PINEAPPLE FERTILIZER INVESTIGATIONS IN SOUTH-EASTERN QUEENSLAND

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SUMMARY.

Fertilizer trials were carried out during 1951-1954 on four soil types differing mainly in their potassium content. Four applications per annum were made into the base leaves of the plants.

There were only limited responses to nitrogen, and only one trial produced significant increases in yield of the plant crop from progressive increments. In this case the yield increased from 23.8 tons per acre with 100 lb. of nitrogen to 25.2 tons with 300 lb. It is concluded, based on growth measurements, that the requirements of the crop up to the time of flowering do not exceed 100 lb. of nitrogen per year, but that the rate may be increased with advantage during the post-flowering period. The higher rates of nitrogen applied after harvesting of the plant crop promoted suckering, which resulted in progressive yield increases up to 5.9 tons per acre in the ratoon crop.

There were no responses to phosphorus in either plant growth or yield of the plant crop in any of the trials. There was, however, an unexplained yield response in the ratoon crop in one of the trials.

The response to potassium was most marked, and the results indicate that pineapples grown on soils below 0.2 m-equiv. of replaceable potassium per 100 g. require potassium at the rate of at least 166 lb. per acre per year. There was virtually no response to added potassium on soils with a replaceable potassium content of 0.5 m-equiv. and over per 100 g.

Fruit quality determinations showed that potassium tends to increase both sugars and acids, whereas nitrogen has the reverse effect.

I. INTRODUCTION.

In Queensland, fertilizing practices in pineapples have for many years been based on the use of a 10 : 6 : 10 mixture, alternating with sulphate of ammonia and applied at regular intervals and at a fixed rate irrespective of the soil type. This schedule supplies approximately 300 lb. of N, 36 lb. of P and 116 lb. of K per acre per annum. Since the soils on which pineapples are grown vary greatly in chemical composition, it has been felt for some time that adherence to a fixed fertilizing schedule would provide inadequate amounts of nutrients for some soils or entail luxury feeding in other cases. These investigations were, therefore, undertaken with the object of determining a basis for more efficient fertilizing on representative soil types, having regard to their chemical composition.

II. LOCATION OF TRIALS.

The trials reported herein were laid down in the autumn of 1951 on four soil types of the North Coast, and on land which had previously been cropped for a number of years. They were as follows:—

No. 1.—*Light-brown Sandy Loam* (Glasshouse) derived from sandstone, a common soil type in the Beerwah-Glasshouse district.

No. 2.—*Red-brown Loam* (Flaxton) of basaltic origin, and the typical soil of the Blackall Range.

No. 3.—*Dark-brown Clay Loam* (Dagun) derived from a manganiferous quartzite and allied rocks, and characteristic of much of the Mary Valley (near Gympie). Similar soils also occur in the Yeppoon district of Central Queensland.

No. 4.—*Dark-grey Clay Loam* (Maroochy Experiment Station, Nambour) derived from sandstone and intermediate igneous rocks, and a less common soil type on the North Coast.

Analyses of composite soil samples obtained prior to the inception of the trials are set out in Table 1.

Table 1.

CHEMICAL ANALYSES OF SOILS FROM TRIAL AREAS.

Soil.	pH.	Total N (%).	*Available P_2O_5 (p.p.m.).	Replaceable Bases (m-equiv. per 100 g.).	
				K.	Total.
No. 1	5·1	0·06	80	0·18	2·83
No. 2	4·4	0·34	85	0·18	2·91
No. 3	5·1	0·19	80	0·50	10·83
No. 4	5·4	0·42	140	0·60	13·77

* Estimated by the Queensland Bureau of Sugar Experiment Stations Method.

Nitrogen was variable and not closely related to soil type, being extremely low in the sandy loam (No. 1). All samples were much higher in available P_2O_5 than in soils in the virgin state, as reported by Vallance (1938), who found that the level rarely exceeded 10 p.p.m. of available P_2O_5 (Truog's method). This is presumed to be the result of a build-up of phosphate from previous fertilizer applications, since in all cases the land had been under pineapples for many years. There were marked differences in the potassium content of the soils, the two clay loams being considerably higher in replaceable potassium than the lighter soils.

III. EXPERIMENTAL DESIGN AND TREATMENTS.

The trials were laid out as 3 x 3 x 3 factorials, with two absolute replications at each centre. Individual plots consisted of paired rows 40 ft. long, containing 80 plants, except in Trial 1, which had 84 plants in 42 ft. rows. No border rows were provided between adjacent rows, but buffers 5 ft. or more in length were allowed between adjoining plots in the same row.

