SWEET POTATO (*IPOMOEA BATATAS*) FERTILIZER TRIALS ON THE GAZELLE PENINSULA OF NEW BRITAIN: 1954 - 1976

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ABSTRACT

The influence of fertilizer on sweet potato yields was examined in 17 field and 6 pot trials on a young volcanic soil. Nitrogen (N) had the greatest effect on yield and it gave large yield increases, especially at grassland sites. In three fertilized plantings of a block cropped continuously with sweet potato (Soil Exhaustion Trial), however, nitrogen depressed tuber yield. It is suggested that different responses to N were due to varietal differences. Nitrogen increased top growth in all trials where this was assessed.

Phosphate (P) improved top growth and yield in only a few trials. Negative responses to residual P occurred in most plantings of the Soil Exhaustion Trial. Large yield responses to applied and residual potash (K) fertilizer were recorded in the Soil Exhaustion Trial. Potassium did not affect top growth in any trial but it increased tuber number. No responses to other nutrients were recorded in field trials except a response to residual magnesium (Mg) in two plantings. In the pot trials there were top growth responses to N, P, K, Mg and manganese. Fertilizer (N-P-K or N-K) gave large yield increases in a rotation trial, especially in narrow rotations. A significant negative relationship was found between the magnitude of fertilizer responses and control yields.

Soil analyses, fertilizer placement and the economics of fertilization are discussed. Recommendations for fertilizers for sweet potato are made for both grassland and former forest areas.

INTRODUCTION

As well as being the most important subsistence crop in Papua New Guinea, sweet potato (*Ipomoea batatas* (L.) Lam.) is a significant cash crop. Large quantities are grown in both the highlands and lowlands for sale in the markets and to institutions. Because of its cash crop status, information on fertilizer requirements is needed.

Many sweet potato fertilizer trials have been conducted overseas and there is an extensive literature on the subject, much of it from the U.S.A. A precis of de Geus' (1973) review of the literature is as follows: Potash is generally considered a key factor in the fertilizer programme of sweet potato. A number of experiments have indicated that sweet potato does not require very large quantities of phosphate for root development, although yield increases due to phosphate application have been obtained. Many experiments have shown an appreciable yield increase resulting from nitrogen application. An excess of nitrogen should be avoided however because this may cause excessive top growth but a reduction in tuber yield. Yield responses to magnesium (Hester *et al.* 1951), to boron (Nusbaum 1947; Landrau and Samuels 1951), and to manganese (Anderson *et al.* 1962) have also been recorded.

The trials reported here were conducted on highly fertile, young, volcanic ash derived soils on the Gazelle Peninsula of New Britain. The soils vary somewhat from location to location. Nitrogen (N) is the main nutrient to which responses have been recorded on this soil type. Responses to N have occurred for a wide range of annual and perennial crops (Sumbak 1970; Byrne 1971; unpubl. data L.A.E.S.). Yield responses or deficiency symptoms have been recorded from a number of crops for sulphur (S), manganese (Mn) and magnesium (Mg). Sorghum has responded to phosphorus (P),

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Plate 1.— Fertilizer is applied to the soil surface in a band before ridging and planting

Plate 2.— Ridges are made over the fertilizer

potash (K) and copper (Cu) application and foliar deficiency symptoms in citrus have been alleviated by zinc (Zn) application.

This paper reviews 17 field and 6 pot trials most of which have not previously been reported in published form. The present author conducted 13 of the field trials. The other 4 field trials and the pot trials were conducted by previous staff L.A.E.S. (Lowlands Agricultural Experiment Station, Keravat, East New Britain) (see Acknowledgements). The trials are considered as three groups. These are general trials, the Keravat Soil Exhaustion Trial and the Keravat Rotation Trial.

I GENERAL TRIALS

Seven trials were conducted in various locations on the Gazelle Peninsula, three in grassland areas and four in former forest areas. Five of the trials were NPK factorials.

MATERIALS AND METHODS

Trial Sites

The Trial 1 site had been cropped with sweet potato for many years and soil fertility was considered very low. The Trial 2 area had also been gardened for many years. Part of the area was covered in *Sorghum propinquum* and part with *Pueraria phaseoloides* and *Mimosa invisa*. Two sorghum crops preceded the trial. Trials 3 and 4 were situated in nearby areas which had been under gardens and fallows for many years. Kunai grass (*Imperata cylindrica*) and *Sorghum propinquum* were the dominant species at the two sites respectively. Trial 5 was also in a kunai grassland area which had been used for gardens occasionally.

Trials 6 and 7 were in former forest areas. The Trial 6 site had been under various root crops for five years prior to the trial. The Trial 7 site had been used for gardens and fallows for many years. A short term fallow of volunteer sweet potato with some cassava and *Sorghum propinquum* preceded the trial. The area had been gardened continuously for at least three years prior to this.

Trial details

Trial design, fertilizer application (*Table 1*) and treatment of vegetation varied from trial to trial. For Trial 2, the sorghum was slashed and turned under. At the grassland sites (Trials 3, 4, 5) the grass was slashed and burnt. For Trials 6 and 7 previous crop residues were removed prior to cultivation.

Ridges were used for all trials except Trial 7 where mounds were used. Ridges and mounds were formed with hand hoes and were some 25 cm in height. Ridges were triangular in cross section. Mounds were about 50 cm across at the base. A single row of cuttings was planted in the ridges with one, two or three cuttings per planting position. For Trials 2 to 7, fertilizer was applied to the soil in a band before planting and the ridge or mound built over it (*Plates 1* and *2*). Urea or ammonium sulphate provided nitrogen, and superphosphate and muriate of potash provided phosphate and potash respectively. Guard rows were used for Trials 1 and 2.

Soil samples were collected for chemical analysis from Trials 4, 5 and 6. One sample was collected per plot between soil cultivation and planting and the samples were bulked to give a composite sample per trial.

RECORDINGS

Top growth vigour and colour were assessed visually for Trials 2 to 7. Scores for vigour and colour were allocated to each plot on a 0 to 10 scale, higher scores indicating greater vigour or colour. Results for vigour and colour for all trials, including the Soil Exhaustion and Rotation Trials, were analysed using the X^2 test for independence. For Trials 2 to 7 tubers were classified as saleable on the basis of size, and saleable yield recorded as well as total yield. Tubers longer than 10 cm and with a diameter of over 5 cm were classed as saleable in Trials 2 and 3. For Trials 4 to 7 the critical size was reduced, and tubers more than 140 g in weight were considered saleable. This classification approximates to that used by local farmers.

Table 2.— **Soil Analysis, 0 - 30 cm. Trials 4, 5, 6**

Parameter	Trial 4	Trial 5	Trial 6
Nitrogen %	.47	.26	.40
Carbon %	5.6	3.2	3.8
C/N ratio	11.9	12.1	9.6
Olsen P p.p.m.	6.3	35.2	34.5
Exch. Ca m.e.%	13.1	18.5	32.5
Exch. Mg m.e.%	3.1	3.8	4.0
Exch. K m.e.%	1.7	>3.0	>3.0
Exch. Na m.e.%	1.2	1.1	1.0
Cation exchange capacity m.e.%	22.2	24.6	35.4
pH	5.9	6.4	7.0
Specific conduc. mhos x 10^3	.069	.068	.120
Total soluble salts	.021	.020	.036
K/N ratio	3.5	>11.5	>7.6

