PRELIMINARY REPORT ON THE ROOT SPREAD IN SUGAR CANE AS REVEALED BY RADIOISOTOPES

By G. H. WOOD

Summary

This paper describes preliminary work with radiophosphorus (P-32) undertaken by the author at the S.A.S.A. Experiment Station, Mount Edgecombe. In order to study the root spread of N:Co.376, radiophosphorus in solution was injected into the soil at various distances, positions and depths in relation to the cane row. (Cane planted 3rd October, 1962.) Uptake of this radiophosphorus by the plant was estimated by sampling the middle 12 ins. of the 3rd leaf lamina.

Radiophosphorus distribution throughout the plant was found to be similar though initially not identical to total phosphate distribution, becoming more nearly similar with the passage of time.

The feeding roots were found to be concentrated mainly beneath the stool with no such roots at lateral distances (6 in. depth) greater than about 4 ft. from the centre of the row. The highest concentration ot roots to the side of the stool was found to be at the 3 in. depth.

It was also found that the plant takes up phosphate strictly in proportion to its growth and that the highest phosphate uptake during the year considered (25th February, 1963 — 25th February, 1964) was in the period 25th February, 1963 to about 25th April, 1963 and again during the beginning of 1964. There was a slow but steady uptake during winter and spring.

Future expansion of root studies with P-32 is envisaged.

Introduction

It is only during the past two decades that radioisotopes have been used to any extent in agricultural research and the increase in their use during this period has been phenomenal, spreading to every sphere of agriculture and biology. Radioisotopes are helping scientists to study problems that were difficult or impossible to solve by conventional methods. This is due to the fact that the radioisotope of an element is for all practical purposes chemically and biologically identical and interchangeable with the natural element and yet it emits radiation which can be easily detected and measured, thus distinguishing it from the natural element. The uptake and translocation of a plant nutrient by the plant can thus be easily followed and studied, in addition to being able to distinguish between the nutrient derived from soil and fertilizer in the plant tissues.

The most widely used radioisotope in Agricultural research is phosphorus-32 although the isotopes of many other plant nutrients are used, some extensively. Phosphorus - 32 (P-32) is ideally suited for soil-plant studies for a number of reasons, viz:—

(*a*) The relative immobility of phosphate in the soil, thus ensuring that it will stay approximately where it has been placed in the soil even for extended periods.

(*b*) Its half-life (i.e. the time taken for its radioactivity to fall to half its initial value). This is 14.3 days for P-32 which is sufficiently long for measurable results to be obtained for 3 to 4 months after treatment and yet short enough to obviate elaborate disposal measures. (After 6 months there is only 0.0001 of the original activity left, and after 1 year only about 0.00000001.)

(*c*) It emits only beta radiation of 1.7 MeV maximum energy which is easily detectable with a Geiger counter and yet can be completely stopped with $\frac{1}{4}$ in. perspex. There is no gamma radiation requiring elaborate protective shielding for personnel.

(*d*) It is relatively cheap and produced on a large scale at numerous centres overseas in a pure state. Its transport presents no problem.

The purpose of the investigations described in this paper was to determine the spread and activity of the root system of sugarcane at different distances from the cane row and depths, and also to obtain some idea of the variation in phosphate uptake with age and season. The activity of roots in a certain fixed volume of soil to which a standard amount of P-32 has been added should be proportional to the amount of P-32 appearing in the plant to the concentration of P-32 in a particular part of the plant provided the distribution of P-32 throughout the plant remains reasonably constant with time. Hence, analysis of a sample of plant tissue should reflect the activity of the roots in the P-32 treated soil zone.

Since work with P-32 was only started on the 25th February, 1963, being partly undertaken to familiarize the writer with the technique and handling of radioactive isotopes, the results are of necessity exploratory and preliminary, but are nevertheless of considerable interest.

