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PINEAPPLE GROWTH AND NUTRITION OVER A PLANT CROP CYCLE IN SOUTH-EASTERN QUEENSLAND. 2. UPTAKE AND CONCENTRATIONS OF NITROGEN, PHOSPHORUS AND POTASSIUM

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SUMMARY

The concentrations and quantities of N, P and K in the leaves, stems, roots and reproductive parts are presented for pineapple plants from a standard commercial planting. A spring planting of slips of the Cayenne variety was used and the monthly sampling terminated at the green fruit stage.

N and K concentrations in the leaves and stems reached well-defined peaks at the February sampling following planting. The leaves had higher concentrations of K while the stems had higher concentrations of N. P concentrations followed a different trend, with low concentrations at the March sampling following planting.

Concentrations of nutrients are a more precise index of nutritional status than absolute data. However, the latter were used as a measure of plant nutrient requirements.

Absolute amounts of N, P and K fell during the first three establishment months and during the late winter–early spring period of 2½ months. In both these periods there was an increased rate of senescence of old leaves, including dying back of leaves from the tip.

During the first summer of growth, water uptake, N and K uptake, dry-weight increase and P uptake occurred in that order of commencement.

Nutrient uptake during the second summer commenced with good rain in mid October and proceeded more rapidly than during the first summer uptake period. The rate of nitrogen uptake during the second summer was nearly three times that for the first, while the potassium uptake rate doubled. Phosphorus was also taken up at a rapid rate during the second summer.

The need to keep heavy nitrogen applications within these nutrient uptake periods is stressed. Potassium uptake was greater than nitrogen uptake and a similar ratio should be maintained in the available nutrients. The main region for the accumulation of K^+ ions appears to be the leaves.

I. INTRODUCTION

The fertilizer requirements of Queensland-grown pineapple plants have been determined over the years by many field trials. Nothing has been known of the nutrient uptake requirements for nitrogen, phosphorus and potassium, though it is known that in most situations and soils the pineapple plant responds favourably and in a varying degree to added nitrogen and potassium (Cannon 1957).

The most popular of the early side-dressing schedules remained in use because of their general suitability to all soil types and particularly to the more highly leached, impoverished replant soils. Thus the old schedules, of up to approximately 30 cwt of mixed fertilizer per acre per annum, tended to be wasteful in order to ensure good growth from poor soils and situations.

With the present trend toward reducing the cost of production, the "law of diminishing returns" from added fertilizer increments has had to be obeyed. Many growers accomplished this by simply increasing the intervals of time between successive applications of side-dressing fertilizer. One of the most popular of these lighter, more economical fertilizer schedules has been the use of a preplant soil dressing of phosphorus and potassium together with frequent foliage applications of a 10% urea spray (Cannon 1960).

The lighter fertilizer schedules have led to much greater differences in growth response according to the natural fertility of the soil. Thus the preplant urea spray schedule produces excellent results when used on a highly fertile soil containing 0·25% N or above and 0·5 m-equiv. of replaceable K per 100 g soil or above, but poor results when used on soils of lower fertility. On poor soils, the nitrogen status of the plants may drop very low, as evidenced by their yellow colour and nitrogen content, and their potassium status may also drop to a low level towards the end of the plant crop cycle (Black and Page, unpublished Departmental report 1962).

If light fertilizer schedules for pineapple nutrition are to remain, they must be flexible enough to allow the grower to adjust applications to soil fertility conditions. The schedule should be based on the actual quantities of nutrients taken up into a healthy, vigorous pineapple plant, rather than on the smallest amount required on certain favoured soil types. The schedule can then be reduced as the soil fertility of the situation allows.

The present work aims at determining the amounts of nitrogen, phosphorus and potassium required by the pineapple plant and also the influences of season and stage of growth cycle. Information on seasonal trends of plant nutrient concentrations will also be useful as a basis for future diagnostic work in pineapple plant nutrition.

II. MATERIALS AND METHODS

Sampling site.—A spring planting of slips (Cayenne variety) on south-facing Block G3 of the Pineapple Industry Demonstration Farm, Beerwah, was chosen for the sampling. The soil type, preplanting treatments and other cultural practices have been described before for the general growth study (Black 1962).

Fertilizing was by side-dressings of a 10:2·6:8·3 mixture except for a side-dressing of 12: 0·9:12·5 mixture applied in March 1960. The first side-dressing contained copper and zinc and was hoed in between the sub-rows 3 weeks after planting. The fertilizer treatment times are indicated in Figures 11 and 12.

Sampling methods.—Five sampling blocks were marked out running across the slope. Each block consisted of three adjacent double rows, each row containing 50 sampling units. Six or more guard plants were left at each end of each double row. The sampling unit consisted of six adjacent plants in the double row. The datum plant was the central plant of the three in the northern sub-row.

On the monthly sampling days, one sampling unit was selected at random from the 150 sampling units of each block. The datum plant for each block was then carefully removed from the soil, its roots and leaves syringed thoroughly, wrapped in plastic, and then removed to the laboratory.

After further washing using "Teepol" detergent, and removal of dead leaf material, the fresh weights of the leaves and stems were obtained. The fresh material was then cut into sections and dried in a forced-draught oven at 65°C. After a thorough washing using detergent, the whole root system was dried at 65°C and its oven-dry weight obtained.

Separate fresh and dry weights of the inflorescence heads which first appeared at the 12th sampling on August 1, 1960, were obtained. After the differentiation of fruit, the tops were removed, the fruit was severed from the stalk and the stalk was severed from the stem. The fresh and dry weights were obtained for the tops, fruit and stalks.

All the suckers and enlarged resting buds of each flowering plant were removed, bulked, and their fresh and dry weight obtained. Where the flowering plant also possessed slips, these and any enlarged resting buds present were removed and treated in the same way as for the suckers.

Analytical methods.—All dried samples to be analysed were ground to a powder using a high-speed blender. The dry powder was stored in sealed specimen tubes at approximately 2°C to avoid loss of nitrogen (Steyn 1959). Subsamples taken for analysis were brought to constant oven-dry weight by 2 hr of drying at 65°C.

Total nitrogen determinations were done by a semi-micro Kjeldahl method using 0·01N HC1 for the titration. Samples for phosphate analysis were dry-ashed at 530°C, the extract was treated with molybdo-vanadate reagent, and the transmission was measured at 436 mμ wavelength.

Potassium in the leaves, stem and reproductive parts was determined by the flame photometric method of Mathis (1955) except that the aqueous extraction period was extended to 30 min of mechanical shaking. Samples of leaves and stems checked with repeated 30 min extractions and extraction blanks showed that 99 to 100% of the extractable K was read after a 30 min extraction period.

The root samples were not ground finely enough with the blender to allow adequate extraction using the shaking technique and were therefore extracted by 1 hr of boiling in distilled water. This technique resulted in the same order of extraction efficiency for the roots as for the leaves and stems.

III. RESULTS

(a) Nitrogen

Nitrogen concentrations (Figure 1) were higher in the stems than in the leaves until flower initiation in May. The early loss of stem nitrogen was probably caused by the use of some stored nutrient during the initial phase of root growth (Black 1962, Figure 3).

The percentage nitrogen in the roots decreased over most of the sampling period, although a slight increase was evident from flowering onwards (Figure 1).