Table 1. — **Details of general trials**

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**	**Trial 6**	**Trial 7**
Location	L.A.E.S., Keravat	L.A.E.S., Keravat	Vunadidir Village	Vunadidir Village	Palnakiau Village	Sonoma College	George Brown High School
Original vegetation	Forest	Forest	Grassland	Grassland	Grassland	Forest	Forest
Experimental design	2^4 factorial in an 8 x 8 quasi-latin square design	3 x 3 x 5 factorial with 2 replicates	3 x 3 x 4 factorial	½ replicate of 4^3 factorial with 2 blocks	½ replicate of 4^3 factorial with 2 blocks	½ replicate of 4^3 factorial with 2 blocks	Randomized blocks. 3 treatments, 5 replicates
Treatments	2N x 2P x 2Ca x 2 minors	3N x 3P x 5K	3N x 3P x 4K	4N x 4P x 4K	4N x 4P x 4K	4N x 4P x 4K	1. $N^0P^0K^0$ 2. $N^1P^1K^1$ 3. $N^2P^2K^2$
Levels (kg N/ha) and form of N	0, 25 A/S (1)	0, 45, 90 Urea	0, 45, 90 Urea	0, 45, 90, 135 A/S	0, 45, 90, 135 A/S	0, 45, 90, 135 A/S	0, 50, 100 A/S
Levels of P (kg P/ha)	0, 10	0, 25, 50	0, 25, 50	0, 25, 50, 100	0, 25, 50, 100	0, 25, 50, 100	0, 15, 30
Levels of K (kg K/ha)	(2)	0, 93, 186, 372, 744	0, 93, 186, 372	0, 90, 180, 360	0, 90, 180, 360	0, 90, 180, 360	0, 85, 170
Plot size (m)	4.8 x 4.8	9.1 x 4.3	9.1 x 4.3	9 x 4	9 x 4	9 x 4	5.5 x 4.5
Variety	K1	V23	V23	V23	V23	V23	V2
Between row and within row spacing	1.2 m, 30 cm	1.1 m, 30 cm	1.1 m, 30 cm	1 m, 30 cm	1 m, 30 cm	1 m, 30 cm	(3)
Planting density (cuttings/ha)	81,000	62,000	62,000	67,000	67,000	67,000	30,000
Planting date	9/11/1954	16/9/1971	17/11/1971	8/5/1973	3/4/1973	9/4/1973	16/4/1974

(1) A/S = Ammonium sulphate

(2) No K treatment. Other treatments were Ca and Mg applied as dolomite at 0, 63 kg/ha and minor elements (Fe, Mn, Zn, Cu, B, Mo) at 0, 63 kg/ha.

(3) Mounds not ridges used

TABLE 3. — **Visual top growth vigour assessments. Main effect means. Trials 2 - 6. On a 0 - 10 scale, higher scores indicate greater vigour.**

Treatment	Trial 2 12 weeks	Trial 3 12 weeks	Trial 4 8 weeks	Trial 5 8 weeks	Trial 6 8 weeks
N^0	8	8	4	4	7
N^1	9	8	5	5	8
N^2	9	9	5	7	9
N^3			5	8	8
P^0	9	8	5	6	8
P^1	8	8	5	6	8
P^2	9	9	5	7	8
P^4			5	6	8
K^0	8	8	5	6	8
K^1	9	9	5	6	8
K^2	9	8	5	6	8
K^3	9	8	5	6	8
K^4	9				
Significant effects	N (0.001) P (0.05)	N (0.01)	N (0.01)	N (0.001)	—

TABLE 4. — **Visual top growth colour assessments. Main effect means. Trials 2 - 6. On a 0 - 10 scale, higher scores indicate greater colour.**

Treatment	Trial 2 12 weeks	Trial 3 12 weeks	Trial 4 8 weeks	Trial 5 8 weeks	Trial 6 8 weeks
N^0	7	8	7	7	8
N^1	8	8	8	7	8
N^2	9	9	8	8	9
N^3			9	9	9
P^0	8	8	8	8	9
P^1	8	9	8	7	8
P^2	8	9	8	8	9
P^4			8	8	8
K^0	8	8	8	8	9
K^1	8	8	8	7	8
K^2	7	9	8	8	8
K^3	8	8	8	8	8
K^4	8				
Significant effects	N (0.01)	N (0.05)	N (0.01)	N (0.01)	—

TABLE 5.— **Total tuber yield (kg/ha). Main effect means. Trial 1**

Treatment	Yield
N^0	25,200
N^1	25,200
P^0	25,100
P^1	25,200
Ca^0/Mg^0	24,500
Ca^1/Mg^1	25,900
$Minors^0$	25,300
$Minors^1$	25,100
Significant effect	—
L.S.D. (0.05)	2,100

TABLE 7. — **Saleable tuber yield, visual top growth vigour and colour assessments. Trial 7**

Treatment	Saleable tuber yield (kg/ha)	Visual top growth assessment 8 weeks on a 0 - 10 scale	
		vigour	colour
Control	4,100 a	9	9
$N^1P^1K^1$	5,200 ab	9	9
$N^2P^2K^2$	5,900 b	10	9
Level of significance	0.05	0.001	N.S.
L.S.D. (0.05)	1,200	—	—

Yield values followed by the same letter are not significantly different at p = 0.05.

TABLE 6.— **Saleable tuber yields (kg/ha). Main effect means. Trials 2, 3, 4, 5, 6**

Treatment	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
N^0	18,100	6,900 a	6,900 a	4,900 a	18,000
N^1	18,400	10,100 b	9,900 ab	7,200 ab	20,200
N^2	18,200	11,700 b	11,300 bc	7,200 ab	20,500
N^3			14,200 c	10,100 b	20,500
P^0	16,500 a	9,500 ab	10,500	6,000	19,100
P^1	19,900 b	8,000 a	0,100	8,200	19,000
P^2	18,300 ab	11,300 b	10,600	8,000	20,500
P^4			11,200	7,000	20,700
K^0	18,700	9,900	9,300	8,400	19,600
K^1	18,200	10,700	8,700	6,400	20,200
K^2	17,700	9,800	12,100	7,800	21,800
K^3	19,500	8,000	12,300	6,500	17,700
K^4	17,100				
Significant effects	P (0.01)	N (0.001) P (0.05)	N (0.01)	N (0.05)	—
L.S.D. (0.05) N or P	2,000	2,300	3,400	3,400	3,400
L.S.D. (0.05) K	2,600	2,700	3,400	3,400	3,400

For significant treatments, values in columns for each nutrient followed by the same letter are not significantly different at P = 0.05.

RESULTS

Soil analysis from the Trial 4, 5 and 6 sites showed that all three soils were well supplied with nutrients although N was low at the Trial 5 site (*Table 2*). The carbon/nitrogen (C/N) ratio was moderately high for Trials 4 and 5, indicating that nitrogen unavailability was possible for the Trial 4 site and likely for the Trial 5 site (D.W.P. Murty, pers. comm.).

Top growth vigour and colour were significantly improved by nitrogen for Trials 2 to 5 (*Tables 3, 4*). Phosphate fertilizer significantly improved top growth vigour early in Trial 2 and colour early in Trial 3. Potassium had no significant effect on top growth. Fertilizer significantly improved vigour in Trial 7 (*Table 7*). It was observed that weeds were more vigorous in high N plots for Trials 4 and 5.

In Trial 1, yield levels were high and fertilizer did not significantly influence total tuber yield (*Table 5*). Large significant responses to N occurred for the three grassland sites (Trials 3, 4 and 5). An apparent N response in Trial 6 was not statistically significant. Significant responses to P were recorded for Trials 2 and 3, although in Trial 3 the result was not clear, as the P^1 yield was less that P^0, and the significance lay in the difference between P^1 and P^2. Potassium had no effect on yield except for a possible but non-significant response in Trial 4 (*Table 6*). A significant response to $N^2P^2K^2$ occurred for Trial 7 (*Table 7*).

Cracking of tubers was observed to be more severe than normally experienced in Trials 3, 5 and 6. Cracked tubers were weighed for Trials 4 and 5 and assessed for Trial 6. The percentage of cracking was not related to fertilizer treatments except for Trial 5 where potassium significantly reduced the percentage of cracked tubers from 30% at K^0 to 20% at K^4 ($p = 0.05$).

II SOIL EXHAUSTION TRIAL

In 1954 a soil exhaustion trial was laid down at Keravat on an area formerly under forest. The aim was to exhaust the soil with continuous cropping of sweet potato and then investigate the fertilizer requirements for sweet potato yield restoration to the original levels (Newton and Jamieson 1968). Eight fertilizer trials have been conducted on the trial site, six with sweet potato and two with sorghum. The sweet potato fertilizer trials are reported here. No fertilizer was used at any planting other than those plantings involving fertilizer trials.

There were 10 sweet potato plantings in the first 6 years of the trial. The 11th and 12th plantings were used for fertilizer trials and these were followed by another 4 plantings without fertilizer. The 17th planting was used for another fertilizer trial. Sorghum fertilizer trials were conducted on the site after the 19th and 25th plantings. The 26th, 30th and 31st plantings were also used for sweet potato fertilizer trials.