Magistad and Farden (1934) advocated larger plots for pineapples, but practical considerations, which limited the total area of the trials to half an acre each, necessitated the use of the smaller plot size. For the same reason, border rows were omitted on the ground that application of the fertilizer directly into the basal leaves would limit lateral movement of nutrients between plots. This evidently did not introduce a large source of error, since the standard error per plot ranged from 2 to 8 per cent. of the general mean and exceeded 5 per cent. in only one case.

(1) Fertilizer Levels.

In view of the normal seasonal variation in soil nitrogen, there were no "nil" treatments and the same three levels of nitrogen were included in all trials. In the case of phosphorus and potassium, however, the levels were varied according to the soil analyses. Details of the experimental levels in terms of total per acre per annum are given in Table 2.

Table 2.

EXPERIMENTAL FERTILIZER LEVELS (LB./AC./ANNUM).

N.		P.		K.	
N1	100	PO	Nil	KO	Nil
N2	200	P1	9	K1	41
N2	300	P2	18	K2	83
		P3	36	K3	166

Nitrogen was supplied as sulphate of ammonia, phosphorus as superphosphate, and potassium as sulphate of potash. To facilitate uniform application the 27 mixtures were made up to a standard volume by the addition, where necessary, of a fine sand "filler."

In Trials 1, 2 and 3, where available P_2O_5 was of the order of 80 p.p.m., the levels of P0, P2 and P3 were used; P0, P1 and P2 were used in Trial 4, where available P_2O_5 was 140 p.p.m. The potassium levels in Trials 1 and 2, with replaceable K at 0·18 m-equiv. per 100 g., were K0, K2 and K3, and K0, K1 and K2 were used in Trials 3 and 4, where replaceable K was 0·50 and 0·60 m-equiv. per 100 g. respectively.

(2) Method and Times of Application of Fertilizer.

All fertilizer mixtures were applied into the basal leaves of the plants, which is the normal practice in the crop. A measured volume of the appropriate mixture was applied with a small metal scoop designed to hold the requisite quantity for a single plant.

Over the period of the plant crop cycle, which occupied a little under two years, seven fertilizer applications were made, as follows:—

1951: Mid-April, early September and early December;

1952: Early February, late April, early September and mid-November.

Trial 4, which was carried through to the ratoon crop, received a further four applications during 1953 at times corresponding to those for 1952.

(3) Cultural Methods.

Tops (or crowns) were used as planting material on account of their known superiority to slips and suckers in uniformity of behaviour. To further reduce plant variability the tops were graded for size on a weight basis, allowing a tolerance of ±1 oz. within a replication. The standard planting layout was followed—i.e., plants spaced 12 in. apart in paired rows 2 ft. apart, the paired rows (or beds) being 6 ft. apart, centre to centre.

Planting was carried out by hand and took place under favourable conditions in March 1951. All trials were planted within a few days of one another. Good rain fell at Glasshouse (Trial 1) and Maroochy Experiment Station (Trial 4) immediately after planting. As a result, the plants in these trials established quickly and made considerable growth before winter. At the other two centres the trials did not have the same initial advantage, but were reasonably well established before winter. In Trial 2 (Flaxton) the cooler conditions encountered in this locality (elevation 1,000 ft.) resulted in slower growth than elsewhere. At Dagun (Trial 3) a long dry period in the spring and early summer of 1951 affected growth and the crop was correspondingly backward.

Standard cultural methods were followed in handling the crop, weeds being controlled by the use of PCP sprays. At Dagun, ferrous sulphate sprays were applied regularly to correct manganese-induced iron deficiency, which occurs on this soil.

One of the common difficulties in assessing yields in pineapples is irregularity in flowering of otherwise apparently uniform plants. To overcome this, artificial flower induction with alpha-napthalene acetic acid (ANA) was employed to produce uniform flowering for a summer crop. Accordingly, ANA at 10 p.p.m. was introduced into the hearts of the plants in May 1952 in all but the Dagun trial. In this case, treatment was deferred until October, by which time 10 per cent. of the plants had already flowered naturally; these were disregarded, yields being based on the main crop in the autumn. In the one trial (No. 4) which was carried through to the ratoon, ANA treatment was applied again in May 1953 and resulted in a summer ratoon crop.

IV. SEASONAL GROWTH RESPONSES.

Seasonal responses to treatments were estimated by means of a series of growth measurements over intervals corresponding to the periods between successive fertilizer applications. These were not commenced until the spring following planting, and were discontinued at or about flowering, when the plants entered the reproductive phase.

(1) Methods of Growth Measurement.

In these trials, the growth of the immature leaves in the central part of the plant was used as an index of the growth of the whole plant. A leaf approximately 30 cm. in length was selected as the first datum leaf and measured at the beginning and the end of a particular growth period to ascertain its increase in area. At the end of the first growth period a second leaf was chosen on the same basis, and its increase in area over the ensuing period calculated, and so on. At the end of each period a count was also made of the number of leaves intermediate between the original and the second datum leaf, these being the leaves which had elongated beyond 30 cm. within the period.