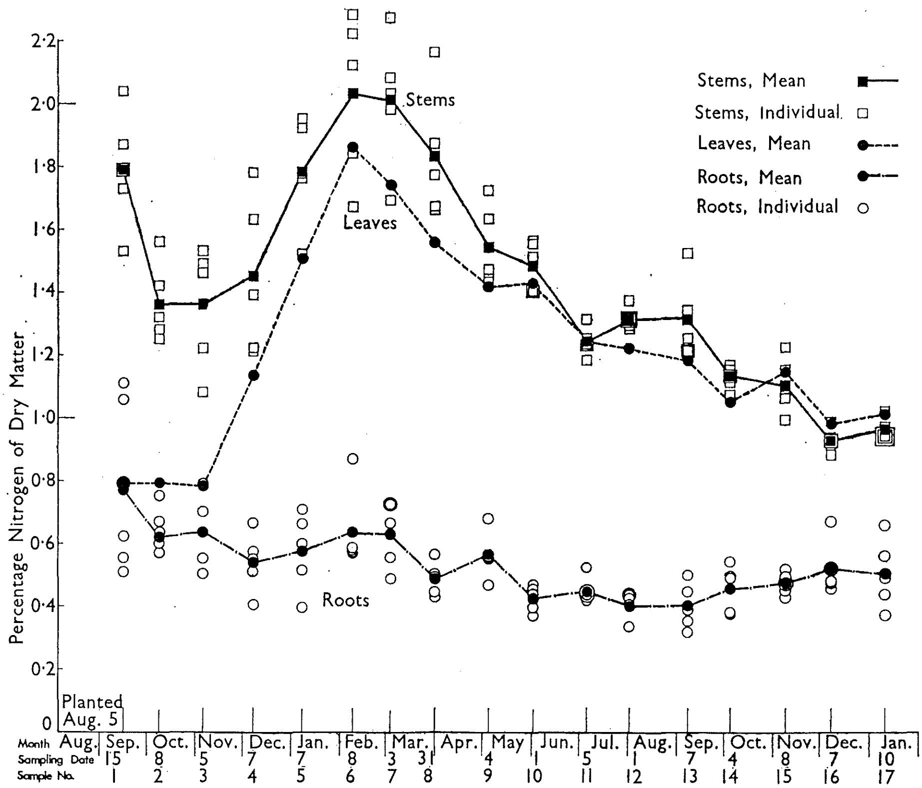

Fig. 1.—Percentage nitrogen of dry matter plotted as individual plants for stems and roots, and as means for stems, leaves and roots for the five plants at each sampling.

This trend was quite different from those of the stems and leaves. To some extent, the periods of higher nitrogen concentration in the roots corresponded to periods of active root growth (Black 1962, Figures 1, 2, 3).

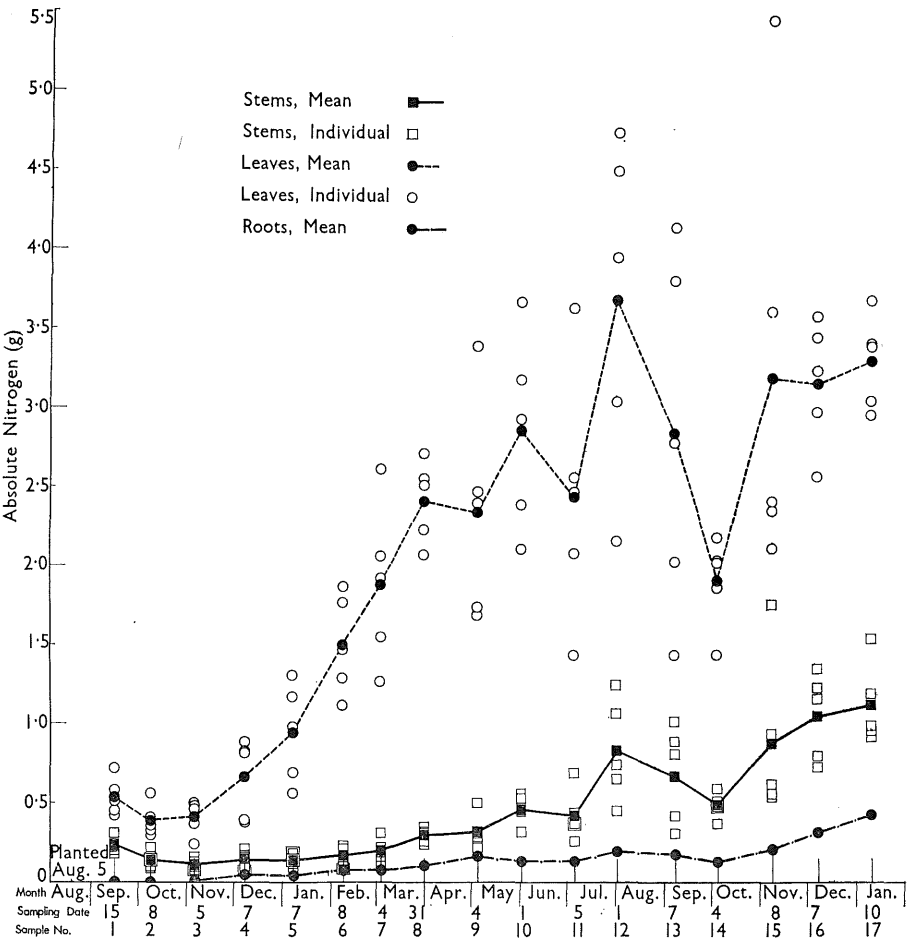

Fig. 2.—Absolute nitrogen in grams plotted as individual plants for stems and leaves, and as means for stems, leaves and roots for the five plants at each sampling.

The absolute amounts of nitrogen for the leaves, stems and roots (Figure 2) generally followed the same trends as the oven-dry weight data (Black 1962, Figures 3, 5). In all cases the trend was a general increase over the whole sampling period, with a large depression in early October 1960 which probably reflected the effect of the dry late winter and early spring. The subsequent increase in absolute nitrogen coincided with rapid growth from October to January.

The total amount of nitrogen for the whole plant, including suckers, slips and fruit structures (Figure 11), followed the same trends. The falling off in values for the two August to October periods was again apparent.

The first period of rapid nitrogen uptake extended from the 3rd sampling on November 5, 1959, to the 8th sampling on March 31, 1960, and showed an increasing rate. The second period of rapid uptake extended from the 14th sampling on October 4, 1960, to the 17th sampling on January 10, 1961.

(b) Potassium

The potassium concentrations (Figure 3) showed much the same overall trends as the nitrogen concentrations (Figure 1), with a peak in early February and a fall over the rest of the sampling period. For both nutrients, the peak concentrations in the stems were spread over a longer period than for the leaves.