MATERIALS AND METHODS

The Soil Exhaustion Trial contained 64 plots each 4.6 m square. Plot size varied slightly for certain plantings. In the 30th and 31st plantings a growth analysis study was performed. Data presented here for these two plantings is from the final sampling at 22 weeks. Plot size for this sampling was 3.6 m x 2.7 m. Trial design, treatments, and variety varied for the different fertilized plantings (*Table 8*). Ridges were used for all plantings and guard rows were used in the latter three fertilized plantings. The method of fertilizer application varied from planting to planting. In the 11th planting the ridges were formed to a height of 10 cm, the fertilizer applied to the top of the ridges and then ridging was completed. For the 12th planting fertilizer was applied in three applications, 4, 9 and 23 weeks after planting. For the 17th planting all fertilizer except superphosphate was split into four applications and was applied at 5, 10, 15 and 20 weeks after planting. Phosphorus was applied at 5 weeks only. Fertilizer was applied to the soil surface and ridges built over it for the 26th, 30th and 31st plantings.

Treatments in the fertilizer trial at the 12th planting were the same as in the 11th planting and were applied to the same plots. For the 17th planting phosphate treatments were applied to the same plots as for the 11th and 12th plantings while other treatments were re-randomized. Treatments were completely re-randomized for the 26th planting and again for the 30th planting. Treatments and plots for the 31st planting were identical to those for the 30th. Gypsum was applied to P^0, P^1 and P^2 plots in the 17th planting to bring calcium and sulphur levels to a uniform rate on all plots. A basal dressing of elemental sulphur was applied to all plots at 60 kg/ha in the 26th planting.

Soil samples were collected from each plot for 0 to 30 cm depth, mixed to give a plot sample and analysed at various times during the trial. Top growth vigour and colour were assessed visually during the 12th, 17th and 26th plantings by allocating a score to each plot. Scores have been converted to a 0 to 10 scale. The weight of top growth at harvest was recorded for the 17th, 26th, 30th and 31st plantings and number of tubers for the 17th, 30th and 31st plantings.

A fertilizer pot trial was conducted on soil collected prior to the 11th planting. Between the 12th and 17th plantings, five fertilizer pot trials were conducted in a shadehouse (D.A.S.F. 1965).

RESULTS

Soil analyses

Values of most parameters have declined with time, particularly between the 17th and 20th samplings. Exchangeable K has shown the greatest decrease (*Table 9*).

TABLE 8.— **Soil Exhaustion Trial. Details of fertilized plantings**

	11th planting	12th planting	17th planting	26th planting	30th planting	31st planting
Experimental design	½ replicate of 4^2 x 2^3 factorial in four blocks	½ replicate of 4^2 x 2^3 factorial in four blocks	¼ replicate of 4 x 2^6 factorial in four blocks	¼ replicate of 4^2 x 2^4 factorial in two blocks	4 x 4 factorial with four replicates	4 x 4 factorial with four replicates
Treatments	4N x 4P x 2Fe x 2Zn x 2Minors (Mn,Cu,B,Mo,Co)	4N x 4P x 2Fe x 2Zn x 2Minors (Mn,Cu,B,Mo,Co)	2N x 4P x 2K x 2Mg x 2Mn x 2Cu x 2Minors (Fe,Zn,B,Mo)	4N x 2P x 4K x 2Mg x 2Cu x 2Mn	4N x 4K	4N x 4K
Nutrient levels (kg element/ha) and form						
N	0,55,110,220 Urea	0,55,110,220 Urea	55,220 Urea	0,20,40,80 Urea	0,75,150,225 Urea	0,75,150,225 Urea
P	0,50,100,200 Superphosphate	0,50,100,200 Superphosphate	0,12,25,50 Superphosphate	0,20 Monosodium phosphate	—	—
K	—	—	0,90 Muriate of potash	0,41,83,166 Muriate of potash	0,125,250,375 Muriate of potash	0,125,250,375 Muriate of potash
Mg	—	—	0,22 Magnesium sulphate	0,30 Magnesium chloride	—	—
Fe	0,6 Ferrous sulphate	0,6 Ferrous sulphate	0,6 Ferrous sulphate	—	—	—
Zn	0,7 Zinc sulphate	0,7 Zinc sulphate	0,11 Zinc sulphate	—	—	—
Mn	0,6 Manganese sulphate	0,6 Manganese sulphate	0,6 Manganese sulphate	0,10 Manganese chloride	—	—
Cu	0,4 Cupric sulphate	0,4 Cupric sulphate	0,6 Cupric sulphate	0,10 Copper oxychloride	—	—
B	0,3 Boric acid	0.3 Boric acid	0,1 Boric acid	—	—	—
Mo	0,0.6 Ammonium molybdate	0,0.6 Ammonium molybdate	0,0.03 Sodium molybdate	—	—	—
Co	0,3 Cobalt sulphate	0,3 Cobalt sulphate	—	—	—	—
Variety	K1	K1	K1	K9	K9	K9
Between and within row spacing	1.2 m, 30 cm	1.2 m, 30 cm	1.2 m, 30 cm	90 cm, 30 cm	90 cm, 30 cm	90 cm, 30 cm
Planting density	81,000	81,000	81,000	72,000	37,000	37,000
Planting date	26/4/1960	24/11/1960	16/5/1964	22/11/1972	28/8/1974	10/2/1975

TABLE 9. — **Soil Exhaustion Trial. Soil analysis, 0 - 30 cm**

Parameter	1st sampling	13th sampling	17th sampling	20th sampling
Sampling date	early 1954	June, 1961	June, 1964	January, 1971
Planting	Prior to 1st planting	After 12th planting	Prior to fertilizer application, 17th planting	After 25th planting
Nitrogen %	.47	.47	.46	.21
Carbon %	4.9	4.4	4.3	1.9
C/N ratio	10.6	9.5	9.1	8.7
Olsen P p.p.m.	8.0	10.8	27.2	12.7
Exch. Ca m.e.%	17.5	16.8	15.7	8.9
Exch. Mg m.e.%	1.8	2.3	1.6	.8
Exch. K m.e.%	1.2	.6	.7	.3
Exch. Na m.e.%	—	.91	.46	.23
Cation Exchange Capac. m.e.%	19.9	20.3	21.5	12.1
pH	6.8	6.3	6.6	5.7
Specific conduct. mhos x 10^3	.083	.170	.239	.020
Total soluble salts %	—	—	—	.006
K/N ratio	2.5	1.4	1.6	1.4

TABLE 10. — **Soil Exhaustion Trial. Visual top growth vigour and colour assessments. Main effect means. Using a 0 - 10 scale with higher scores indicating greater vigour and colour. 12th, 17th, 26th plantings**

Treatment	Top growth vigour			Top growth colour	
	12th planting 10 weeks	17th planting 20 weeks	26th planting 7 weeks	17th planting 20 weeks	26th planting 7 weeks
N^0	1	6	6	8	5
N^1	5		7		6
N^2	6		8		8
N^4	10	9	9	10	9
P^0	6	8	7	9	7
P^1	6	8	8	8	7
P^2	5	8		9	
P^4	5	8		8	
K^0		8	7	9	7
K^1		8	8	9	8
K^2			8		7
K^4			7		7
Mg^0		8	8	9	7
Mg^1		8	7	9	7
Mn^0		8	8	9	7
Mn^1		8	7	9	7
Cu^0		8	7	8	7
Cu^1		8	8	9	7
$Minors^0$		7		9	
$Minors^1$		8		9	
Significant effects	N (0.001)	N (0.001)	N (0.001)	N (0.001)	N (0.001)

TABLE 11. — **Soil Exhaustion Trial. Weight top growth at harvest (kg/ha). Main effect means. 17th, 26th, 30th, 31st plantings**

Treatment	17th planting	26th planting	30th planting	31st planting
N^0		5,700 a	3,400 a	3,900
N^1	16,000 a	6,600 ab	5,100 b	6,000
N^2		7,500 b	5,200 b	5,600
$N^{3/4}$	24,000 b	9,900 c	7,200 c	6,700
P^0	21,100	7,300		
P^1	19,200	7,600		
P^2	20,400			
P^4	19,100			
K^0	19,300	7,600	5,400	6,100
K^1	20,600	8,100	5,300	5,300
K^2		7,500	5,200	5,800
$K^{3/4}$		6,500	5,000	5,100
Mg^0	20,500	7,200		
Mg^1	19,400	7,700		
Mn^0	19,700	7,500		
Mn^1	20,300	7,400		
Cu^0	19,300	7,400		
Cu^1	20,700	7,500		
$Minors^0$	18,900			
$Minors^1$	21,100			
Significant effects	N (0.001) NP (0.01) PK (0.05)	N (0.001)	N (0.001)	—
L.S.D. (0.05) 2 levels	2,900	1,000		
L.S.D. (0.05) 4 levels	4,100	1,400	1,200	2,000

For significant treatments, values in columns for each nutrient followed by the same letter are not significantly different at p = 0.05.