The increase in area of this group of leaves was taken to be proportional to that of the datum leaf, and the increase in total leaf area of this part of the plant was calculated as—

$$\frac{\text{Datum leaf increase} \times \text{No. of intermediate leaves}}{2}$$

For the purposes of discussion this has been designated the "growth increment."

Leaf length was measured by gently inserting a slender graduated scale between the leaf bases and reading off the length at the leaf tip. Width was measured at about one-third the distance from the base, where the pineapple

Table 3.

GROWTH INCREMENTS (SQ. CM./PLANT), OCTOBER–DECEMBER, 1951.

Treatment.	Glasshouse. 17/10/51 to 5/12/51.	Dagun. 7/11/51 to 13/12/51.	M.E.S. 15/11/51 to 12/12/51.
N1	96	65	92
N2	109	77	107
N3	104	69	102
P0	104	70	105
P1	..	..	95
P2	106	73	102
P3	99	68	..
K0	91	69	95
K1	..	68	96
K2	105	74	111
K3	113	..	..
Mean	103	70	100
Necessary differences for significance 5%	20	14	24
Necessary differences for significance 1%	28	19	..

leaf is more or less parallel-sided. For this purpose a light flexible metal scale, which conformed to the curvature of the leaf blade, was used. The datum leaves were identified by marking the tips with paints of different colours to facilitate their subsequent recognition.

Measurements were based on samples of four plants per plot, the size of the sample being dictated by practical considerations in handling this work. Larger samples would, no doubt, have reduced the high sampling variance of the data and have made it possible to recognise smaller differences.

(2) Results.

Growth responses were determined for four periods which corresponded roughly with spring, summer, autumn and winter; the first and last series were omitted in Trial 2. As there were no significant interactions between treatments, the main effects only will be discussed. Figs. 1-3 show graphically the responses for each of the four growth periods; the results are set out in Tables 3–6.

Table 4.

GROWTH INCREMENTS (SQ. CM./PLANT), DECEMBER, 1951–FEBRUARY, 1952.

Treatment.	Glasshouse. 5/12/51 to 12/2/52.	Flaxton. 18/12/51 to 19/2/52.	Dagun. 13/12/51 to 13/2/52.	M.E.S. 12/12/51 to 11/2/52.
N1	440	180	201	443
N2	444	210	220	493
N3	375	196	200	458
P0	404	186	201	482
P1	..	..	..	435
P2	419	196	214	476
P3	406	203	207	..
K0	362	175	208	446
K1	..	..	204	427
K2	407	208	209	521
K3	461	202	..	..
Mean	410	195	207	465
Necessary differences for significance 5%	60	N.S.	34	N.S.
Necessary differences for significance 1%	82	N.S.	45	N.S.

Table 5.

GROWTH INCREMENTS (SQ. CM./PLANT), FEBRUARY–MAY, 1952.

Treatment.	Glasshouse. 12/2/52 to 29/4/52.	Flaxton. 19/2/52 to 6/5/52.	Dagun. 13/2/52 to 30/4/52.	M.E.S. 11/2/52 to 1/5/52.
N1	730	563	576	1,185
N2	753	568	626	1,243
N3	669	611	590	1,275
P0	690	546	589	1,302
P1	..	..	..	1,190
P2	732	601	593	1,210
P3	729	597	610	..
K0	633	526	604	1,194
K1	..	..	581	1,172
K2	750	598	607	1,337
K3	768	618	..	..
Mean	717	581	594	1,234
Necessary differences for significance 5%	72	73	68	126
Necessary differences for significance 1%	97	99	92	171

Table 6.

GROWTH INCREMENTS (SQ. CM./PLANT), MAY–SEPTEMBER, 1952.

Treatment.	Glasshouse. 29/4/52 to 9/9/52.	Dagun. 30/4/52 to 15/9/52.	M.E.S. 1/5/52 to 17/9/52.
N1	355	691	860
N2	376	766	891
N3	348	763	941
P0	356	725	869
P1	..	..	936
P2	359	741	886
P3	363	754	..
K0	315	720	907
K1	..	734	904
K2	376	767	881
K3	387	..	..
Mean	360	740	897
Necessary differences for significance 5%	33	59	N.S.
Necessary differences for significance 1%	44	80	N.S.

Rate of growth generally showed a marked increase from the spring on to the autumn period, with a decline during the winter.