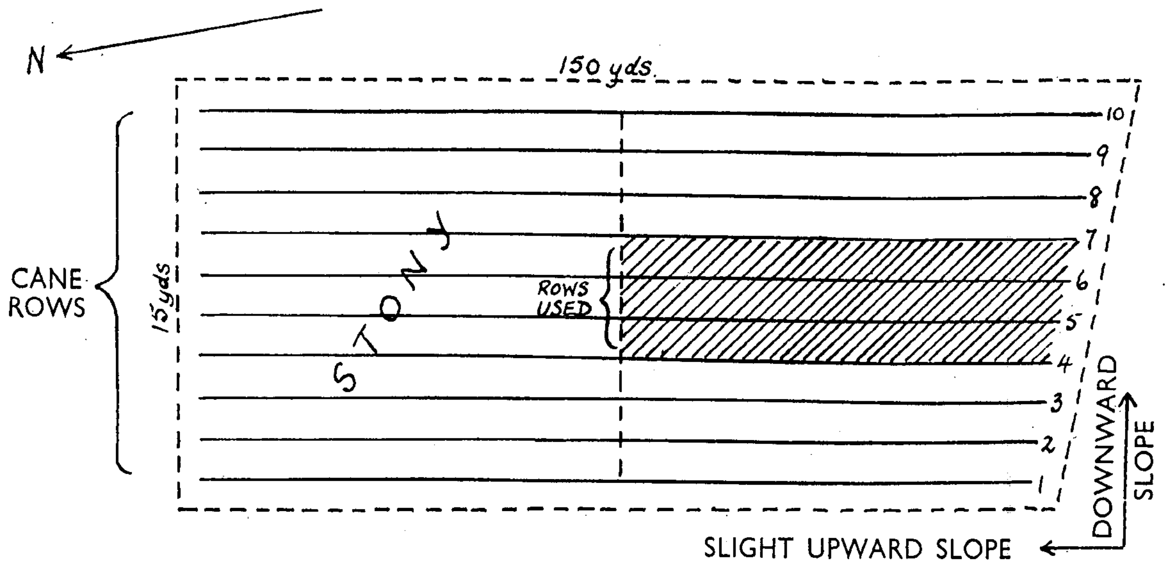
Experimental Details

The experimental site selected was a field on the Experiment Station 15 x 150 yds. which had been planted to N:Co.376 on 3rd October 1962, the row width being about 4 ft. 6 ins.

The soil was a Black Dolerite, Rydal Vale Series.

A plan of the experimental site is given in figure 1, showing the interrows (shaded) used for the present experiment. The P-32 treatments were restricted to the southern half of the field owing to the pronounced stony character of the other half. As can be

FIGURE I



PLAN OF FIELD USED FOR P32-EXPERIMENT

seen from the diagram, the slope faced approximately S.E. The age of the cane at the first application of P-32 (25th February, 1963) was 4.7 months.

Owing to the radioactive decay of the P-32, fresh applications had to be made every 3 to 4 months, the treatments being as follows:

Application No. 1 (25th February, 1963)

5 mc. of P-32 (Specific Activity 500 mc./gP.) contained on receipt in 10 ml. solution was divided into 3 and 2 mc. and diluted to 1 litre and 170 ml. respectively.

The interrow between rows 5 and 6 was chosen for the treatments. The P-32 solution was injected into the soil at a depth of 6 ins. by means of a 20 cc. veterinary syringe and a foot-long 11-gauge needle. Each treatment consisted of 8 evenly spaced 20 cc. injections in a line 2 ft. long parallel to the cane row. The 3 mc./l. solution was used to effect 6 treatments of approximately 0.5 mc. each. The 2 mc./170 ml. solution was used for 1 treatment of approximately 2 mc.

Table 1

Treatment	mc.	Distance (ft.) from		
		Row 4	Row 5	Row 6
1	0.5	5.2	0	3.8
2	0.5	—	0.5	4.1
3	0.5	—	1.0	3.2
4	0.5	—	1.5	3.2
5	0.5	—	2.0	2.4
6	2.0	—	1.7	2.0

Treatment 7 (0.5 mc.) was made across row 6 and perpendicular to it.

Application No. 2 (10th June, 1963)

5 mc. of P-32 (Specific activity 500 mc./gP.) contained on receipt in 10 ml. solution was divided into 3 and 2 mc. and diluted to 836 and 848 respectively. (3.59 mc/l. and 2.50 mc./l. respectively.)

The same interrow was used as for Application 1. In this case each treatment consisted of 12 evenly spaced 20 cc. injections 6 ins. deep in a line 3 ft. long parallel to the cane row.

Table 2

Treatment	mc.	Distance (ft.) from		
		Row 5	Row 6	Row 7
1	0.60	3.4	0	4.3
2	0.60	0.5	3.4	—
3	0.86	3.0	1.0	—
4	0.86	1.5	3.0	—
5	0.86	2.3	2.0	—
6	0.60	4.0	0	4.4

Treatment 7 (0.5 mc.) was made across row 6 and perpendicular to it.