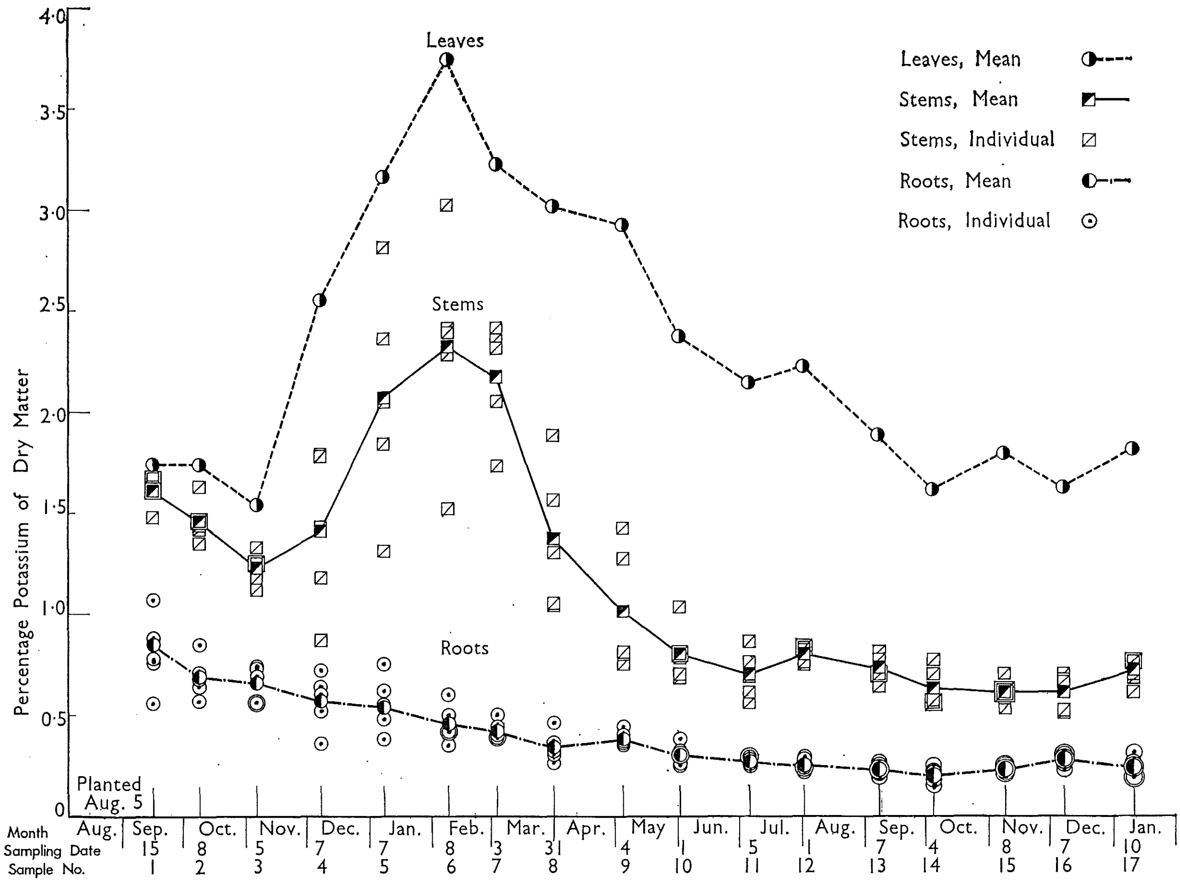

Fig. 3.—Percentage potassium of dry matter plotted as individual plants for stems and roots, and as means for leaves, stems and roots for the five plants at each sampling.

The concentrations of potassium in the leaves and stems of the planting material were very similar at the first sampling (Figure 3), but during the remainder of the growth cycle the leaves maintained a considerably higher concentration of potassium than the stems. This differed from the pattern for nitrogen concentrations (Figure 1), where the stems commenced with higher concentrations than the leaves but came together during the later stages of the growth cycle.

The percentage of potassium in the roots decreased gradually throughout the growth cycle (Figure 3). This was probably because of the increasing proportion of older roots.

The absolute potassium levels in the roots were generally lower than the absolute nitrogen levels (Figure 4). The low level of potassium in the roots

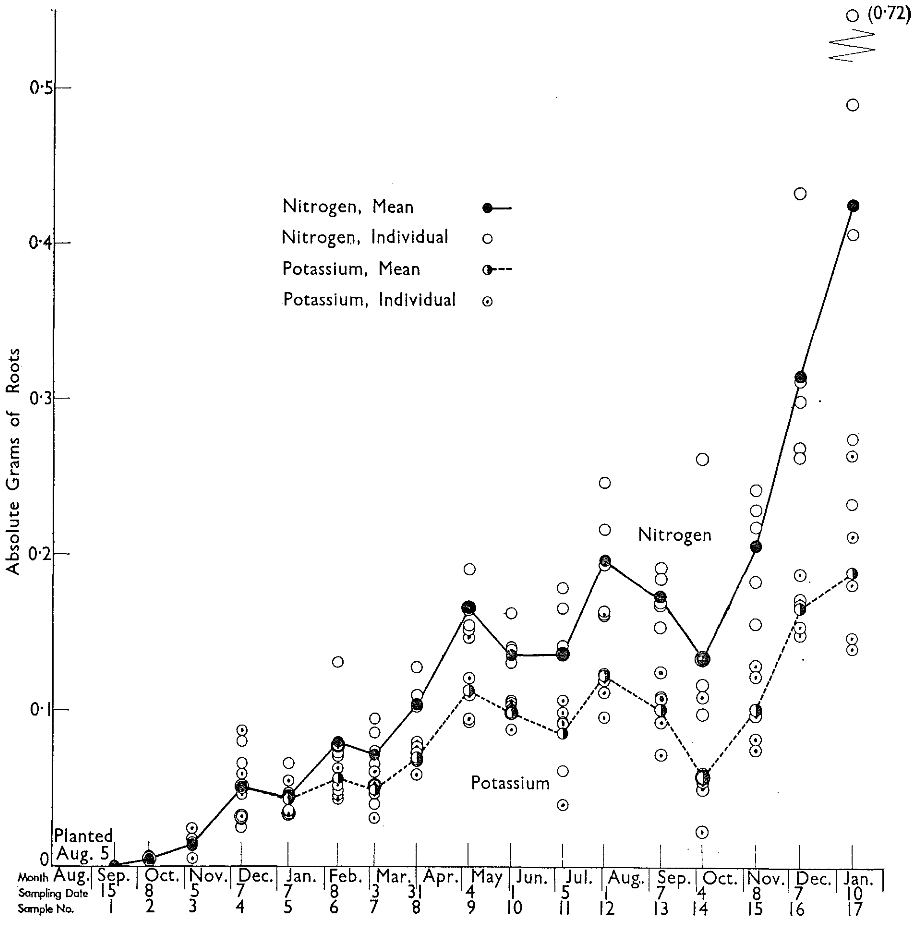

Fig. 4.—Absolute grams of nitrogen and potassium in roots plotted as individual plants and as means for the five plants at each sampling.

would be to some extent due to leaching during the preparation of the samples. It is impossible to remove all the soil from a root system without removing some K^+ ions.

The potassium concentrations in the stems were generally lower than the nitrogen concentrations except about the period of peak values at the 6th sampling in February (Figures 1, 3). On the other hand, potassium concentrations in the leaves were always considerably higher than nitrogen concentrations (Figure 5).

The absolute potassium data for the leaves, stems and roots (Figure 6) followed the same trends shown by the absolute nitrogen data (Figure 2). The total potassium data for the whole plants and over the two periods of rapid uptake (Figure 11) also closely followed the nitrogen data.

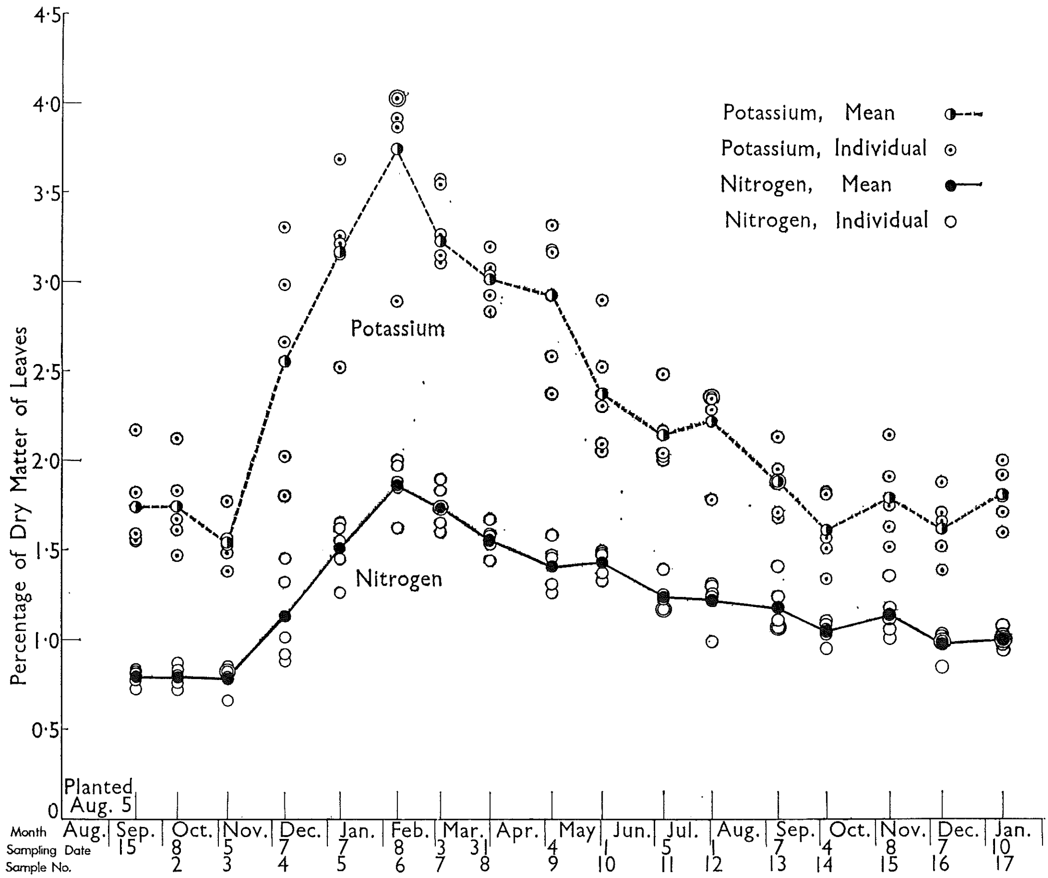

Fig. 5.—Percentage potassium and nitrogen of dry matter for leaves plotted as individual plants and as means for the five plants at each sampling.

