Effect of Potassium on Tuber Yield and Nutrient Uptake of Yams

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The highest tuber yields of *D. cayenensis* and *D. rotundata* (var. aro) were produced using 30 kg K_2O/ha, whereas *D. alata* and *D. rotundata* (var. efuru) gave optimum performance with 60 kg K_2O/ha. Yield differences due to varieties were significant in both years of the experiment, but significant responses to K application were obtained only in the 1975 experiment at the farm site where the exchangeable soil K was 0.151 meq/100 g.

K fertilizations raised the percentage of marketable (ware) tubers of all species except *D. rotundata* (var. aro). There were also varietal differences in the crude protein (5.2–8.3%) and mineral nutrient content. Nitrogen and potassium constituted the major nutrients removed in large amounts. The average nutrient removal via the tuber ranged between 128 and 155 kg N, 16.9 and 19.4 kg P, and 155 and 184 kg P per hectare.

Yams, *Dioscorea* spp., constitute a major staple food in the African diet, and are of socioeconomic importance in the life of the growers. Despite the enormous labour requirements in land preparation, staking, and harvesting and the large quantity of planting material required for yam production (at least 2.5 t/ha) yams continue to be extensively grown in the tropics. Their popularity over other root crops like cassava, for example, may be ascribed to their high market value and the ease of their preparation.

Yam production is a multi-million Naira industry in Nigeria, which produces about half of the world's total supply on approximately 1.7 million ha (FAO 1974). Yam cultivation is done mainly by peasant farmers who have been advised by the Ministries of Agriculture to apply a complete fertilizer at the rate of 376 kg/ha for yam and all other crops (Anonymous 1962, 1963). However, it is essential to establish the response of yam varieties to fertilizers under different soil fertility levels, because earlier works (Obi 1959, Baker 1962, Sobulo 1972) did not give this sufficient attention. Our work investigated the performance of different yam varieties under different soil fertility levels.

Materials and Methods

Four commonly grown yams: *D. rotundata* (var. efuru); *D. rotundata* (var. aro); *D. alata* (water yam); and *D. cayenensis* (yellow yam) were obtained from the local market and planted as early yams on 19 December 1973 and 12 January 1975. The first experiment (1974) was conducted at the University of Ibadan farm on land that had not been continuously cropped for several years. Before ploughing and ridging, random soil samples were taken (0–15 cm) to establish the level of soil fertility. Planting was done on ridges 90 cm apart and at a spacing of 90 cm. A plot size of 3.6 × 6.4 m gave 40 plants/plot or about 17 285 setts/ha.

Potassium fertilizer was applied by band placement in trenches along the ridges and a few centimetres away from the yam setts at the rate of 0, 30, 60, 90, and 120 kg K_2O/ha as muriate of potash with basal dressing of 90 kg N and 60 kg P_2O_5/ha in the form of ammonium sulfate and superphosphate, respectively. The yam vines were staked, and weeded as required. The crops were harvested when most of the leaves had dried up.

Results

D. alata usually shed its leaves and dried up earliest, whereas *D. cayenensis* retained its leaves longest and matured last. In the 1975 experiment, there was a premature shedding of leaves, and all the *D. alata* plants dried out as early as July. The leaves showed characteristic insect damage symptoms, but leaf samples taken for microbiological examination revealed the causative agent to be *Cercospora.* The leaves of *D. rotundata* and *D. cayenensis* were resistant to this fungus. At harvest in 1975, some of the tubers of *D. rotundata* (var. efuru) were rotten, whereas tubers of *D. cayenensis* and *D. alata* were not affected.

Tuber Yields

At harvest, the tubers from each plot were weighed and separated into marketable (ware)

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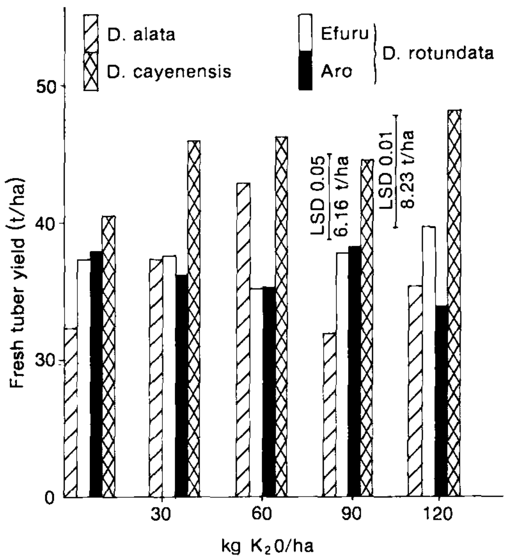