TABLE 12.— **Number of tubers/ha. Main effect means. 17th, 30th, 31st plantings**

Treatment	17th planting	30th planting	31st planting
N^0		79,900	73,100
N^1	69,500 a	75,500	88,900
N^2		73,400	85,900
$N^{3/4}$	53,500 b	75,500	91,000
P^0	56,000 b		
P^1	68,300 a		
P^2	65,300 ab		
P^4	56,300 b		
K^0	56,300 a	60,600 a	75,700
K^1	66,600 b	78,500 b	82,400
K^2		76,400 b	86,300
K^3		88,700 b	94,400
Mg^0	63,400		
Mg^1	59,500		
Mn^0	62,000		
Mn^1	60,900		
Cu^0	62,000		
Cu^1	60,900		
$Minors^0$	59,500		
$Minors^1$	63,400		
Significant effects	N (0.001) P (0.05) K (0.01)	K (0.01)	—
L.S.D. (0.05) 2 levels	6,900		
L.S.D. (0.05) 4 levels	9,700	15,500	16,700

For significant treatments, values in columns for each nutrient followed by the same letter are not significantly different at p = 0.05.

TABLE 13. — **Soil Exhaustion Trial. Total tuber yields (kg/ha). Main effect means for fertilized and subsequent plantings. Fertilizer applied at 11th and 12th plantings.**

Treatment	11th planting	12th planting	13th planting	14th planting	15th planting	16th planting
N^0	5,300 a	8,500 a	10,800	3,200	4700	1,500
N^1	4.900 a	7,100 b	9,300	3,000	4,400	1,600
N^2	4.600 a	6,500 b	9,400	3,300	4,200	1,600
N^4	3,300 b	5,300 c	9,500	3,300	4,900	1,700
P^0	4,300	7,200	10,400	3,700	5,600	1,800
P^1	4,400	6,500	9,300.	2,900	4,500	1,700
P^2	4,700	7,000	9,800	3,100	4,200	1,300
P^4	4,600	6,700	9,700	3,100	4,000	1,700
Fe^0	4,700	7,100	10,100	3,200	4,800	1,600
Fe^1	4,300	6,600	9,400	3,200	4,300	1,600
Zn^0	4,700	7,000	10,000	3,100	4,600	1,500
Zn^1	4,400	6,700	9,500	3,300	4,500	1,800
$Minors^0$	4,400	6,700	9,700	3,000	4,500	1,400
$Minors^1$	4,600	7,100	9,900	3,400	4,600	1,800
Significant effects	N (0.001)	N (0.001)	—	—	—	—
L.S.D. (0.05) N or P	900	1,200	1,300	800	1,200	700
L.S.D. (0.05) Fe, Zn or Minors	600	800	900	600	800	500

For significant treatments, values in columns for each nutrient followed by the same letter are not significantly different at p = 0.05.

TABLE 14. — **Soil Exhaustion Trial. Total tuber yield (kg/ha). Main effect means for fertilized and subsequent plantings. Fertilizer applied at 17th planting.**

Treatment	17th planting	18th planting	19th planting	20th planting	21st planting
N^1	6,300 a	7,200	8,600	20,500	12,800 a
N^4	4,500 b	6,500	8,200	22,800	11,500 b
P^0	5,500	7800 a	10,200 a	23,500	13,200
P^1	5,900	7,300 a	8,400 b	20,800	11,600
P^2	5,500	6,600 ab	7,700 b	21,700	12,400
P^4	4,700	5,700 b	7,400 b	20,400	11,400
K^0	4,600 a	5,700 a	8,500	22,900	12,200
K^1	6,100 b	8,000 b	8,400	20,300	12,100
Mg^0	5,600	6,300 a	8,100	19,300 a	11,900
Mg^1	5,200	7,400 b	8,800	23,900 b	12,300
Mn^0	5,100	7,000	8,400	21,800	12,000
Mn^1	5,600	6,700	8,500	21,400	12,200
Cu^0	5,400	6,900	8,200	22,800	11,800
Cu^1	5,300	6,800	8,600	20,400	12,500
$Minors^0$	5,000	7300 a	8,600	22,700	12,400
$Minors^1$	5,700	6,300 b	8,300	20,500	11,800
Significant effects	N (0.001) K (0.001)	P (0.01) K (0.001) Mg (0.05) Minors (0.05)	P (0.01)	Mg (0.05)	N (0.05)
L.S.D. (0.05) N, K, Mg, Mn, Cu, Minors	700	800	1,100	4,500	1,200
L.S.D. (0.05) P	1,000	1,200	1,500	6,400	1,700

For significant treatments, values in columns for each nutrient followed by the same letter are not significantly different at p = 0.05.

TABLE 15. — **Soil Exhaustion Trial. Total tuber yield (kg/ha). Main effect means for fertilized and subsequent plantings. Fertilizer applied at 26th planting.**

Treatment	26th planting	27th planting	28th planting	29th planting
N^0	8,300 a	4,800	5,500	2,200
N^1	9,900 b	4,400	5,300	2,200
N^2	11,500 c	4,300	4,900	2,200
N^4	14,900 d	4,700	4,900	2,100
P^0	11,000	4,600	5,500 a	2,300
P^1	11,300	4,500	4,800 b	2,100
K^0	8,700 a	4,000 a	4,400 a	2,000 a
K^1	11,500 b	4,200 a	5,100 ab	2,100 a
K^2	11,900 b	4,600 a	5,500 b	2,100 a
K^4	12,500 b	5,400 b	5,700 b	2,600 b
Mg^0	11,100	4,600	5,100	2,200
Mg^1	11,200	4,500	5,300	2,100
Mn^0	11,500	4,600	5,100	2,200
Mn^1	10,800	4,500	5,200	2,100
Cu^0	11,000	4,500	5,200	2,200
Cu^1	11,300	4,600	5,200	2,100
Significant effects	N (0.001) K (0.001)	K (0.01)	P (0.05) K (0.01)	K (0.05)
L.S.D. (0.05) N or K	1,600	700	800	400
L.S.D. (0.05) P, Mg, Mn or Cu	1,100	500	600	300

For significant treatments, values in columns for each nutrient followed by the same letter are not significantly different at p = 0.05.

TABLE 16. — **Soil Exhaustion Trial. Total tuber yield (kg/ha). Main effect means for fertilized and subsequent plantings. Fertilizer applied at 30th and 31st plantings.**

Treatment	30th planting	31st planting	32nd planting	33rd planting
N^0	5,900 a	4,400 a	6,600	2,100 a
N^1	7,900 b	7,000 bc	6,500	2,000 a
N^2	8,200 b	5,500 ab	6,700	2,200 a
N^3	10,300 c	7,700 c	7,900	2,700 b
K^0	6,200 a	5,100 a	4,700 a	1,700 a
K^1	7,700 a	5,200 a	6,600 b	2,200 b
K^2	8,100 a	7,000 b	8,000 c	2,400 bc
K^3	10,300 b	7,400 b	8,400 c	2,700 c
Significant effects	N (0.001) K (0.01)	N (0.001) K(0.05)	K (0.001)	N (0.01) K (0.001) NK (0.05)
L.S.D. (0.05)	2,000	1,700	1,300	400

For significant treatments, values in columns for each nutrient followed by the same letter are not significantly different at p = 0.05.