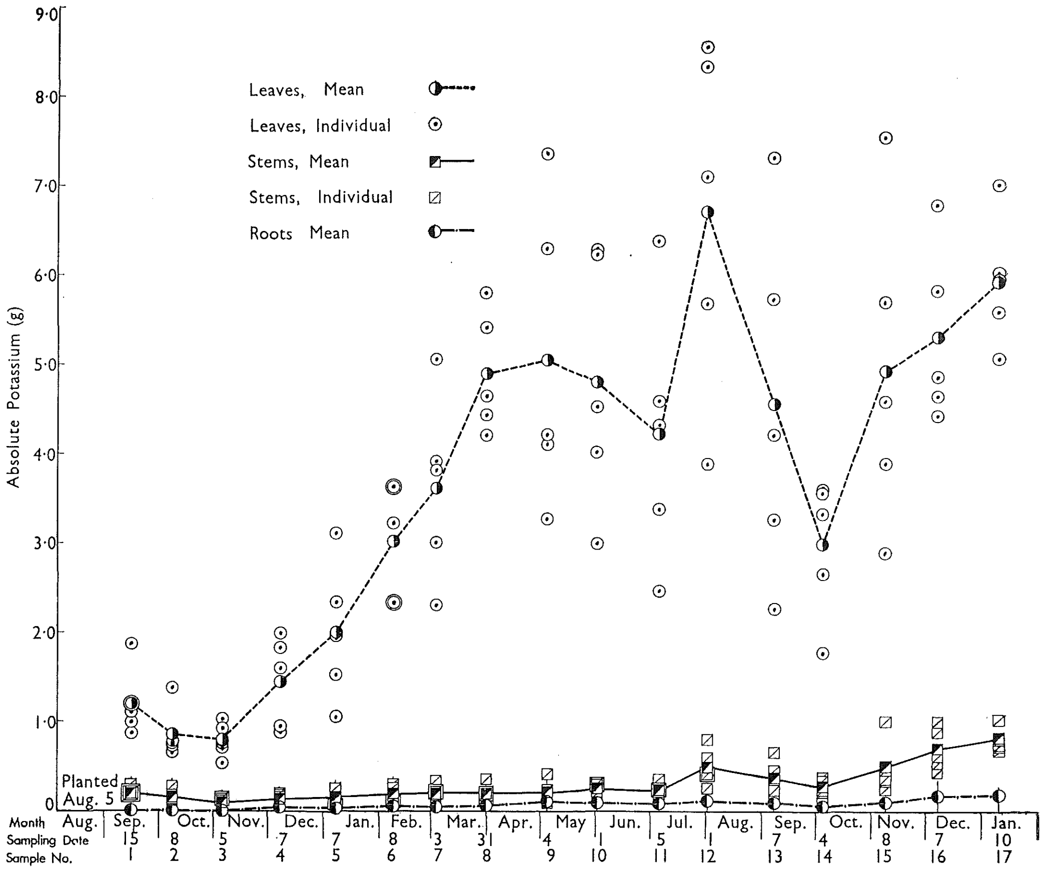

Fig. 6.—Absolute grams of potassium plotted as individual plants for leaves and stems, and as means for leaves, stems and roots for the five plants at each sampling.

(c) Phosphorus

The phosphorus concentrations in the stems and leaves (Figure 7) followed a different pattern from that for nitrogen and potassium (Figures 1, 3). Whereas nitrogen and potassium concentrations reached well-defined peak values at the 6th sampling in early February, the phosphorus concentrations dropped to a low value at the 7th sampling in early March. There followed a rapid build-up of phosphorus concentrations during March, April and May, when nitrogen and potassium concentrations decreased.

For the plants at the first sampling, the relationship of the phosphorus concentrations of the stems and leaves was very similar to that for nitrogen, the nitrogen levels being approximately 10 times those for phosphorus (Figures 1, 7). However, the stem phosphate concentrations did not show the initial loss as for nitrogen, suggesting a much slower movement of phosphorus from the stem into the developing roots and leaves.

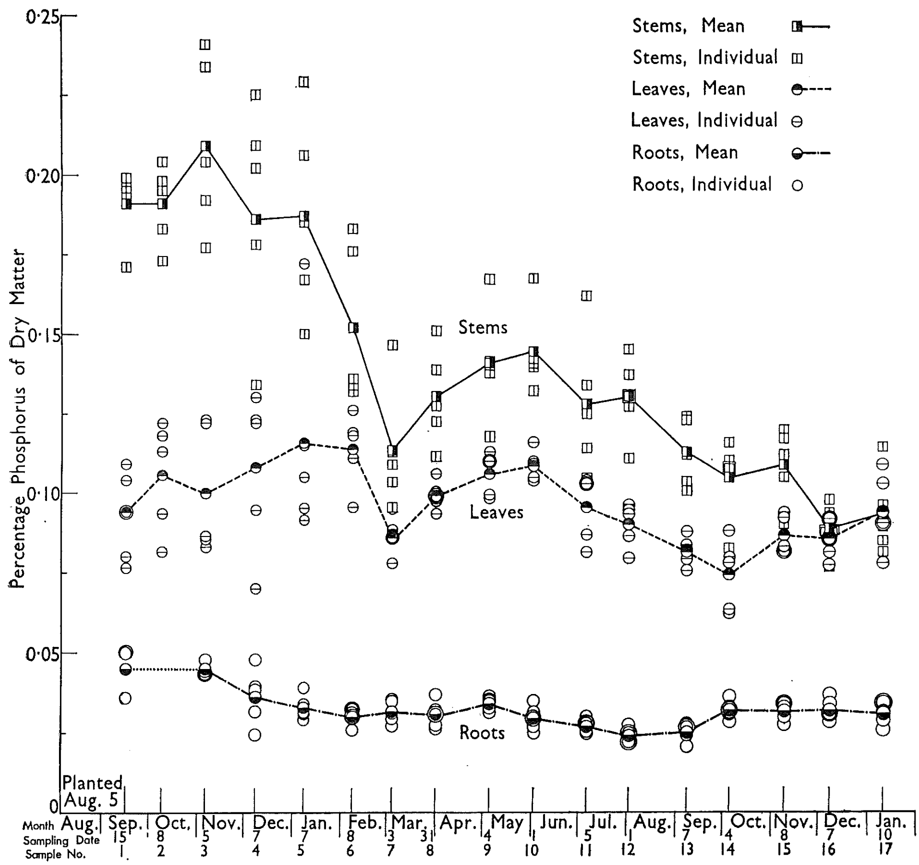

Fig. 7.—Percentage phosphorus of dry matter plotted as individual plants and as means for stems, leaves and roots for the five plants at each sampling.

The percentage of phosphorus in the roots (Figure 7) followed similar trends to the percentages of nitrogen (Figure 1).

The absolute phosphorus contents of the leaves (Figure 8), when compared with those for nitrogen and potassium (Figures 2, 6), showed that rapid uptake of phosphorus was delayed until early March during the first summer but was not delayed beyond the commencement of growth in the second summer. The absolute phosphorus content of the stems (Figure 8) had its lowest point at the 7th sampling in early March. The lowest point for both the nitrogen and the potassium contents of the stems was at the 3rd sampling in early November (Figures 2, 6)

The absolute phosphorus data for the leaves, stems and roots (Figures 8, 12) showed that a rapid rate of uptake of phosphorus commenced from the 7th sampling in early March. This was 4 months later than the commencement indicated for nitrogen and potassium at the 3rd sampling in early November (Figures 2, 6, 11). This difference in timing was not apparent following the commencement of growth and fruit development in the second summer.