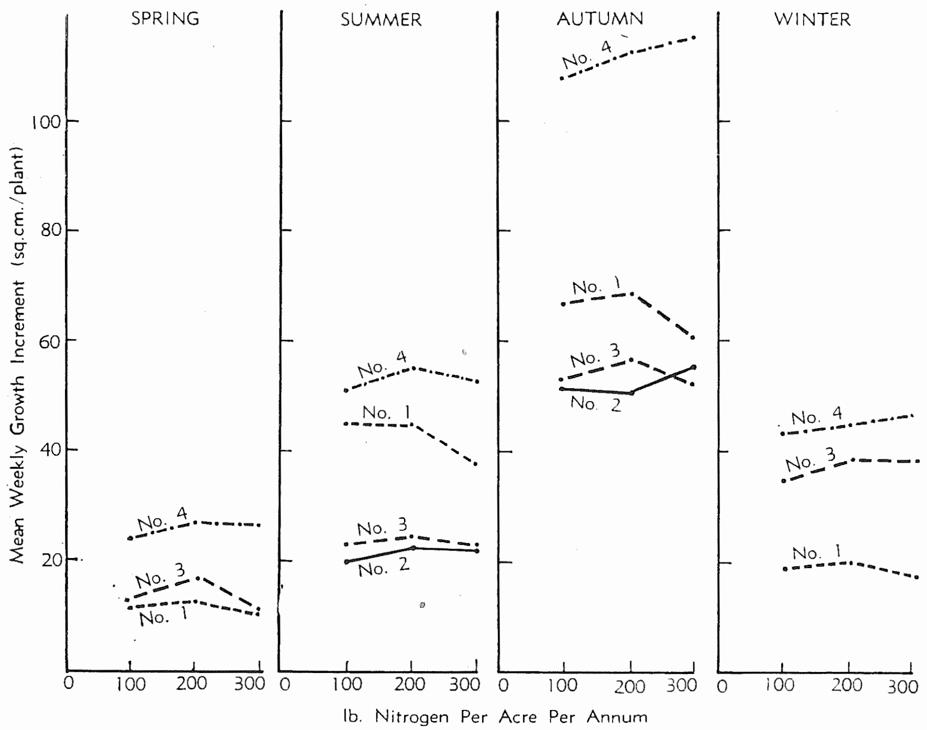

Fig. 1.

Mean Weekly Growth Increments at Three Levels of Nitrogen for Each of Four Growth Periods.

Nitrogen.—The growth curves show a consistent rise in all trials and over all periods with increase in nitrogen from 100 to 200 lb. per acre per annum. In general, the differences were not great and were all below the 5 per cent. level of significance. From 200 to 300 lb. of nitrogen there was in most cases a downward trend, which was most pronounced in Trial 1, in which it reached significance over the summer and autumn period.

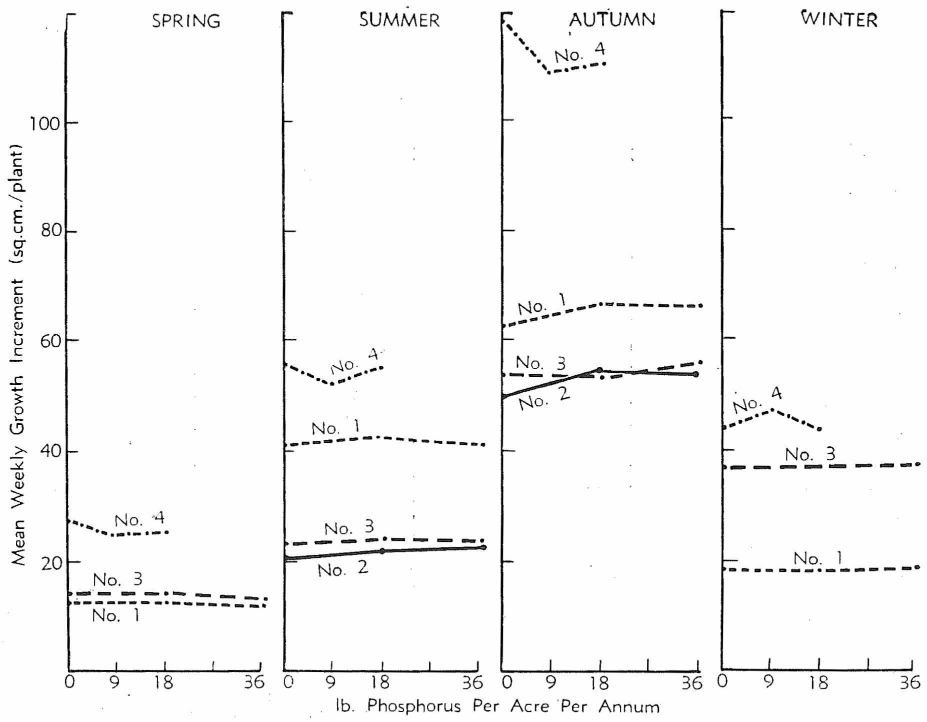

Fig. 2.