Values of a number of parameters were influenced by previous fertilizer application. The most significant was soil P which increased as a result of phosphate fertilizer applications applied prior to the 13th, 17th and 20th samplings. Soil pH was significantly lower in high N plots in the 13th and 20th samplings; Mg was significantly higher in Mg^1 plots and the C/N ratio was significantly lower in the Cu^1 plots in the 20th sampling.

Pot trials

The only significant effect in the pot trial conducted before the 11th planting was a response to P (Newton and Jamieson 1968). In the five pot trials conducted between the 12th and 17th plantings, top growth responded to N, P, K, Mg and Mn. Doubtful responses to copper and calcium also occurred (D.A.S.F. 1965).

Top growth

Nitrogen improved top growth vigour and colour in all six fertilized plantings (*Table 10*) and increased the weight of top growth at harvest in the four plantings where this was measured (*Table 11*) (see *Plate 3*). In the 12th and 17th plantings large responses to N were recorded in the visual assessments just prior to harvest.

Phosphorus improved top growth vigour to some degree early in the crop in the 11th planting. In the 17th planting it decreased the weight of top growth at N^1, but increased it at N^4.

Number of tubers

Nitrogen significantly depressed tuber number in the 17th planting. However, at the 31st planting there was a trend towards tuber number increasing with increasing N. Potassium increased tuber number at all plantings. The effect of P on tuber number was tested only in the 17th planting where it caused a significant increase at the P^1 and P^2 levels but not at P^4 (*Table 12*).

Total tuber yield

Nitrogen significantly depressed tuber yield in the 11th, 12th and 17th plantings, but increased it in the 26th, 30th and 31st plantings (*Tables 13, 14, 15, 16*). Potassium increased the total tuber yield in all four plantings where it was tested (*Tables 14, 15, 16*). A positive NK interaction occurred in the 26th and 30th plantings, responses to both N and K being greater when both were supplied together than when one was supplied without the other.

Total tuber yields for all plantings were plotted against time (*Figure 1*). Where significant responses to applied or residual fertilizer occurred, the yield plotted is that of the control plots (for example N^0K^0 for the 26th planting). Yields declined rapidly from an initial level of 27 t/ha to 4 t/ha by the 10th planting. Following fertilization applied after the 10th,

Plate 3.— A large top growth response to nitrogen in the 30th planting of the Soil Exhaustion Trial. Growth is poor in the N^0 plot in the foreground, the soil surface is exposed and leaves are yellow-green in colour. In the N^3 plot behind the figure, growth is lush and leaves are dark green

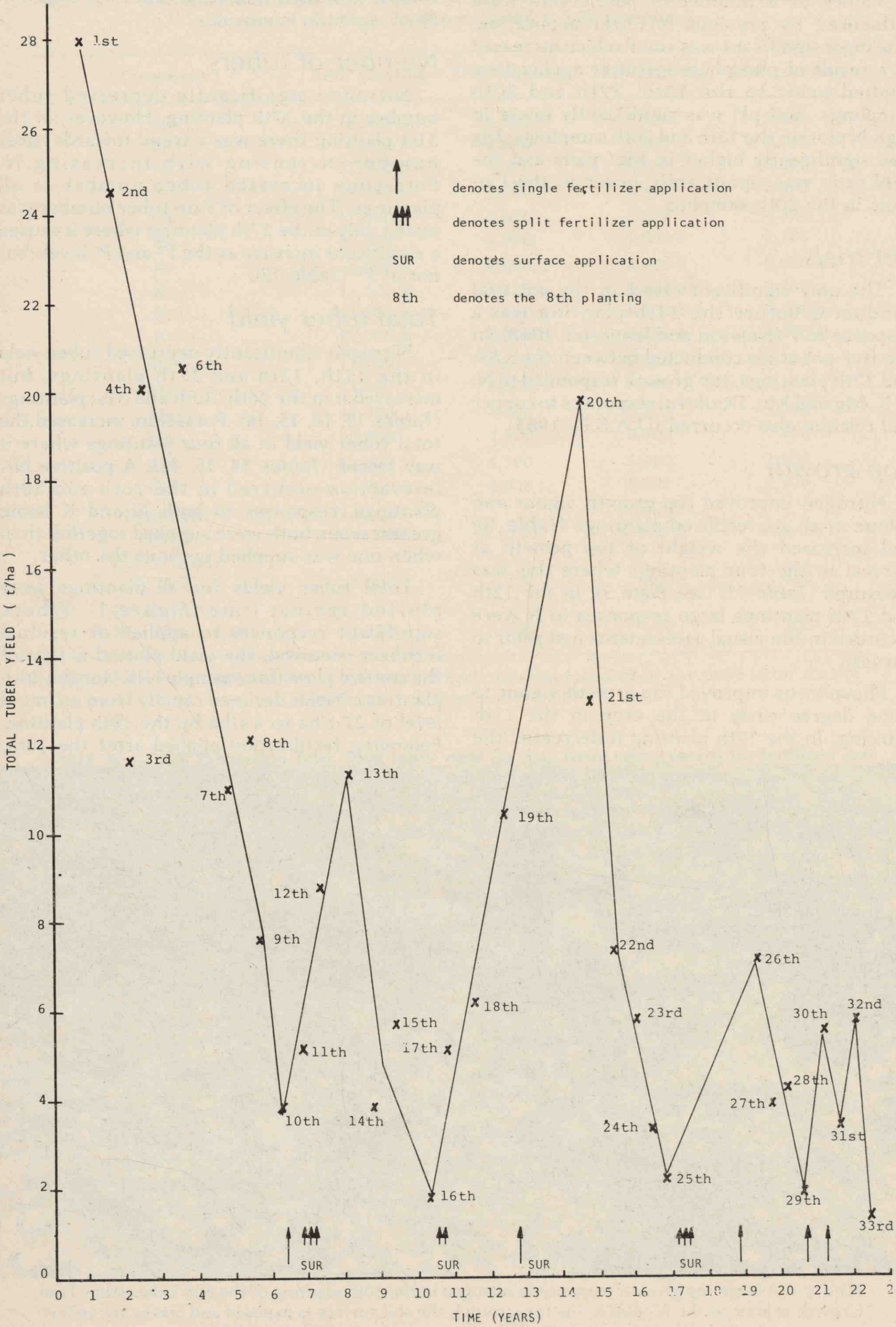

Figure 1. — Soil Exhaustion Trial Total tuber yield (or control yield) v. time

11th, 16th, 19th, 25th and 29th plantings, yields rose initially and then declined until the next fertilizer application.

Residual effects

Yields of plantings following fertilized ones indicated residual effects of applied fertilizer. A small but significant yield depression from residual N occurred in the 21st planting (*Table 14*) and there was a significant yield increase in the 33rd planting (*Table 16*). Yield depressions from residual P occurred in most plantings and the effect attained significance in the 18th, 19th and 28th plantings (*Tables 14, 15*).

Residual K significantly increased yields in the 18th, 27th, 28th, 29th, 32nd and 33rd plantings (*Tables 14, 15, 16*). Residual Mg significantly improved yields in the 18th and 20th plantings; and minors (Fe, Zn, B, Mo) apparently depressed yields in the 18th planting (*Table 14*).

III ROTATION TRIAL

The Keravat Rotation Trial was laid down in 1954 adjacent to the Soil Exhaustion Trial to study the effects of rotational cropping on crop yields and soil fertility (Newton and Jamieson 1968). Basically the trial consists of seven rotations which compare continuous cropping of food crops with a rotation of food crops and leguminous cover crops. In 1973 the trial was modified and fertilizers were used in certain rotations. Here the results of four fertilized plantings of sweet potato are presented. A full description of the trial up to 1973 is given by Bourke (in press).

MATERIALS AND METHODS

The trial includes seven rotational treatments, each with a different sequence of six plantings (*Table 17*). Each complete sequence of six plantings is termed a cycle and takes 3-3½ years to complete. There are 63 plots in the trial consisting of 7 treatments x 3 replicates in space x 3 replicates in time.