Application No. 3 (23rd September, 1963)

6 mc. of P-32 (Sp. activity 500 mc./gP.) contained on receipt in 10 ml. solution was diluted to 2 litres (exact concentration 2.97 mc./l.).

Interrow used: Between rows 6 and 7.

Injections: Same as application 2, except that in treatments 6, 7 and 8 the injections were 9, 3 and ½ ins. deep respectively.

Table 3

Treat-ment	mc.	Distance (ft.) from			Depth (ins.)
		Row 5	Row 6	Row 7	
1	0.71	4.5	0	4.0	6
2	0.71	—	0.5	3.3	6
3	0.71	—	3.0	1.0	6
4	0.71	—	1.5	3.0	6
5	0.71	—	2.0	2.0	6
6	0.71	—	0.5	3.6	9
7	0.71	—	0.5	3.4	3
8	0.71	—	0.5	3.7	½

Application No. 4 (3rd February, 1964)

6 mc. of P-32 (Specific activity 500 mc./gP.) contained on receipt in 10 ml. solution was diluted to 2l. (Exact concentration 3 mc./l.).

Interrow used: Between rows 4 and 5.

Injections: Same as application 3.

Table 4

Treat-ment	mc.	Distance (ft.) from		Depth (ins.)
		Row 4	Row 5	
1	0.72	0	4.7	6
2	0.72	0.5	4.2	6
3	0.72	1.0	3.3	6
4	0.72	1.5	2.6	6
5	0.72	2.0	2.2	6
6	0.72	0.5	4.2	10¾
7	0.72	0.5	4.6	3
8	0.72	0.5	4.9	½

All treatments were spaced sufficiently apart to prevent one plant picking up P-32 from two sources.

Sampling

(a) Application 1

Treatments 1 — 6: Six 3rd leaves were removed at random along 2 ft. of cane row opposite the treatment (13 samples).

Treatment 7: Three samples were taken at distances 1, 3 and 6 ft. along the row from the treatment. Each consisted of six 3rd leaves, three from either side of the treatment.

Punch discs were taken by means of a leaf punch sampler at evenly spaced intervals along the middle 12 ins. of the laminae of all the 6 leaves in each sample. The number of punch discs taken depended on the size of sample required for ashing.

(b) Application 2

Treatments 1 — 6 (excluding row 6 of treatment 6): In order to decrease the sampling variance and cut damage to the plants to a minimum, the 3rd leaves were not removed as in application 1, but punch discs were taken at evenly spaced intervals from the middle 12 ins. of one lamina only of 18 attached leaves, randomly selected along the 3 ft. of cane row opposite the treatment.

Treatment 7: Three samples were taken at distances 1, 2.2 and 5 ft. along the row from the treatment. Each consisted of punch discs taken at evenly spaced intervals from the middle 12 ins. of one lamina only of 12 attached leaves, 6 on either side of the treatment.

(c) Applications 3 and 4

All samples were taken as for treatments 1 — 6 of application 2. As the sample size for ashing had now been standardized at 1g. dry matter, 23 discs from each lamina were found to be sufficient.

Samples were taken every Monday until 8th April, 1963, after which they were taken every second Monday. First samples for each application were taken 1 week after treatment.

Preparation of the sample for assay of P-32 and total phosphate

The punch discs were transferred to petri dishes and dried in an oven at about 105°C for 3 hours or longer. Aliquots (225, 450, 900 or 1000 mg. in the case of application 1, 0.5 or 1g. in the case of application 2 and 1g. subsequently) from each sample were weighed into 50 cc. Erlenmeyer flasks and 10 ml. (for 225g.), 15 ml. (for 450g.) or 20 ml. (subsequently) of acid mixture added (mixture: 116 ml. conc. H_2SO_4, 200 ml. perchloric acid (72%) made to 1 l. with 55% HNO_3). The material was digested slowly on a hot plate, gradually increasing the temperature until fumes of H_2SO_4 filled the flasks, after which they were heated for a further 5 minutes.

10 ml. distilled water was added to the cooled digest in all cases and the P-32 content determined by means of a Philips Type 18525 (M6H) liquid Geiger counter and Ekco Type N529C Scaler. Radioactive standards were prepared from the original solution to convert counts per minute to microcuries P-32/ml. and hence the amount of P-32 (microcuries) in the sample could be calculated taking the radioactive decay, final volume, self-absorption due to solution density, and, in the case of low counts, the radioactive potassium — 40 content obtained from potash analysis of samples into account. The results obtained were corrected for radioactive decay to 6.00 pm. on the date of application, giving the concentration of P-32 which would have been present in the plant had no decay taken place.