Mean Weekly Growth Increments at Four Levels of Phosphorus for Each of Four Growth Periods.

Phosphorus.—With the exception of Trial 4, varying rates of phosphorus had little effect on the growth rate at any period of the year. In this case, a single increment depressed growth over the spring to autumn period, but growth increased with the second increment.

Potassium.—In all trials the rise in growth rate with increase in potassium was fairly consistent over the whole period during which growth measurements were taken. This growth response was significant throughout in Trial 1, but did not reach significance in Trials 2 and 4 until the autumn (that is, just prior to flower initiation).

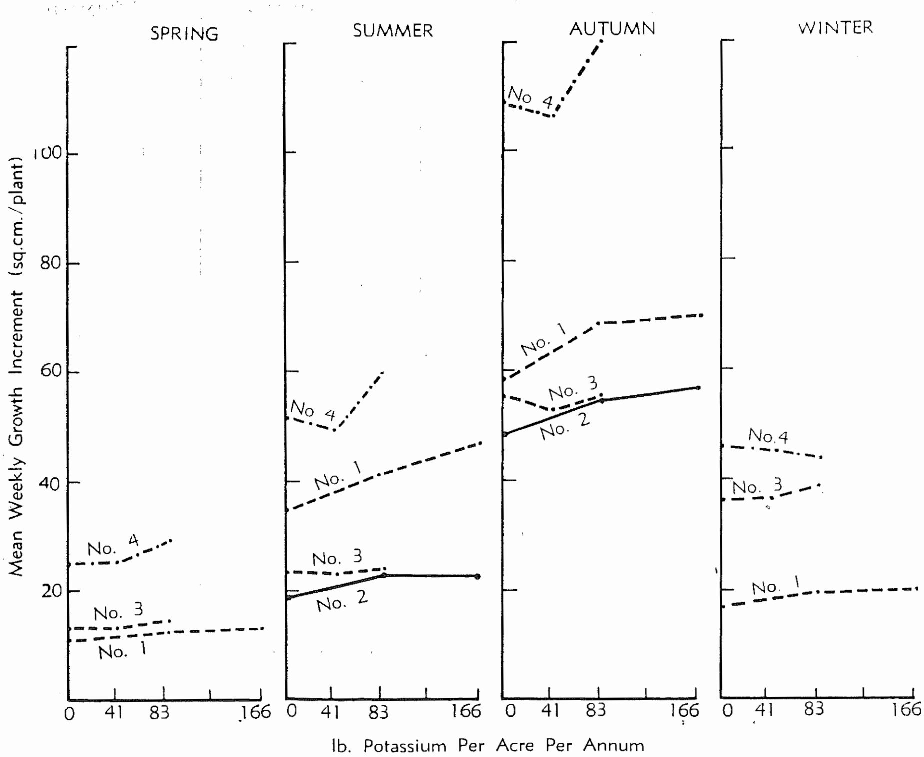

Fig. 3.

Mean Weekly Growth Increments at Four Levels of Potassium for Each of Four Growth Periods.

V. TIME OF FLOWERING.

Flower counts were made in the spring of 1952 to determine whether fertilizer treatments had influenced the time at which the inflorescence appeared. Differences would, of course, be masked by artificial flower induction, and counts were therefore based on the number appearing in advance of the main flowering. This did not apply in Trial 3, where induction treatment was deferred from May to October, and where about 10 per cent. of natural flowering occurred in September.

These effects are set out in Table 7 and shown graphically in Fig. 4. The clearest picture is obtained in Trial 3, since artificial flower induction was not applied until after the natural spring flowering.

Table 7.

FLOWERING COUNTS (MEAN NUMBER OF PLANTS PER PLOT), SPRING, 1952.

Treatment.	Glasshouse. 9/9/52.	Dagun. 1/10/52.	M.E.S. 12/9/52.
N1	31·2	12·7	9·7
N2	31·6	9·3	9·7
N3	32·6	7·7	5·8
P0	33·4	9·4	8·6
P1	..	..	8·2
P2	30·3	10·8	8·4
P3	31·7	9·5	..
K0	37·9	12·2	8·9
K1	..	8·3	8·0
K2	32·9	9·2	8·3
K3	24·6	..	..
Mean	31·8	9·9	8·4
Necessary differences for significance 5%	5·1	2·9	3·9
Necessary differences for significance 1%	6·9	4·0	5·2

On the high-potassium soils (Trials 3 and 4), increase in nitrogen delayed flowering, the effect of the highest level being significant in Trial 4. On a low-potassium soil (Trial 1) a similar effect was produced by each increment of potassium. The overall effect of potassium in delaying flowering was also manifest in Trial 3 on a soil high in potassium.