(d) Reproductive Parts

Though the purpose of the planting was a summer crop, only 58% of the remaining datum plants actually produced summer fruit. This, together with the fact that facilities for processing large ripening fruit were not available, led to the termination of sampling on January 10, 1961. At this stage the fruit were still green, the largest weighing 1,173 g fresh weight.

Where the reproductive parts were not borne on all five plants sampled, all the mean data calculated for them (Figures 9, 10) were based on the number of plants actually bearing these structures. These data were also used for calculating the total nutrient requirements of the plants (Figures 11, 12).

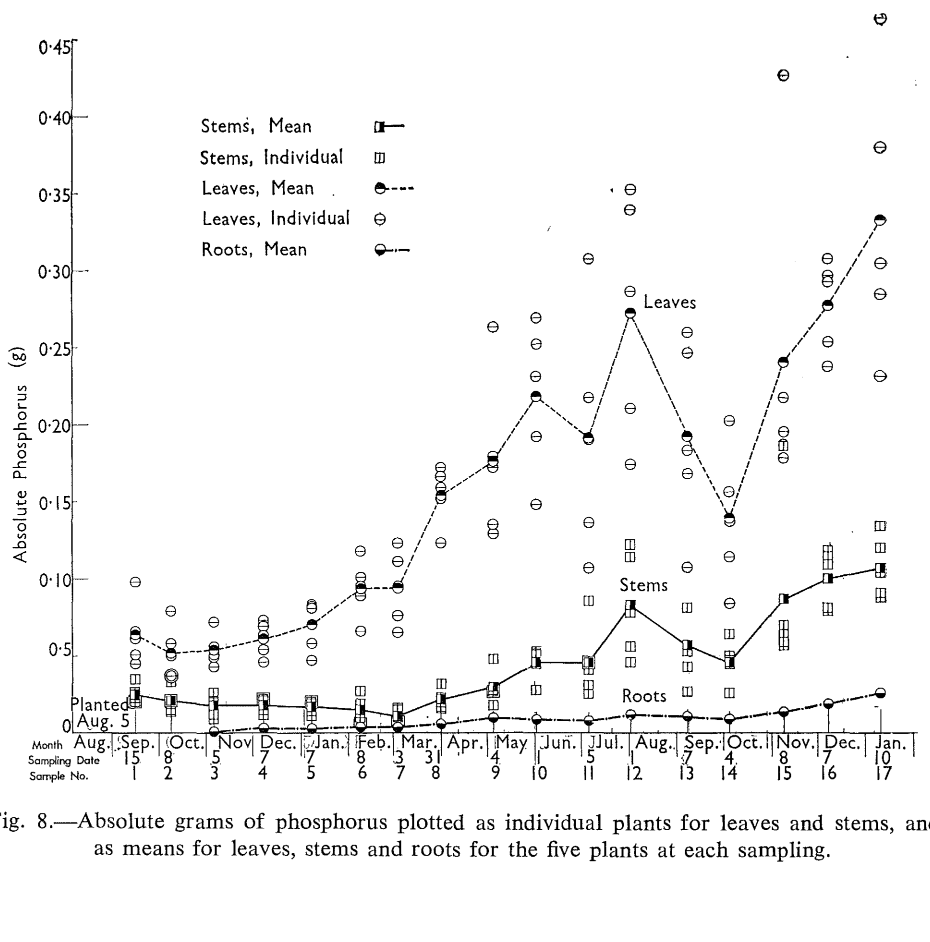

Fig. 8.—Absolute grams of phosphorus plotted as individual plants for leaves and stems, and as means for leaves, stems and roots for the five plants at each sampling.

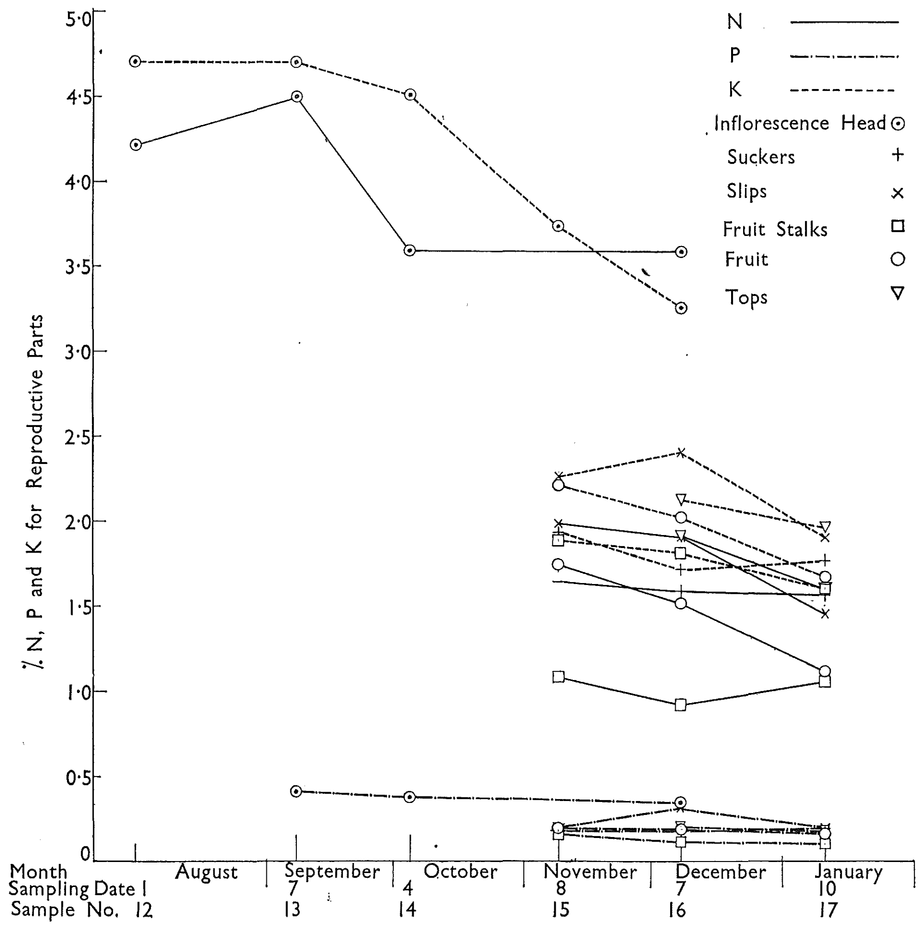

Fig. 9.—Percentage nitrogen, phosphorus and potassium of dry matter for reproductive parts plotted as means on the basis of the number of plants bearing these parts for any sampling.

General information on the growth and development of the reproductive parts was given in an earlier paper (Black 1962).

The concentrations of N, P and K in the undifferentiated inflorescence heads (Figure 9) were very high compared with the vegetative plant parts (Figures 1, 3, 7). This is to be expected from the meristematic nature of the tissue forming the inflorescence head. However, the absolute amounts of nutrient elements in these structures were very small (Figure 10).

The concentrations of N, P and K in the differentiated reproductive parts over the last three samplings remained fairly constant or tended to decrease (Figure 9). Because of the rapid growth of these parts, fruit stalks excepted (Black 1962, Figures 6, 7), the absolute nutrient amounts taken up rose rapidly (Figure 10) and formed a significant contribution to the total nutrient requirements of the plants (Figures 11, 12).

IV. DISCUSSION

(a) General Considerations

The absolute data for N, P and K of the replicates for each sampling generally show a greater variability than the concentration data expressed as percentage of oven-dry weight. Thus concentrations appear to be a more precise index of the nutritional status of the plant at any particular stage of the growth cycle. However, the absolute data, which take into account the additional variability of growth, give a useful measure of the plant nutrient requirements.