Fig. 1. Effect of K fertilization on tuber yields of yams (1974).

and nonmarketable yams. Figures 1 and 2 show the influence of K fertilization on tuber yields in 1974 and 1975, respectively. The 1974 crop gave a yield range of between 32.5 t/ha (*D. alata*) and 40.5 t/ha (*D. cayenensis*) without fertilizer, and between 43.0 t/ha (*D. alata*) and 46.5 t/ha (*D. cayenensis*) at the optimum fertilizer levels. *D. cayenensis* significantly outyielded the other species. Generally, response to K was rather low, with the best yield levels being obtained at rates of 30–60 kg K_2O/ha (Fig. 1).

Considerably lower tuber yields were obtained in the 1975 experiment. These low yields were probably due to the poorer nutrient status of the experimental site and *Cercospora* attack on *D. alata*. However, there was a generally significant response to K fertilizer with significant interactions among the varieties. As in the previous year's result (Fig. 1), *D. cayenensis* significantly outyielded the other species (Fig. 2).

Response to K in 1975 was rather inconsistent (except for *D. alata*) although there was a definite trend of yield increases due to K application. *D. rotundata* (var. aro) and *D. cayenensis* gave highest yields when fertilized at 30 kg K_2O/ha, *D. alata* at 60 kg K_2O/ha, and *D. rotundata* (var. efuru) at 90 kg K_2O/ha (Fig. 2). The differences between the mean yields from fertilizer treatments were significant.

An assessment of the percentage of waretubers from the 1975 harvest showed that increased K application appreciably improved the amount of marketable tubers. This indicates that K fertilization not only increases tuber yield but also the quantity of marketable produce.

Nutrient Removal

The average nutrient contents for the yam species are shown in Table 1. The data reveal that among the yam species, *D. alata* tubers without the peel had the highest crude protein (8.26%, on dry weight basis) and mineral content, whereas *D. cayenensis* had the lowest protein (5.19%) and lowest mineral content. The two varieties of *D. rotundata* (aro and efuru) also showed distinct differences in nutrient composition. The highest values were recorded for *D. rotundata* (var. efuru).

The nutrient levels obtained in this work are comparable to those reported by Ferguson (1969) who found that tubers of *D. alata* contained about 1.3% N (dry weight basis) and produced the lowest amount of dry matter (24.9%). The dry matter production of *D. rotundata* (var. efuru), *D. rotundata* (var. aro), and *D. cayenensis* was 32.9, 34.4, and

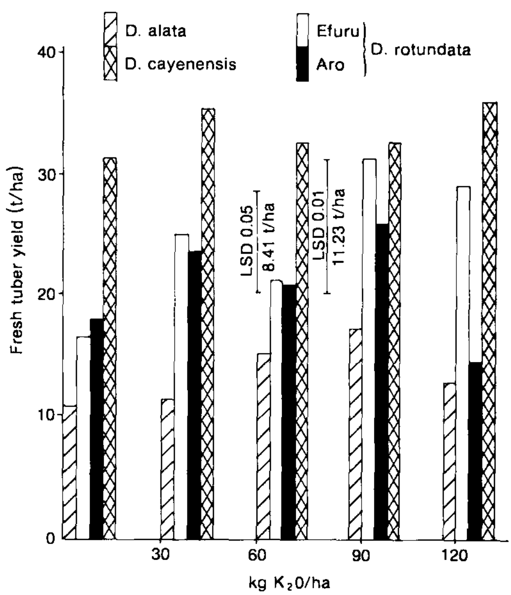

Fig. 2. Effect of K fertilization on tuber yields of yams (1975).

Table 1. Average nutrient content (mg/100 g tuber) of yams (dry weight basis).

Species	Portion analyzed	N	P	K	Ca	Mg
D. alata	unpeeled tuber	1.42	0.187	1.79	0.031	0.088
	peeled tuber	1.32	0.129	1.55	0.02	
D. rotundata	unpeeled tuber	1.28	0.150	1.45	0.032	0.088
(var. efuru)	peeled tuber	1.22	0.124	1.33	0.02	
D. rotundata	unpeeled tuber	1.15	0.148	1.27	0.028	0.092
(*var. aro*)	peeled tuber	1.12	0.130	1.17	0.015	
D. cayenensis	unpeeled tuber	0.91	0.127	1.19	0.025	0.086
	peeled tuber	0.83	0.098	0.93	0.015	

Table 2. Nutrient removal (kg/ha) through the tubers of the yam species.