It would appear that the effect of treatments on flowering time is associated with vegetative growth. The absence of any effect from nitrogen on the low-potassium soils is probably due to the fact that potassium, rather than nitrogen, was the limiting factor in growth.

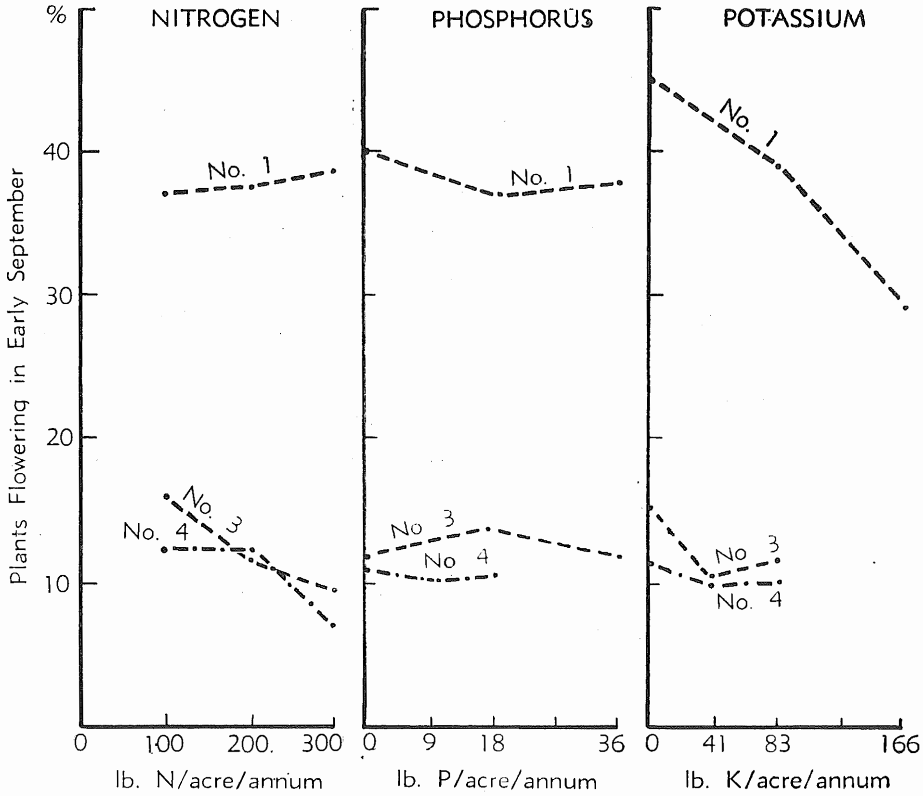

Fig. 4.

Percentages of Plants Flowering in Early September, in Advance of Main Flowering (Trials 1, 3 and 4).

VI. YIELDS.

Yields were based on the summer plant crop, except in Trial 3, where the crop was harvested in the late autumn. Where necessary, and depending on the significance of the regression, yields were adjusted for stand irregularities due to minor disease incidence. The results appear in Tables 8 and 9.

The effect of potassium on yield on the two low-potassium soils (Trials 1 and 2) was similar to the growth response prior to flowering. In the case of Trial 4, the effect of increases in nitrogen was quite apparent in the yields, although the differences in plant growth were not significant.

Table 8.

YIELDS OF FRUIT (TONS/AC. "TOPS OFF") ADJUSTED FOR STAND.
PLANT CROP 1953.

Treatment.	No. 1.	No. 2.	No. 3.	No. 4.
N1	18·8	14·0	25·9	23·8
N2	18·8	13·9	25·2	24·8
N3	18·8	14·5	25·4	25·2
P0	18·7	13·9	25·4	24·5
P1	..	..	..	24·7
P2	18·8	14·4	25·1	24·7
P3	18·9	14·1	26·0	..
K0	17·3	13·2	25·6	24·5
K1	..	..	25·5	24·5
K2	19·0	14·4	25·4	24·9
K3	20·0	14·8	..	..
Necessary differences for significance 5%	0·7	0·8	N.S.	0·7
Necessary differences for significance 1%	1·0	1·1	N.S.	0·9

Table 9.

NUMBER OF FRUIT AND YIELDS (TONS/AC. "TOPS OFF")—1ST RATOON CROP,
TRIAL NO. 4, SUMMER 1954.