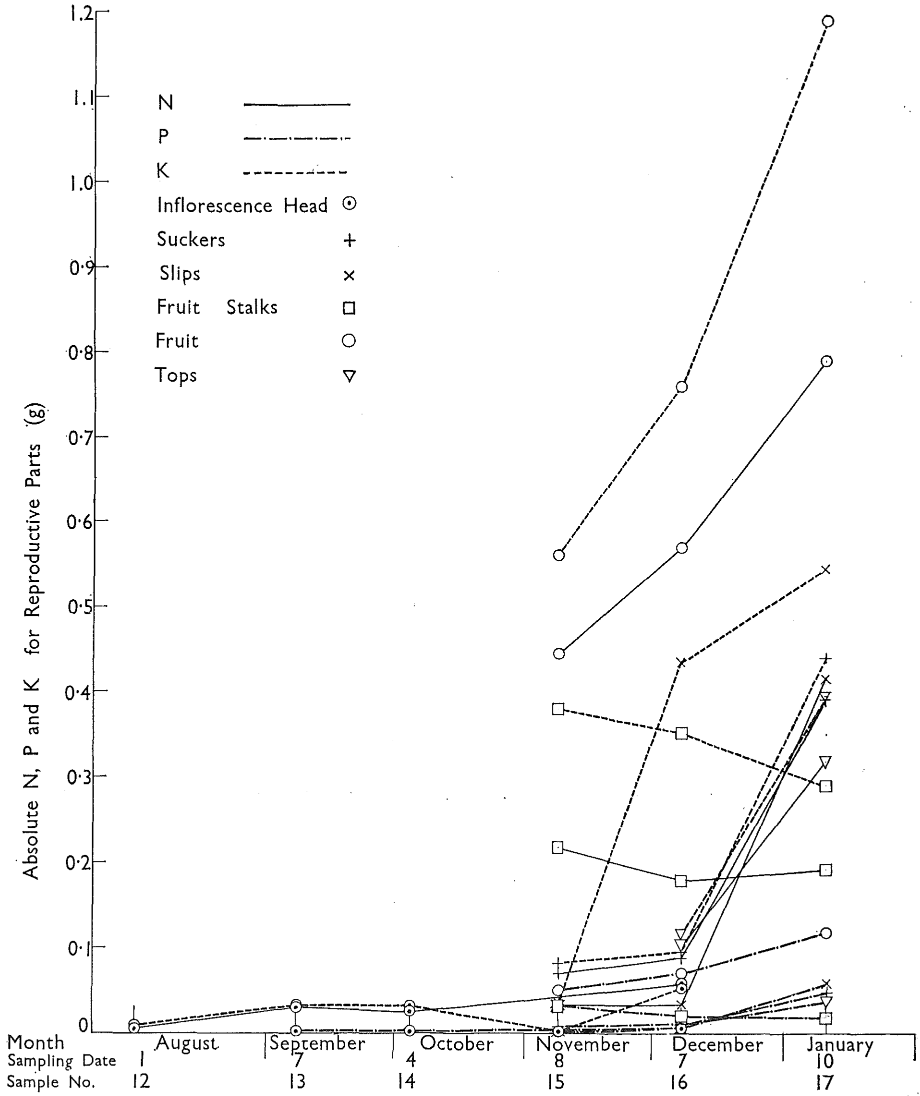

Fig. 10.—Absolute grams of nitrogen, phosphorus and potassium for reproductive parts plotted as means on the basis of the number of plants bearing these parts for any sampling.

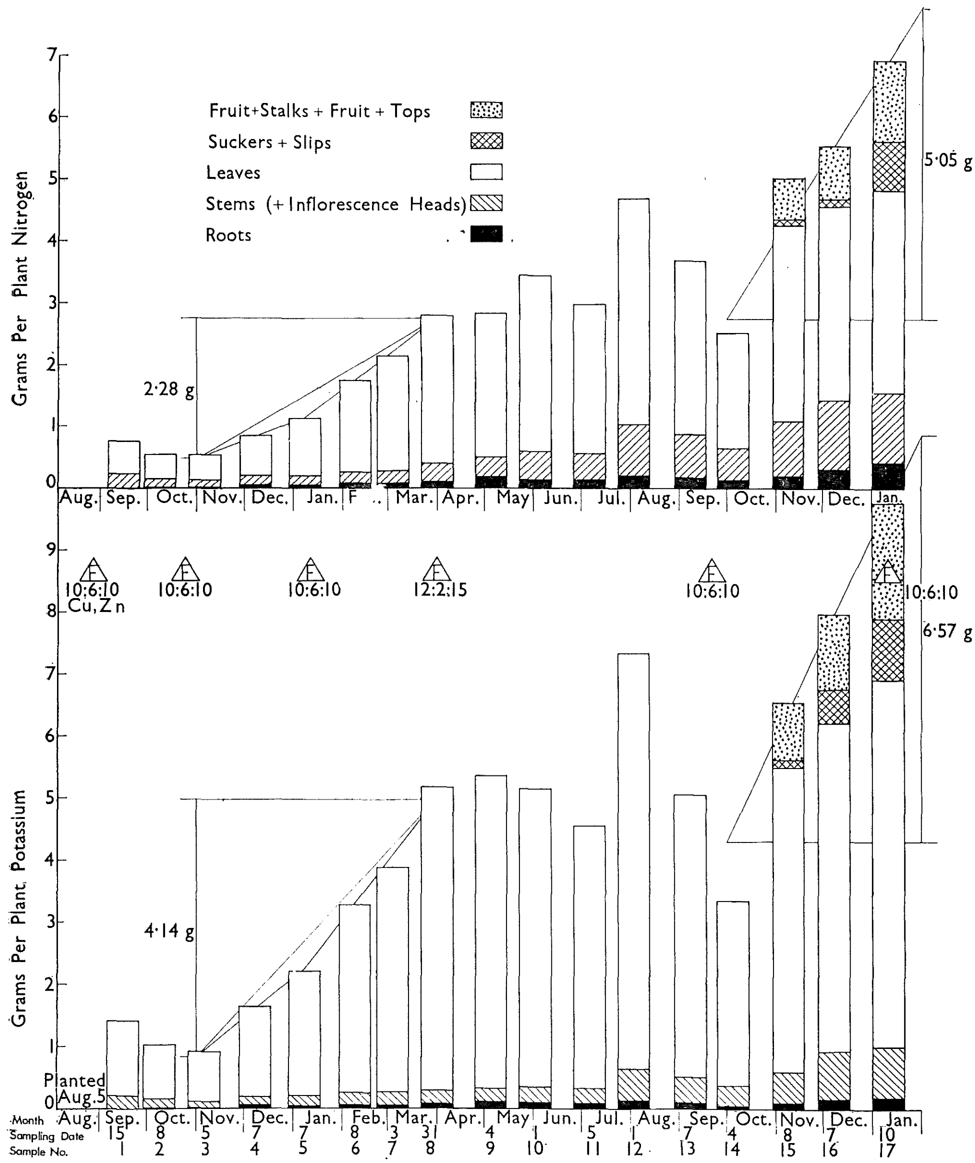

Fig. 11.—Total absolute grams of nitrogen and potassium from mean data for all plant parts, both vegetative and reproductive, for each sampling. Nutrient uptake rates for the two summer uptake periods are shown by the slope of the thin lines.