Total phosphate was measured on a suitably diluted digest using a molybdenum blue method with amino-naphthol sulphonic acid reagent as reductant. The final results were expressed as specific activity (uc. P-32/gP.).

Variation of radioactivity of samples with time

The number of counts per minute given by the samples from any single application is determined by two opposing factors, viz., the uptake of P-32 by the plant and its radioactive decay (half-life 14.3 days). At first the former predominates causing a sharp increase in sample counts per minute with time, but after three to five weeks the latter starts to predominate causing a progressive decrease in counts. A graph of counts per minute (cpm.) vs. time (figure 2) thus has a maximum at 3 to 5 weeks and thereafter gradually tends to a negative exponential-like curve, the radioactive decay eventually completely masking the uptake.

Due to decay, the useful life of a single P-32 experiment has been found to be not more than 120 days, after which the standard deviation of the nett counts becomes so large as to render the results meaningless.

Distribution of P-32 in the cane plant

Before considering the results it was important to have some idea of how the P-32 distributed itself in the plant and whether this distribution changed appreciably with time. For this purpose, a sample of two sticks complete with foliage was taken from application 2, treatment 6, row 6 every fortnight, and divided up into 17 parts. Each part was weighed before and after drying at 105°C, ground up and 1g. dry matter (amount of material permitting) taken as a sample. The samples were ashed with 20 cc. acid mixture and treated as above.

The results are presented in figures 3 to 5.

FIGURE 2

VARIATION OF SAMPLE COUNTS PER MINUTE WITH TIME

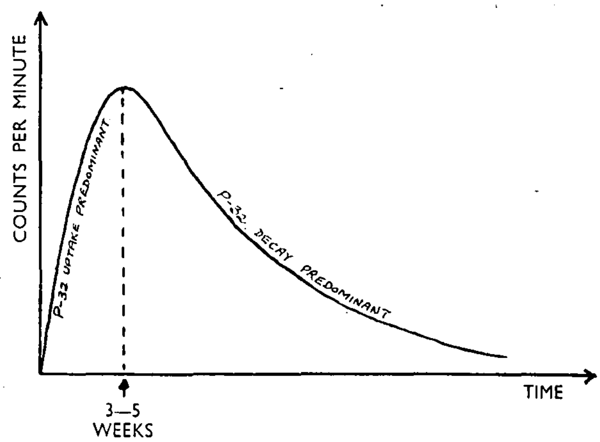
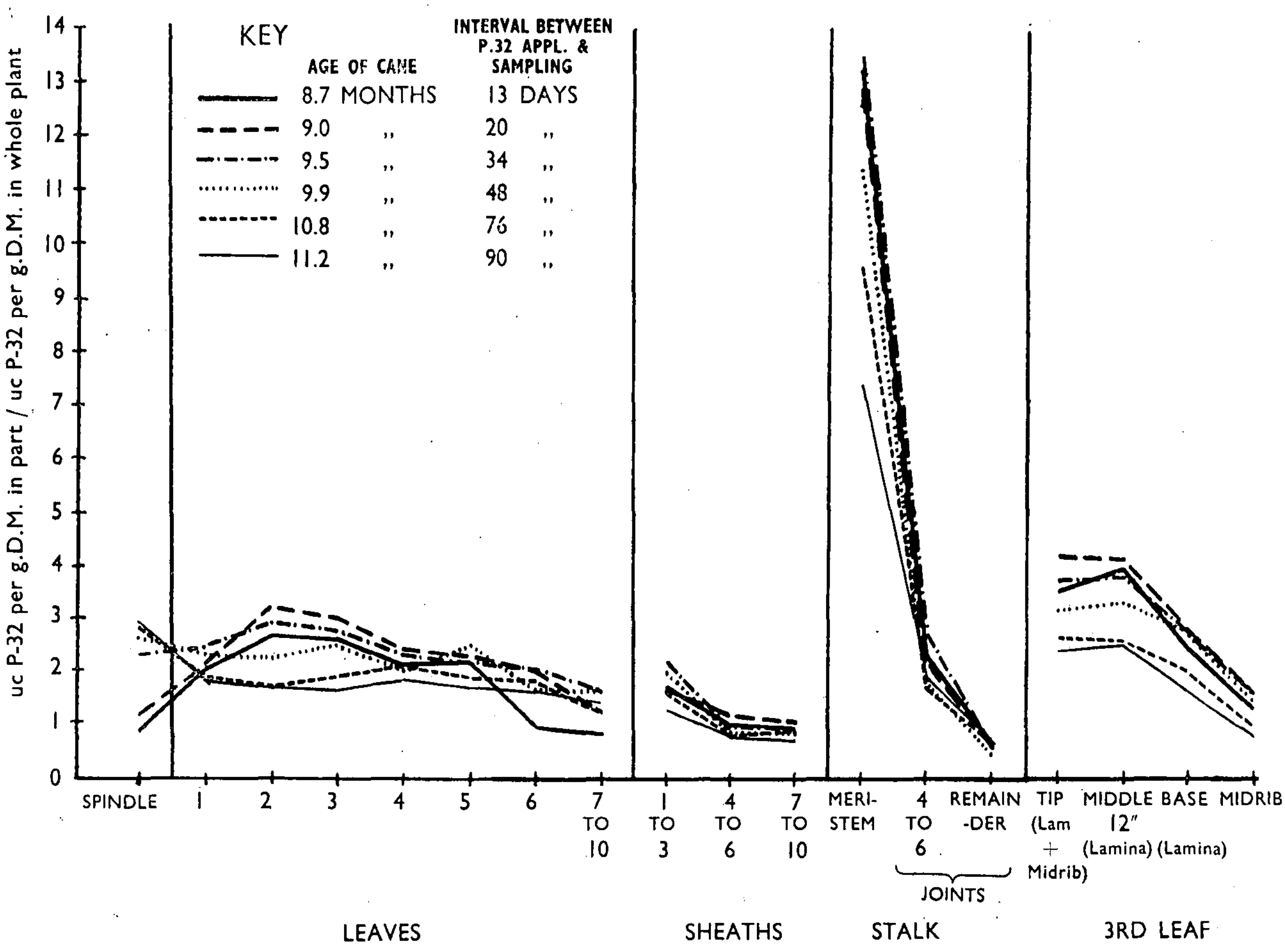