Treatment.	Number of Fruit/80 Plants.				Yields (80 Plants).			
	N1.	N2.	N3.	Mean.	N1.	N2.	N3.	Mean.
P0	87·8	110·7	124·8	107·8	13·7	17·3	19·7	16·9
P1	111·0	110·7	125·8	115·8	18·1	17·9	21·6	19·2
P2	93·2	115·7	136·0	114·9	15·3	19·0	22·2	18·8
K0	95·8	110·8	136·7	114·4	15·1	17·9	22·6	18·6
K1	98·2	108·2	118·7	108·3	16·2	17·6	19·4	17·7
K2	98·0	118·0	131·3	115·8	15·7	18·7	21·6	18·7
Mean ..	97·3	112·4	128·9	112·9	15·7	18·1	21·2	18·3
Necessary differences for significance (main treatments 5%	..	..	..	10·9	..	..	..	2·1
Necessary differences for significance (main treatments 1%	..	..	..	14·8	..	..	..	2·9

Trial 4 was carried through to the ratoon crop, which was produced in the succeeding summer (1954), following artificial flower induction. Since the yield of a ratoon crop is influenced by the number of suckers bearing fruit, fruit counts, as well as yields, have been included in Table 4.

The effect of progressive increments of nitrogen on the number of suckers was most pronounced. Yields were directly proportional to the number of fruit—i.e., the number of suckers produced. It is evident, therefore, that the importance of nitrogen to the ratoon crop lies in the promotion of suckering. The yield response to phosphorus, on the other hand, cannot be explained in the same way.

VII. FRUIT QUALITY.

Although yields were the major consideration, fruit quality, especially for canning, is also important. It is difficult to resolve quality in terms of chemical analysis, but tests over a number of years in Queensland have shown that sugar and acid content can be correlated with quality as judged by tasting panels. Fruit low in acid is rather insipid and flavour improves as the acidity increases. Sugar, on the other hand, is very necessary to offset an acid taste and to render the fruit palatable.

Estimations of sugars and acid (Table 10) were made on samples of five fruit per plot from Trials 1, 2 and 4, taking one fruit per plot on each of five successive harvests. Since the sugars in the juice of the pineapple represent about 85 per cent. of the total solids, Brix determined hydrometrically was used as an index of the sugar content. Acids were determined by titration against 0·1N NaOH and are given as the citric acid equivalent.

Table 10.

SUGAR AND ACID CONTENT OF FRUIT, EXPRESSED AS MEAN "BRIX" (TOTAL SOLIDS) AND CITRIC ACID EQUIVALENT.

Treatment.	No. 1.		No. 2.		No. 4.	
	Brix.	Acid. %	Brix.	Acid. %	Brix.	Acid. %
N1	14·8	0·54	13·3	0·72	15·2	0·68
N2	14·8	0·52	13·3	0·70	15·2	0·64
N3	14·8	0·50	13·4	0·72	14·8	0·61
P0	14·7	0·50	13·4	0·72	15·0	0·65
P1	..	..	..	..	14·9	0·64
P2	14·8	0·53	13·2	0·70	15·2	0·64
P3	14·8	0·54	13·4	0·72	..	..
K0	14·4	0·44	13·4	0·67	14·9	0·62
K1	..	..	..	..	15·0	0·65
K2	14·9	0·54	13·4	0·73	15·2	0·66
K3	15·0	0·58	13·2	0·74	..	..
Mean	14·8	0·52	13·3	0·71	15·1	0·65
Necessary differences for significance 5%	0·2	0·026	0·2	0·036	0·3	0·047
Necessary differences for significance 1%	0·3	0·036	0·3	0·047	0·4	0·064

Added nitrogen had no effect on sugars in the fruit of pineapples grown on the low-potassium soils, but brought about a progressive decrease on the high-potassium soils, the differences between the highest and lowest levels being significant. It had the opposite effect on acid. Increase in nitrogen progressively decreased the acid content, the differences being significant in two of three trials. The effects of phosphorus were not consistent; in one trial the sugar content was increased and in the other the acid content. The general effect of potassium was to increase both sugars and acid, except for a barely significant decrease in sugars in Trial 2.

VIII. DISCUSSION.

(1) Nitrogen.

Up to the time of flower initiation there was no growth response beyond the level N1, which was equivalent to 100 lb. of nitrogen per acre per annum and only about one-third the amount usually recommended in southern Queensland. In Trial 1 there was actually a suppression of growth at the high level of nitrogen; this was also apparent, though not significant, in Trials 3 and 4. Sideris and Young (1946) reported a similar effect in trials in Hawaii and put forward the view that high NH_4 ion concentrations inhibit intake of potassium.

From flowering to harvesting, a period of about six months, doubling the rate of nitrogen brought about increased growth on the high-potassium soils but not on the low-potassium soils. In the latter soils, it would appear, the major limiting factor was availability of potassium rather than of nitrogen. On one of the high-potassium soils (Trial 4) there were significant yield increases with progressive increments of nitrogen. In the other (Trial 3) the differences were negligible, but it is possible that seasonal influences masked treatment differences. Hence, it may be concluded that nitrogen is required in larger amounts after flowering than in the first year of growth. This is in conformity with the conclusions of Nightingale (1942) that intake of nitrogen is highest during the period of fruit development.