The nutrient data represent average values for whole plant organs or groups of organs such as leaves. They do not make reference to tissue heterogeneity within or between organs in terms of tissue types or tissue differentiation. Work has been presented on the nutrient level differences between different

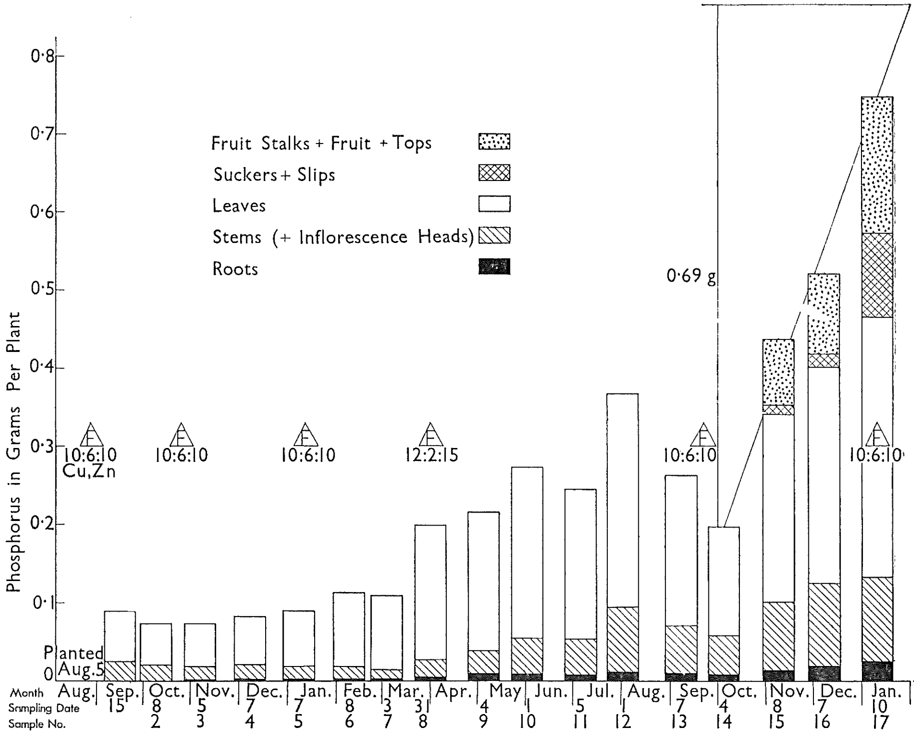

Fig. 12.—Total absolute grams of phosphorus from mean data for all plant parts, both vegetative and reproductive, for each sampling. Nutrient uptake rate for the second summer uptake period is shown by the slope of the thin line.

regions of a leaf and between different classes of leaves for pineapples (Sideris and Young 1945, 1946*a*, 1946*b*, 1946*c*). Generally the concentrations of N, P and K increased towards the older tissue at the leaf tips and often tended to be higher in the old basal leaves. These concentrations were determined on tissue fresh weight.

(b) Growth and Nutrient Uptake Sequence

During the first three establishment months the absolute amounts of N, P and K in the plant decreased and this particularly applied to potassium. The dry weight of the plant also decreased over this period and the only plant constituent to increase was water. The establishment period may be less than 3 months under more favourable conditions.

During the 5 months from early November to early April, N and K were taken up by the plant at a very rapid rate, as also was water over most of this period. The dry weight of the plant increased slowly for the first 3 months of this period, resulting in a rapid increase of N and K concentrations on a dry weight basis. The rate of increase of dry matter rose sharply from the early February sampling and overtook the rates of uptake of N and K. As a result of this, N and K concentrations fell quite rapidly from the early February sampling.

The physiological significance of the upward trends in concentration of leaf N and K in the early uptake phase—as shown by concentrations on a dry-matter basis (Figures 1, 3, 5)—was accentuated by the accompanying uptake of water and lagging of growth in terms of dry matter. The concentrations of potassium on a leaf-water basis did not vary nearly as much (Figure 13). However, as the potassium leaf-water concentration did rise above the stem concentration during the first summer uptake period, this indicates that the leaves were probably the main region of active uptake and accumulation of K^+ ions.

Phosphorus uptake followed a different pattern and proceeded very slowly from early November to early March, resulting in a drop of phosphorus concentration over this period. Phosphorus uptake increased rapidly from early March until June, resulting in increased concentrations.

During the first summer of growth the four growth processes of water uptake, N and K uptake, dry weight increase, and P uptake occurred in that order of commencement.

For the winter period of 4 months from early April to early August, dry matter increase proceeded at a considerable rate. The water content of the leaves had commenced to fall slowly while in the stems it dropped sharply during a build-up of food reserves in this organ (Black 1962, Figure 8). N and K uptakes proceeded more slowly over this period, resulting in a decrease of plant concentrations for these two elements. Potassium concentrations on a leaf-water basis also decreased (Figure 13).

The late winter-early spring period of $2\frac{1}{2}$ months from early August to mid October contrasted sharply with all earlier growth periods. Dry weight of all plants fell considerably and moisture content also decreased (Black 1962, Figures 6, 8). The concentrations of N, P and K decreased slightly over this period, showing that absolute amounts of these elements in the plants decreased at a greater rate than dry weight. These losses were due to an increased rate of senescence of old leaves, including the dying back of leaves from the tip. The results imply poor translocation of N, P and K from the senescing tissue.

The final period of rapid growth commenced with good rains in mid October. Concentrations of N, P and K in the leaves and stems remained fairly constant and thus their uptake proceeded at about the same rate as the accumulation of dry matter. The measure of rates for this period included the development of reproductive parts, where again nutrient concentrations remained fairly constant. The rates of uptake over this final growth period proceeded more rapidly than during the first summer of growth (Figures 11, 12).

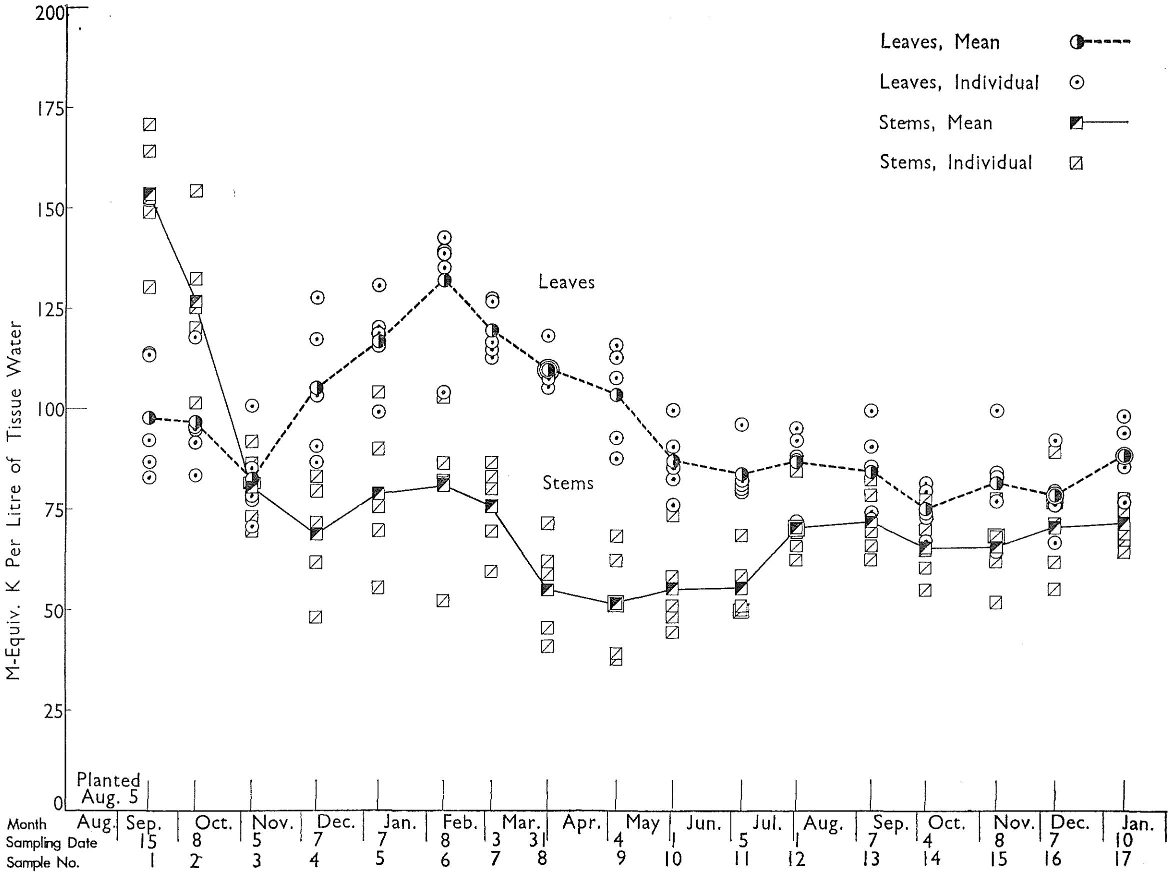

Fig. 13.—Milli-equivalents potassium per litre of tissue water in leaves and stems plotted for individual plants and as means for the five plants at each sampling.