Rotations that include a leguminous fallow are termed wide rotations (rotations 1, 2, 6, 7) and those with no fallow or a short fallow are termed narrow rotations (rotations 3, 4, 5). Plot size is 9 m square. Sweet potato ridges are 1.2 m apart; there is one row per ridge; and within row spacing is 30 cm. Two cuttings of variety K9 are planted per position giving a planting density of 56,000 plants/ha. Guard rows are employed.

Sweet potato is fertilized in rotations 1, 4 and 6. Corresponding unfertilized rotations are 2, 5 and 7 respectively (*Table 17*). Thus rotation 1 should be compared with rotation 2; rotation 4 with rotation 5; and rotation 6 with rotation 7. Fertilizer rates varied from planting to planting (*Table 18*). Ammonium sulphate provided N in the first two plantings. Urea was used in the second two. Superphosphate and muriate of potash were the other fertilizers used. The fertilizer was applied to the soil surface in rows and the ridges built over it.

Vigour and colour of top growth were assessed visually in three of the plantings. At harvest tubers were classified as saleable or unsaleable on the basis of size. Those over 140 g were considered saleable. Soil samples were collected before and during the trial to a depth of 30 cm. The first sampling was done prior to 1st planting, 1st cycle (January, 1954) and the 11th was taken prior to 3rd planting, 6th cycle (March, 1973), prior to fertilizer being used in the trial.

RESULTS

Soil analyses indicate that the levels of most nutrients declined greatly between the 1st and 11th samplings (*Table 19*). The decline was greatest for K and Mg. The C/N ratio altered little with cropping, but the K/N ratio dropped considerably. Fertility was reduced more in the narrow rotations than in the wide rotations.

In the 3rd planting 6th cycle, where the N level was only 20 kg/ha, fertilizer had little effect on top growth vigour and colour (*Table 20*). By contrast, fertilizer significantly improved both top growth vigour and colour for all comparisons for the other two plantings where this was assessed (*Table 20*).

Significant differences in saleable tuber yield occurred between rotations for all four plantings (*Table 21*). For 9 of the 12 comparisons, significant responses to fertilizer occurred and for a further 2 comparisons, large, but not significant, responses were recorded. Yield responses in the narrow rotations were particularly large. In the 5th planting 6th cycle, fertilizer increased yield in the narrow rotations from 2.8 to 12.5 t/ha.

DISCUSSION

Large, significant responses to fertilizer occurred in most trials or plantings reported here. Small, negative or no responses occurred in others. The most important plant nutrients will be discussed individually.

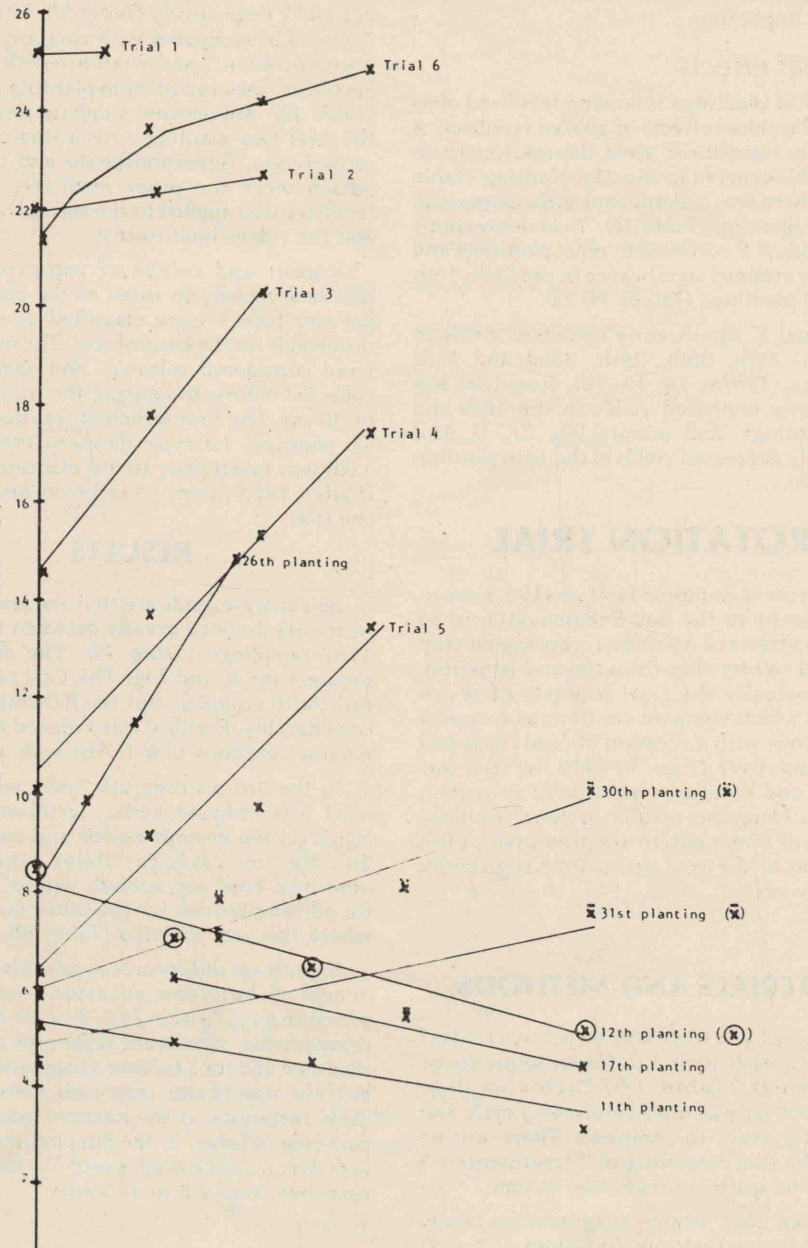

Figure 2. — General Trials and Soil Exhaustion Trial. Total tuber yield (kg/ha) v. nitrogen level

TABLE 17. — **Rotation Trial. Plan of rotations**

Planting	Rotation number and type 1 Wide	2 Wide	3 Narrow	4 Narrow	5 Narrow	6 Wide	7 Wide
1	SP*	SP	SP	SP*	SP	SP*	SP
2	So*	So	So	So*	So	So*	So
3	Pe*	Pe	CP	Pe*	Pe	Pe*	Pe
4	M	M	To	To*	To	Pu	Pu
5	M	M	To	To*	To	Pu	Pu
6	M	M	CP	Ma*	Ma	Pu	Pu

SP	Sweet potato	*Ipomoea batatas*	* Fertilized crop
So	Sorghum	*Sorghum vulgare*	
Pe	Peanuts	*Arachis hypogaea*	
M	Mimosa	*Mimosa invisa*	
CP	Cowpea	*Vigna unguiculata*	
To	Taro	*Colocasia esculenta*	
Ma	Maize	*Zea mays*	
Pu	Pueraria	*Pueraria phaseoloides*	

TABLE 18. — **Rotation Trial. Details of fertilized plantings**

Planting	Cycle	Rotation type	Nutrient level (kg/ha) N	P	K	Planting date
3	6	Wide	20	13	65	23/3/1973
3	6	Narrow	20	13	65	23/3/1973
5	6	Wide	90	50	240	26/2/1974
5	6	Narrow	130	60	260	26/2/1974
1	7	Wide	90	0	180	21/1/1975
1	7	Narrow	130	0	260	21/1/1975
3	7	Wide	130	0	260	9/10/1975
3	7	Narrow	130	0	260	9/10/1975

Nitrogen

The effect of N on top growth is very clear. In almost every trial or planting where top growth vigour or colour was assessed or the weight recorded at harvest, N gave increased top growth. The effect of N on tuber number is not clear.

Nitrogen gave the greatest yield increases in both the general trials and the Soil Exhaustion Trial. A plot of total tuber yield against N level for the 12 trials or plantings where N was tested shows good agreement between the various groups of trials or plantings (*Figure 2*).

Where the control yields are high (Trials 1, 2, 6), responses are negligible or small. Yield responses at the grassland sites (Trials 3, 4, 5) are especially pronounced and the slope of the response line is similar for the three sites. In the three plantings of the Soil Exhaustion Trial where variety K1 was used (11th, 12th, 17th plantings), the negative response is similar. Only for the three plantings where variety K9 was used (26th, 30th, 31st plantings) are the slopes of the response lines markedly different.

