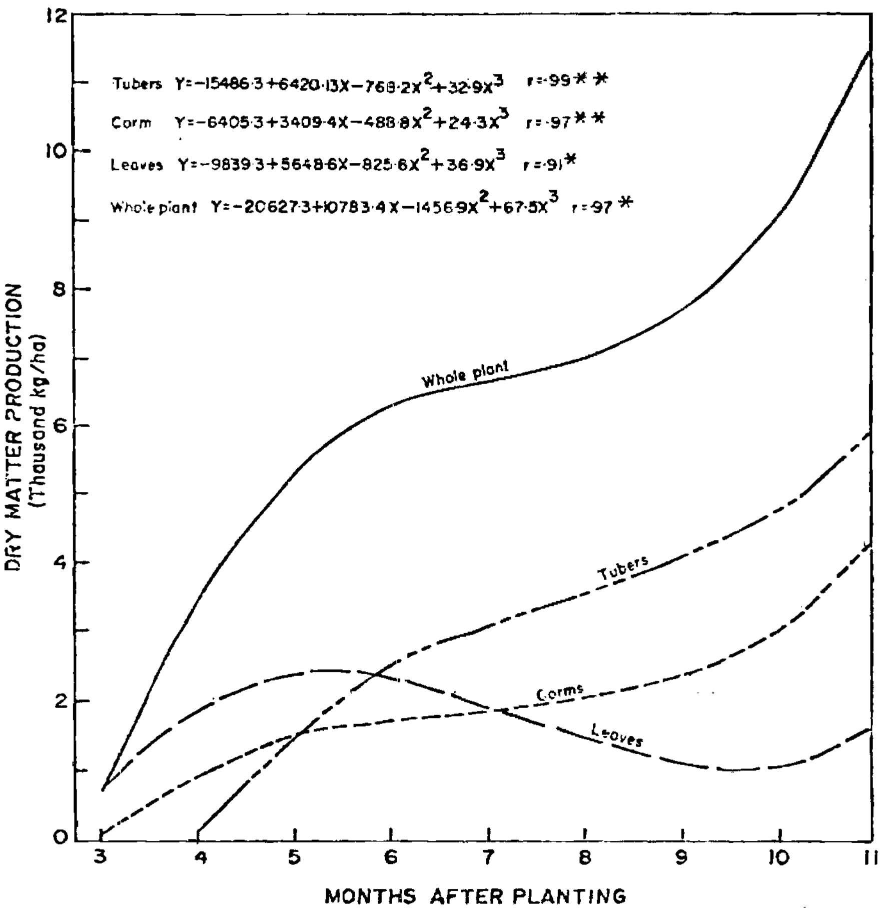

Fig. 5.- Growth rate of different parts of the pigeon pea plant.

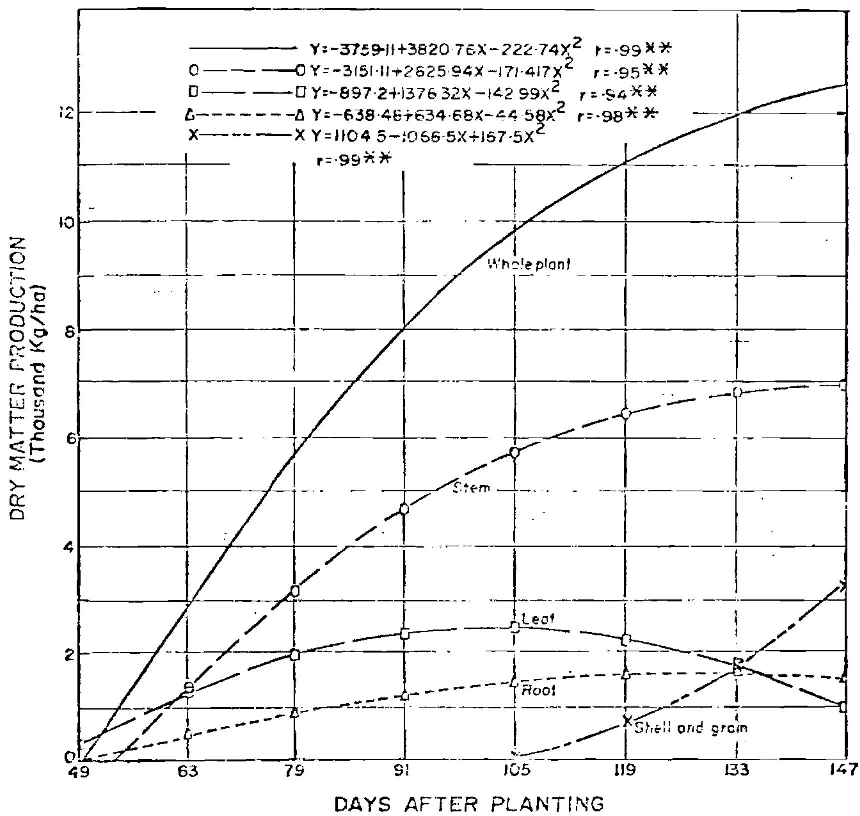

Fig. 6.- Growth rate of different parts of the cassava plant.