(c) Plant Nutrient and Fertilizer Balance

The quantities of N, P and K supplied in five applications of side-dressing fertilizer exceeded the net uptake by the plants (Table 1). However, the gross uptake exceeds these net figures because of losses in senescent tissues and some leaching of potassium. Also there would be some losses, from the soil system, of the nutrients supplied. Therefore, at least for potassium, the gross plant uptake would probably have exceeded the amount supplied.

It is clear that the plant's potential for uptake of potassium is greater than that for nitrogen (Table 1). A similar ratio should therefore be supplied by the fertilizer unless the soil is particularly high in one of these nutrients.

The excess of phosphate supplied was large (Table 1), but considerable quantities of this element are "fixed" by many soil types. Because all fertilizer applications, except the first, were made as surface side-dressing, any immobilization of this nutrient in the surface layers of soil would render it less available to the plant. On the other hand, superphosphate falling into the leaf bases might make phosphate ions directly available to the plant.

TABLE 1

PLANT NUTRIENT AND FERTILIZER BALANCE UP TO LAST SAMPLING*

Weights as elements of N, P and K per 1,000 plants

—	N	P	K
Net plant uptake	6420 g 14·2 lb	673·9 g 1·49 lb	8855 g 19·5 lb
Approximate application by fertilizer	26·0 lb	5·40 lb	22·8 lb

* The 6th fertilizer application on January 10, 1961, excluded.

(d) Uptake Rates and Fertilizer Schedules

The close balance between plant uptake and fertilizer supply of N and K, even when a heavy side-dressing schedule is used (Table 1), and the need for efficient use of fertilizer, led to the calculation of uptake rates for the first and second summer uptake periods. The second summer uptake period was assumed to last for 6 months from October to March inclusive, though only the first 4 months were actually sampled.

The balancing of high uptake rates is particularly important for nitrogen because of the instability of soil additions and the resulting need for supply at short intervals. Where heavy dressings are used, timing must be correct to avoid waste.

The estimate for nitrogen uptake during the second summer period is nearly three times that for the first (Table 2). Only the 10:0·9:16·6 schedule makes any real allowance for this effect. However, usually only two side-dressings are applied prior to a summer crop harvest and commonly a gap of from 3 to 4 months is left between the second of these applications and the finish of the harvest. Improvements may be required to the nitrogen nutrition of this fruit development period. The accomplishment of this would have to be in keeping with the attainment of a satisfactory fruit quality (Cannon 1957), and the correct balance of the added nitrogen with the other major nutrients would be essential for this.

The limited extent of the major nitrogen uptake periods (Figures 2, 11) means that heavy side-dressings applied outside these periods would involve fertilizer wastage. For instance, during the first summer uptake period, two

TABLE 2

MONTHLY UPTAKE AND SUPPLY RATES FOR NITROGEN

Rates expressed as weight of N/1,000 plants/month

—	First Summer Uptake Period—5 months Nov. to Mar.	Second Summer Uptake Period—4 months Oct. to Jan.
Net uptake by plants	455 g 1·0 lb	1,260 g 2·8 lb
Monthly 10% urea foliage spray	30 to 50 gal/ac* 580 g 1·3 lb	50 gal/ac* 720 g 1·6 lb
Two-monthly 10% urea foliage spray	30 to 50 gal/ac* 290 g 0·65 lb	50 gal/ac* 360 g 0·8 lb
Approximate 2½ monthly 10 : 0·9 : 16·6 side-dressing	25 lb/1,000 plants 455 g 1·0 lb	50 lb/1,000 plants 910 g 2·0 lb
Approximate 2½ monthly 10 : 2·6 : 8·3 side-dressing	50 lb/1,000 plants 910 g 2·0 lb	50 lb/1,000 plants 910 g 2·0 lb

* 14,500 plants/acre

applications of 10:2·6:8·3 fertilizer at 50 lb/1,000 plants to cover the 5-month period should supply adequate nitrogen even allowing for soil losses. Of the four applications recommended, the first in September and the last in April would result in wastage. The lower level of nitrogen uptake at these times would best be catered for by a light nitrogen treatment such as urea foliage sprays.

Similarly, during the second summer uptake period, the recommended 50 lb/1,000 plants of sulphate of ammonia immediately after harvest and the subsequent 50 lb/1,000 plants of 10:2·6:8·3 fertilizer in April would probably involve wastage.

The potassium uptake doubled in the second summer uptake period compared with the first (Table 3). The 10:0·9:16·6 schedule has the proper balance but this is not as good as it appears on Table 3 because of the substitution of sulphate of ammonia after harvest. This substitution and its effects also apply to the 10:2·6:8·3 schedule.

Potassium applications have a much greater capacity for retention in the soil than nitrogen and thus would not necessarily have to be applied during the uptake periods. A preplant soil dressing of 0:2·0:31·1 at 70 lb/1,000 plants would

TABLE 3

MONTHLY UPTAKE AND SUPPLY RATES FOR POTASSIUM
Rates expressed as weight of K/1,000 plants/month

—	First Summer Uptake Period—5 months Nov. to Mar.	Second Summer Uptake Period—4 months Oct. to Jan.
Net uptake by plants	830 g 1·8 lb	1,640 g 3·6 lb
Preplant 0 :2·0: 31·1 70 lb/1,000 plants	1,980 g* 4·4 lb.	. . . .
Preplant 0 :2·0 : 31·1 70 lb/1,000 plants	830 g† 1·8 lb	960 g‡ 2·1 lb
Approximate 2½ monthly 10 : 0·9 : 16·6 side-dressing	25 lb/1,000 plants 753 g 1·7 lb	50 lb/1,000 plants 1,510 g 3·3 lb
Approximate 2½ monthly 10 : 2·6 : 8·3 side-dressing	50 lb/1,000 plants 753 g 1·7 lb	50 lb/1,000 plants 753 g 1·7 lb

* Potential supply for first summer uptake period.
† Supply equilibrated with estimated net uptake.
‡ Monthly supply of balance calculated on the basis of a 6-month second summer uptake period.

supply more than sufficient potassium for the first summer uptake period (Table 3). However, if 1·8 lb. K/1,000 plants/month is allowed for this period, the amount remaining would be insufficient for the second summer uptake period even assuming no soil losses (Table 3).

There is a need for research on the potassium requirements for sucker development and good ratoon crops and on the most satisfactory methods of application.

Phosphorus was taken up at a very rapid rate during the second summer uptake period when a considerable quantity moved into the developing fruit and associated parts (Figure 12). The estimated rate was 0·38 lb (172·5 g) of P/1,000 plants/month. The use of 50 lb of 10:0·9:16·6 fertilizer per 1,000 plants at 2½ month intervals would only supply 0·18 lb P/1,000 plants/month. A 10:2·6:8·3 fertilizer at the same rate would supply 0·52 lb P/1,000 plants/month. In both these schedules the rate of supply would be lowered later in the second summer because of the 3–4 month gap prior to harvesting and the application of sulphate of ammonia after the completion of harvesting.

The application of 70 lb/1,000 plants of 0:2·0:31·1 as a preplant fertilizer would only supply 1·44 lb P. This would hardly be sufficient for the net plant uptake of 1·49 lb (Table 1).

More work is required on phosphate uptake during fruit development and the significance of phosphorus for fruit development and ratoon crops. The best method of obtaining satisfactory phosphorus uptake from dressings applied to the soil surface, or from foliage applications, should also be studied.

V. ACKNOWLEDGEMENTS

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