Nitrogen is clearly required in both grassland sites and also in former forested areas where soil fertility has been reduced by cropping. For both grassland areas and the Soil Exhaustion Trial site, N levels could go higher than those used (*Figure 2*). In grassland areas the requirement for N fertilizer could be reduced by either a fallow between burning and planting to allow mineralization of soil N or opening the rotation with another crop such as peanuts. The results from grassland sites are similar to those obtained in grasslands on

TABLE 19. — **Rotation Trial. Soil Analysis, 0 - 30 cm**

Parameter	Rotations 1, 2		Rotations 3, 4, 5		Rotations 6, 7	
	1st sampling	11th sampling	1st sampling	11th sampling	1st sampling	11th sampling
Nitrogen %	.57	.31	.58	.23	.59	.29
Carbon %	6.0	3.0	6.2	2.4	5.9	3.0
C/N ratio	10.6	9.9	10.7	10.7	9.8	10.2
Olsen P p.p.m.	3	9	4	9	5	8
Exch. Ca m.e.%	18.3	9.0	16.0	7.0	21.2	8.7
Exch. Mg m.e.%	2.3	.87	2.5	.65	2.7	.93
Exch. K m.e.%	1.2	.4	1.1	.2	1.4	.4
Exch. Na m.e.%	—	.56	—	.53	—	.54
Cation exch. cap. m.e.%	24.8	12.1	24.4	9.4	26.9	11.6
pH	6.5	5.7	6.4	5.7	6.6	5.7
Spec. conduc. mhos x 10^3	.121	—	.115	—	.128	—
Total soluble salts %	—	.017	—	.011	—	.018
K/N ratio	2.2	1.3	2.0	1.0	2.4	1.3

TABLE 20. — **Rotation Trial. Visual top growth vigour and colour assessments on a 0 - 10 scale with higher scores indicating greater vigour and colour.**

Rotation number and type	Top growth vigour			Top growth colour		
	3rd planting 6th cycle 17 weeks	5th planting 6th cycle 7 weeks	3rd planting 7th cycle 16 weeks	3rd planting 6th cycle 17 weeks	5th planting 6th cycle 7 weeks	3rd planting 7th cycle 16 weeks
1 Wide, fertilized	8	9	8	7	9	8
2 Wide	8	7	6	8	7	6
4 Narrow, fertilized	6	9	6	5	9	6
5 Narrow	4	4	4	6	5	4
6 Wide, fertilized	9	10	9	9	9	8
7 Wide	8	8	7	8	8	7
Level of significance (fertilized v. unfertilized rotations)	N.S.	0.001	0.05	N.S.	0.001	0.01

TABLE 21. — **Rotation Trial. Yield saleable tubers (kg/ha)**

Rotation	Rotation type	3rd planting 6th cycle	5th planting 6th cycle	1st planting 7th cycle	3rd planting 7th cycle
1	Wide fertilized	9,000 b	14,900 ab	9,300 a	9,100 b
2	Wide	5,000 cd	10,500 c	5,200 b	6,600 bc
4	Narrow fertilized	6,100 c	12,500 bc	3,400 b	9,100 b
5	Narrow	2,800 d	2,800 d	3,000 b	2,000 c
6	Wide fertilized	12,600 a	16,900 a	9,200 a	14,700 a
7	Wide	9,200 b	13,600 abc	5,300 b	8,900 b
Level of significance		0.001	0.001	0.001	0.01
L.S.D. (0.05)		2,700	3,400	2,700	4,800

Values in columns followed by the same letter are not significantly different at $p = 0.05$.

Guadalcanal Island in the Solomon Islands (L.D.C. Chase pers. comm.). There 50 kg N/ha applied as urea gave 4 t/ha yield increase in the first two plantings of sweet potato in a soil exhaustion trial.

In the Soil Exhaustion Trial, all significant responses to applied or residual N were negative up to the 21st planting, but after this planting all significant responses were positive, irrespective of potassium levels. The change from variety K1 to K9 was made about the 22nd planting. K1 has a greater leaf area under low N conditions than K9. It is suggested that the different variety used accounts for the reversal of the N response.

Tsunoda (1959) designated varieties of sweet potato as adapted to high, low or medium optimum levels of fertilization. He reported that varieties adapted to light fertilization tend to have a larger leaf area per plant than those adapted to heavy fertilization, at least during earlier growth. In Trinidad a variety with low leaf area and one with high leaf area were compared under low and high N Conditions (Haynes *et al.* 1969). The low leaf area variety produced low yield without nitrogen, and high yield with nitrogen fertilizer. By contrast the high leaf area variety under high N conditions produced excessive leaf area and a low tuber yield when harvested at four months. Haynes *et al.* (1969) suggest the possibility of higher ultimate yield from the high leaf area variety under high N fertilization provided harvest is delayed beyond four months.

Reports of yield reductions in fertilized sweet potato crops have been received from local farmers from time to time. It is likely that varieties adapted to low N conditions were used in these cases.

Newton and Jamieson (1968) suggested that the negative response to N in the 11th and 12th plantings of the Soil Exhaustion Trial may have been associated with omission of potassium and magnesium from the treatments. This hypothesis is not supported by later plantings where variety K9 was used and responses to N were always positive, even in the absence of potassium or magnesium. However, in the 17th planting the deleterious effects of N on yield were greater at K^0 then at K^1, suggesting that potash can reduce the negative effect of N to some degree.

In the 12th and 17th plantings nitrogen was applied as late as 7 and 8 weeks before harvest respectively. The large top growth responses to N recorded just prior to harvest suggest that nitrogen continued to promote top growth at the expense of tuber development right up to harvest.

The lack of any significant relationship between N levels and tuber cracking in Trials 4, 5 and 6 contrasts with the results of Lutz *et al.* (1949) who found that high nitrogen levels and lime increased tuber cracking. It also differs from Nusbaum (1947) who reported that growth cracking was most severe with low P and high N fertilizer mixes and increased in proportion to the rate of applied borax. De Geus (1973) states that an excess of N may result in cracking of tubers.

Phosphorus

Phosphate had little effect on top growth, although it did improve vigour and colour in a number of crops. The significant interaction of nitrogen and phosphorus on top growth weight at harvest in the 17th planting is puzzling. Phosphate fertilizer has had little effect on yield and a significant yield increase over the control occurred in Trial 2 only.

The apparent yield depression from residual superphosphate that occurred in most plantings of the Soil Exhaustion Trial appears to be a real effect. It may be that Ca applied in superphosphate and sodium in monosodium phosphate was antagonistic to K or Mg.

Potassium

Soil potassium levels in this soil are initially high but they decline rapidly with intensive cropping with root crops. Potash fertilizer did not significantly affect top growth in any trial. It increased tuber number in all three plantings of the Soil Exhausion Trial where this variable was measured. At two of the former forest sites where yield levels were high (Trials 2 and 6), no yield response to K occurred. However, in the Soil Exhaustion Trial, K increased tuber yield in the four plantings where it was included. It is obviously required in former forest sites where soil fertility has been reduced. Results from the Soil Exhaustion Trial indicate that, where K deficiency has developed, applied K may carry over a residual effect into succeeding crops.

No clear indication of a requirement for potash was shown at the grassland sites. In Africa, responses to K occur after the first or second year of cropping following a forest fallow, particularly with root crops, but responses to K in the savanna have been disappointing (Nye 1966). A similar situation appears to exist on the Gazelle Peninsula.

Other nutrients

No responses to nutrients other than N, P or K were recorded in field trials except to residual Mg in the 18th and 20th plantings. The indications from the pot trials that magnesium and manganese are required on intensively cropped soil should be borne in mind. No indication of a sulphur requirement was obtained and S free fertilizers such as urea should be satisfactory.

Non-factorial trials

The small response in Trial 7 was unexpected and disappointing. The saleable yield on the control treatment was a fraction of the yield that could have been expected under fertile soil conditions for this variety. The variety used, V2, may not respond to fertilizer. For the wide rotations in the Rotation Trial, responses were about 4 t/ha for all four plantings. This suggests that there has not been a further response to the higher N and K levels used in some of the plantings. It is likely that one or more other nutrients are limiting the response, most likely Mg.