In the ratoon crop (Trial 4) there was a marked response to each increment of nitrogen, both in number of fruit and in total yield. From an examination of the data presented in Table 4 it is obvious that the main effect was a stimulus to sucker production, since yields were directly proportional to the number of fruit (that is, the number of suckers developed). It would also appear that the requirements of the fruit predominate over vegetative needs and that any shortage of nitrogen is reflected in reduced sucker production and subsequent growth.

Fruit quality determinations show that nitrogen tends to decrease both sugars and acid. Excess nitrogen during the period when the fruit is developing is, therefore, likely to have an adverse effect on quality. On the other hand, as indicated above, insufficient nitrogen at this time is liable to reduce suckering and ratoon yields, so that a fairly fine balance is required over this period.

A single series of trials, such as these, cannot take into account seasonal variations, which have an important bearing on nitrogen assimilation. Further work which is in progress to confirm the general conclusions of these trials will no doubt throw more light on this point. In seasons of prolonged cloudy weather, reduction in carbohydrate synthesis may lead to an accumulation of nitrogen in the plant tissues. Hence, seasonal influences will have a bearing on the amount of nitrogen required during this critical period. From the data available it would appear that 100–150 lb. of nitrogen would be required during the six months from flowering to harvesting. Since an important function of nitrogen is the promotion of suckering, the logical procedure would be to supply the bulk of the fertilizer early in the period, when the sucker buds are normally developing.

(2) Phosphorus.

Absence of a response to phosphorus was characteristic of all the trials in the series, except for the inexplicable increase in yield in the ratoon crop of Trial 4. It may be concluded that soils containing 80 p.p.m. or more of available P_2O_5 are sufficiently well supplied to meet the needs of the pineapple plant. Although this was the lowest level in any of the trials, it is not indicative of the status of virgin soils, since Vallance (1938) and Vallance and Wood (1940) reported much lower values for available phosphate in the soils examined in their surveys.

The effect of phosphorus on fruit quality was by no means clear-cut and the results are conflicting. In some cases it appeared to have a tendency to increase acid and possibly sugars, while in others it had the reverse effect.

(3) Potash.

The response to potash was most pronounced on the low-potassium soils. In Trial 1 this was evident through the whole of the growing period, but in Trial 2 it was less marked. In the latter case, it is probable that reduced rate of growth occasioned by lower temperatures was largely responsible for the limited response. Lack of any major responses on the high-potassium soils agrees with Magistad's (1934) conclusions, in relation to Hawaiian pineapple soils, that on soils above the level of 0·50 m-equiv. per 100 g. pineapples do not respond to potassium.

The level K2 was significantly better than K0 in three of the four trials, but was not in all cases significantly inferior to K3. It was evident from growth measurements that potassium is important for vegetative growth and is probably the limiting factor on soils in which replaceable potassium is below at least 0·18 m-equiv. per 100 g.

From the results of these trials it is concluded that relatively large amounts of potassium are required by the pineapple, and that on high-potassium soils these requirements can largely be met from the soil. In Trial 4 there was a response in the autumn before flowering, though not at other times, which would suggest that the maximum demand occurs at this stage.

IX. CONCLUSIONS.

These trials reveal that, in southern Queensland, the most important nutritional requirement of pineapples is potash, whereas nitrogen is less important than was formerly believed. Current fertilizer practices involve the use of somewhat excessive amounts of nitrogen and, in many cases, inadequate supplies of potash. Queensland pineapple soils vary mainly in their potash content, and this should be taken into account in formulating fertilizing schedules for particular areas.

It is concluded that in the first year—that is, up to the flowering stage—100 lb. of nitrogen and 83 lb. of potassium are required on soils containing over 0·50 m-equiv. per 100 g. of replaceable potassium per 100 g., with the amount of potassium at least doubled where replaceable potassium is below 0·20 m-equiv. per 100 g. A small amount of phosphorus may be required to maintain the phosphorus status of the soil.

From flowering to harvesting, these rates should be doubled to supply the same amount of nutrients in six months as proposed for the first 12 months. The bulk of it should be applied soon after flowering to avoid any possible adverse effect on fruit quality from excess nitrogen.

After the plant crop has been harvested, a high level of nitrogen is required to promote sucker growth for the sake of an early ratoon, and the first application should be at a rate of 75 lb. of nitrogen per acre, possibly without the addition of potash. Subsequent applications may correspond with those for comparable stages in the plant crop.

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