Yam species	Average dry matter yield (kg/ha)	Average nutrient removal (kg/ha)				
		N	P	K	Ca	Mg
D. alata	9034	128.3	16.9	161.7	2.8	7.9
D. rotundata (var. efuru)	12133	155.3	18.2	175.9	3.9	10.7
D. rotundata (var. aro)	12197	140.3	18.1	154.9	3.4	11.2
D. cayenensis	15255	138.8	19.4	181.5	3.8	13.1

34.3%, respectively. The level of nutrient removal of the different species is presented in Table 2. Two major aspects are reflected in this table: (1) nitrogen and potassium are the most important nutrients removed from the soil and deposited in the tubers; and (2) yam species have different nutrient requirements. At the yield level of 13 716 kg tubers/ha (dry weight basis), *D. rotundata* (var. efuru) was estimated to remove as much as 175.6 kg N, 20.6 kg P, 198.0 kg K, 4.4 kg Ca, and 12.1 kg Mg per hectare — an equivalent of about 836 kg ammonium sulfate (21% N), 114 kg single superphosphate (18% P_2O_5), and 333 kg muriate of potash (60% K_2O) per hectare.

Discussion

Soil analysis showed that the K nutrient status of the 1974 experimental site was higher (exch. K = 0.218 meq/100 g) than that of 1975 (exch. K = 0.151 meq/100 g). This was probably the cause of the generally low and insignificant response to K fertilizer in 1974, whereas significant yield increases were obtained in 1975. Moreover, the 1974 experimental site was an area cleared from bush that had lain fallow (*Imperata* grass) for some years, while the farm site (1975 experiment) had been under continuous use for many years. It appears that yams will not respond to K fertilizer when the level of exchangeable K is greater than 0.15 meq/100 g soil on newly cleared land.

Our work agrees with the observations made by Heathcote and Stockinger (1970), in savanna areas of northern Nigeria, that cereal crops responded to K fertilizer when the exchangeable K fell below 0.2 meq/100 g soil and of Forde et al. (1966), in southern Nigeria, that the minimum requirements of oil-palms for exchangeable K was 0.10 meq/100 g soil.

Premature death of *D. alata* plants in July owing to *Cercospora* fungus attack indicates the differential susceptibility and resistance of the yam species. *D. cayenensis* with thicker cutinous foliage was not affected by the disease. Many of the tubers of *D. rotundata* (var. efuru) were prone to decay as a result of the high water table during the late rains of August–September 1975, whereas none of the tubers of *D. alata* was adversely affected.

Yield reduction, based on the 1974 crop, was least marked in *D. cayenensis* (26%) followed by *D. rotundata* (var. efuru) (37.7%) and *D. rotundata* (var. aro) (44%). In general, the mean yields obtained in both years were higher than the average of 16 113 kg/ha reported for *D. rotundata* by Sobulo 1972) at a similar planting time (Nov/Dec) but were comparable to those reported by Ferguson and Haynes (1970).

Besides being an important source of carbohydrate and the chief source of saprogenic precursors of cortisone (Martin and Ortiz 1963), yams provide much needed minerals in the diet. Table 2 shows that the tubers of *D. alata* were much richer in protein and mineral nutrients than the other yam species; the protein content of its peeled tuber (8.76%) was about 60% more than that of *D. cayenensis*; 18% more than that of *D. rotundata* (var. aro), and 8% greater than that of *D. rotundata* (var. efuru). Busson (1965) reported that the protein in the tuber of *D. alata* contained even higher amounts of essential amino acids than that of *D. cayenensis*. This is of significant interest to Nigerians who have a preference for using *D. alata* for making a much relished porridge called "Ikokore."

It is to be expected that continuous cultivation of yams in the same soil would rapidly deplete the soil of its nitrogen and potash reserves (Table 2). The danger might not be as imminent in soils derived from metamorphic parent material rich in K reserve, e.g. in the savanna zone of western Nigeria, as in soils of sedimentary origin, e.g. rainforest zone of southern Nigeria, which are known to be very low in potash (Smyth and Montgomery 1962).

Therefore, yam production in the rainforest zone of southern Nigeria requires a judicious application of N and K for high yields.

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Effect of Potassium and Sulfur on Growth, Yield, and Composition of Cassava

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Three field experiments were conducted in Colombia to investigate the differential effects of KCl and K_2SO_4 on cassava root yields. At Pance, where soil $SO_4^{=}$-S content was 9.0 ppm, there were no differences in yields between KCl and K_2SO_4 plots, but at Carimagua and Tranquero where soil $SO_4^{=}$-S content was 4.0–4.5 ppm, K_2SO_4 produced

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