Relationship between responses and control yields

The total tuber yield increase from fertilizer was plotted against the control yield for each general trial, planting of the Soil Exhaustion Trial or comparison in the Rotation Trial (*Figure 3*). The two were found to be related by the following equation:

$$Y = 7.975 - .28x \qquad r = .54^{**}$$

where Y = yield increase from fertilizer (t/ha); x = yield of control treatment (no fertilizer) (t/ha); and r = correlation coefficient, significant at $p = 0.01$.

It can be seen that yield increases from fertilizer tend to decrease as the control yields (soil fertility) increase. Because this equation is derived from trials using different nutrients and rates of those nutrients, no further deductions can be made from it.

Proportion of saleable tubers

Fertilizer increased the proportion of saleable tubers in all general trials and comparisons in the Rotation Trial where a yield response occurred. It is thus important to record the yield of saleable tubers as well as total tuber yield, so as not to underestimate the magnitude of the fertilizer response.

Fertilizer placement

No comparisons were made within trials to evaluate fertilizer placement but the different methods used in various trials have given some indications of the effect of this.

Despite the fact that the site for Trial 1 was considered "exhausted", the average yield for the trial of 25.2 t/ha was one of the best yields ever recorded for this variety. It is suggested that a small quantity of N was washed over all plots and caused an overall yield increase. Further evidence for the movement of fertilizer between plots comes from the Soil Exhaustion Trial where average control yields rose following fertilizer application (*Figure 1*). Following heavy showers of rain, a lot of water moves between plots in this trial and it appears that fertilizer is moved between plots, even when placed under the ridges.

Mixing fertilizer and soil during ridging or mounding may result in more efficient fertilizer use. Fertilizer may have been inadequately mixed in the 30th and 31st planting as responses were less than in the 26th planting (*Figure 2*).

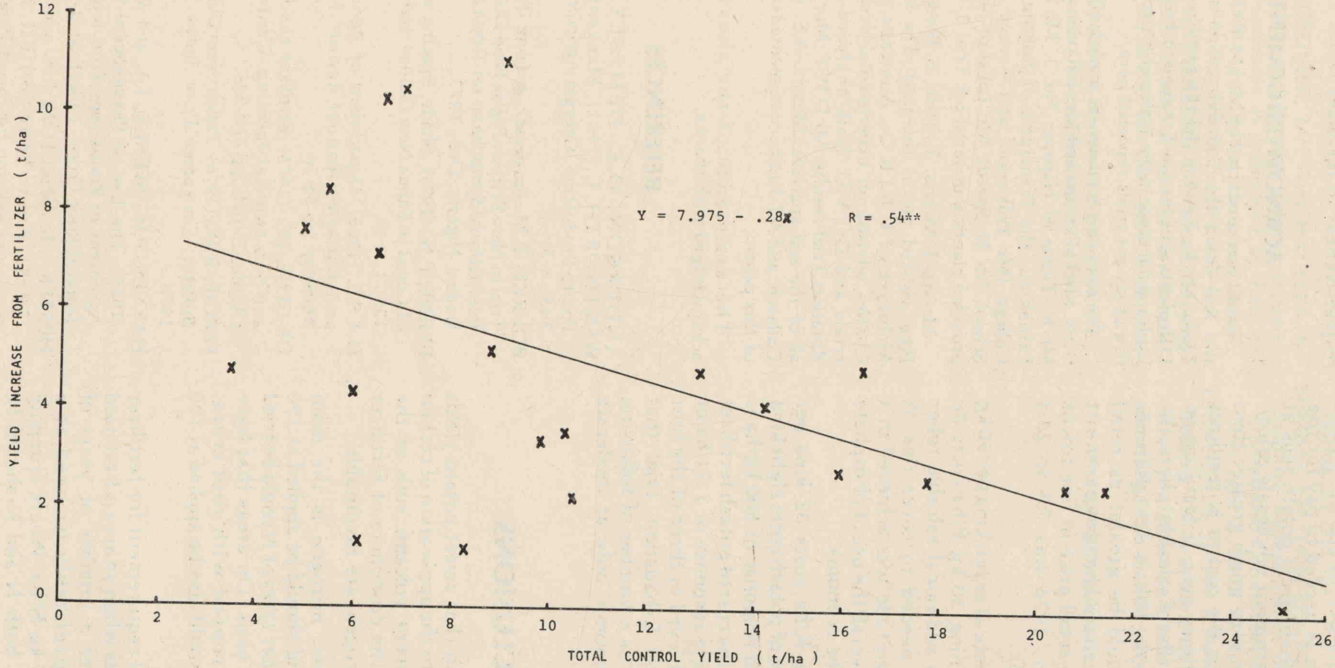

Figure 3. — All trials. Total tuber yield increase from fertilizer v. total control yield

Economics of fertilizer use

With urea at nine kina per 50 kg bag, fertilizer containing 100 kg of nitrogen per hectare costs 40 kina per hectare. A yield response of 600 kg/ha is needed to pay for the cost of N fertilizer when sweet potato sells at 6.5 toea/kg (the government wholesale price). Responses to N were very much greater than this and in most trials the cost of N fertilizer was returned many times over. If fertilization resulted in an extra 4 t/ha of saleable tubers, the value/cost ratio on 100 kg N/ha is 6.5:1. Returns from retail sales would be greater as retail prices are higher than the government wholesale price. The retail price in five towns for the June quarter, 1976 was 7.3 to 23.4 toea/kg (Fergie, 1976).

With superphosphate at seven kina per 50 kg bag, fertilizer containing 50 kg P/ha costs 80 kina per hectare. An additional saleable tuber yield of 1.2 t/ha is needed to cover this. A response of this magnitude was achieved in a few trials only, and overall the use of phosphate fertilizer would not be economic.

Potash at 100 kg K/ha costs 32 kina per hectare when muriate of potash costs eight kina per 50 kg bag. A yield response of 500 kg/ha is sufficient to recover the cost of potash fertilizer at 100 kg K/ha. A yield response of 1.5 t/ha or greater to K^1 was achieved in three of the four plantings of the Soil Exhaustion Trial that evaluated K, as well as a number of following crops. Potash is economic only at moderate rates.

CONCLUSIONS

It has been shown that sweet potato yields are very responsive to the application of certain nutrients on the recent volcanic soils of the Gazelle Peninsula. The economics of fertilizer use, particularly nitrogen, are favourable.

In grassland areas, nitrogen is the main nutrient required and should be applied at 150 kg N/ha as urea. Higher rates of N could be tried on an experimental basis. On areas that have been intensively cropped with root crops, muriate of potash should also be applied at 100 kg K/ha.

There is no initial requirement for fertilizer in former forest areas when an area is first used after a fallow. After a number of years of cropping, N can profitably be used at a moderate rate of 50 kg N/ha. Where cropping has been intensive, both N and K should be applied at a rate of 100 kg/ha.

Fertilizer should be incorporated into the soil prior to planting. Nitrogen should not be applied late in the life of a crop. Fertilizer should be applied cautiously to varieties whose responsiveness to fertilizer is not known.

ACKNOWLEDGEMENTS

Trial 1 was conducted by Mr J.M. Richardson, who also laid down the Soil Exhaustion and Rotation Trials. Mr K. Newton did the fertilizer trial in the 11th planting of the Soil Exhaustion Trial and Mr G.I. Jamieson did those in the 12th and 17th plantings, and five of six pot trials reported here.

The following landowners made land available for trials: Mr ToPinvana and Mrs IaRavien of Vunadidir, Mr K. Tiuria of Napapar No. 1, Mr R. Tading of Palnakiau, the Principals of Sonoma Adventist College (Mr Wilkinson) and George Brown High School (Mr N. Speed). Mr ToLai of Napapar No. 5 provided planting material for Trial 3.

Messrs. J. Morris, T. Tisso, S. Bongbong and M. Piku assisted me in the field. The late Mr G.A. McIntyre of C.S.I.R.O., Australia and Mr A.E. Charles advised on experimental design for most trials and Dr. V.D. Naik analysed some of the Rotation Trial results. Mr D.W.P. Murty supervised all of the soil analyses. Messrs. A.E. Charles, H.E. Gallasch, and A.J. Kimber commented on a first draft of this paper.

The assistance of the above people is acknowledged with thanks.

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(Accepted for publication June, 1977.)