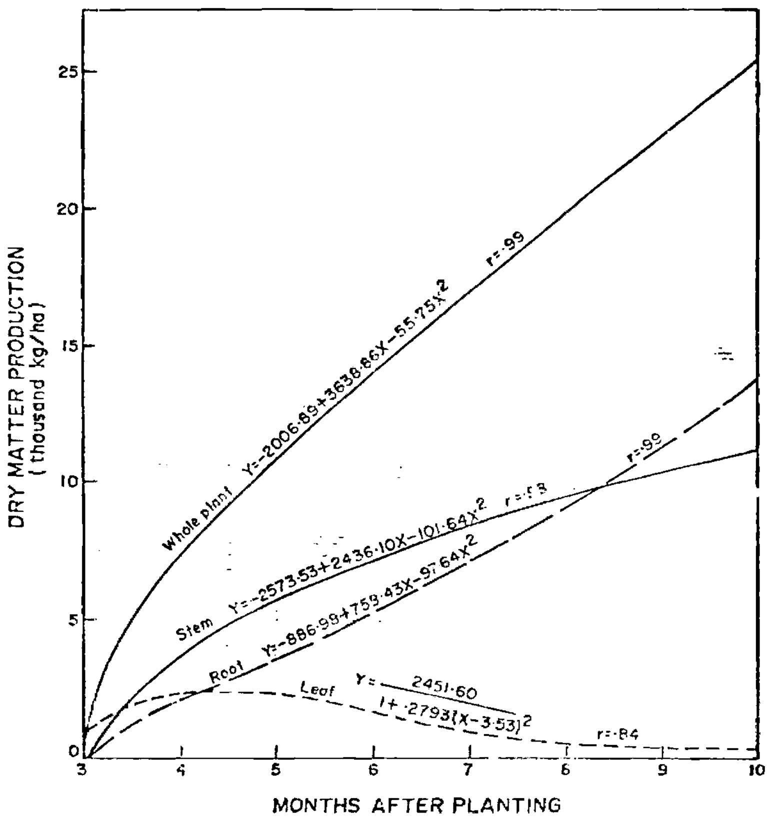

Fig. 7.- Growth rate of different parts of the plantain plant.

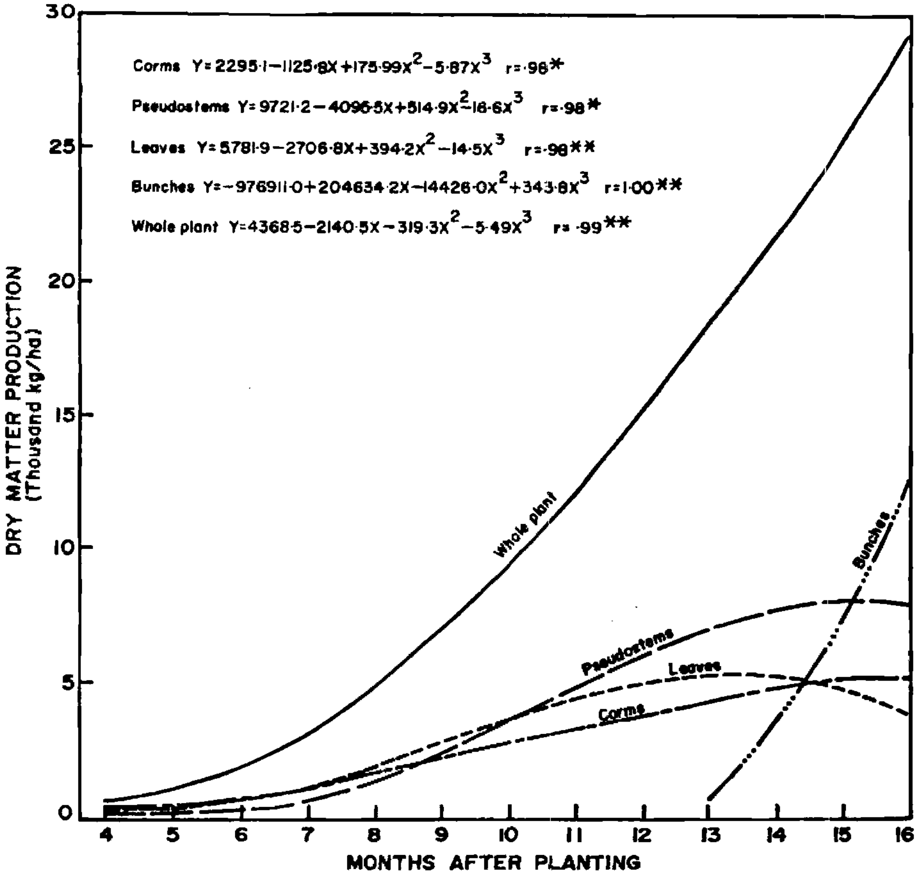

Fig. 8.- Growth rate of different parts of the yam plant.