FIGURE 3

DISTRIBUTION OF P-32 IN CANE (RELATIVE TO WHOLE PLANT)
(P-32 APPLIED 10/6/63)



In order to reduce all the results to the same scale, the P-32 concentration in each part is shown in figure 3 relative to the overall P-32 concentration of the whole plant, since the latter increased about thirty-fold from the first to the last sampling. Similarly, in figure 5 the specific activity in each part is shown relative to the overall specific activity of the whole plant.

Variation of P-32 Uptake with Distance from Treatment and Depth of Application

Application 1

A test of the sampling technique showed the sampling standard deviation to be extremely high (25.4 per cent for treatment 1, row 5 and 57.8 per cent for treatment 2, row 6 on 20th May, 1963). The plants also eventually suffered a considerable set-back due to denudation of foliage caused by the sampling method. The results were, however, of interest and will be discussed.

There was no significant uptake at 5 or 6 ft., although it was considerable at the 4.1 ft. distance. In general, however, the specific activity at each sampling approximately followed an exponential curve of the form $A_d=A_oe^{-kd}$ (where k was found to be approximately 0.83, A_d=specific activity at distance d, A_o=specific activity at d=O, e=base of natural logs). This should indicate that phosphate placed directly beneath the row is taken up most effectively. The results for treatment 7 (sampling at intervals along the row from the treatment) seem to fit into the above curves reasonably well, thus showing that roots from one stool could penetrate through the root zone of adjacent stools. This was further illustrated by a special sampling of treatment 7 on the 20th April, 1963 (five three-leaf samples taken at intervals on either side of the treatment) where the specific activity at 3 ft. 6 in. was relatively high. (8.8 μc./gP. compared with 24.2 μc/gP. at 1 ft).

The increase in uptake of P-32 from the 2.0 mc. treatment compared with the 0.5 mc. treatments was 2-3 fold for the 1.7 foot distance only. The uptake at 2.0 ft. from this treatment was negligible.

Applications 2, 3 and 4

The improved sampling technique had the effect of drastically reducing the sampling variance and damage to the plants. This was obvious from the

FIGURE 4

MEAN DISTRIBUTION OF TOTAL P IN CANE (RELATIVE TO WHOLE PLANT) (MEAN OF ALL SAMPLINGS)

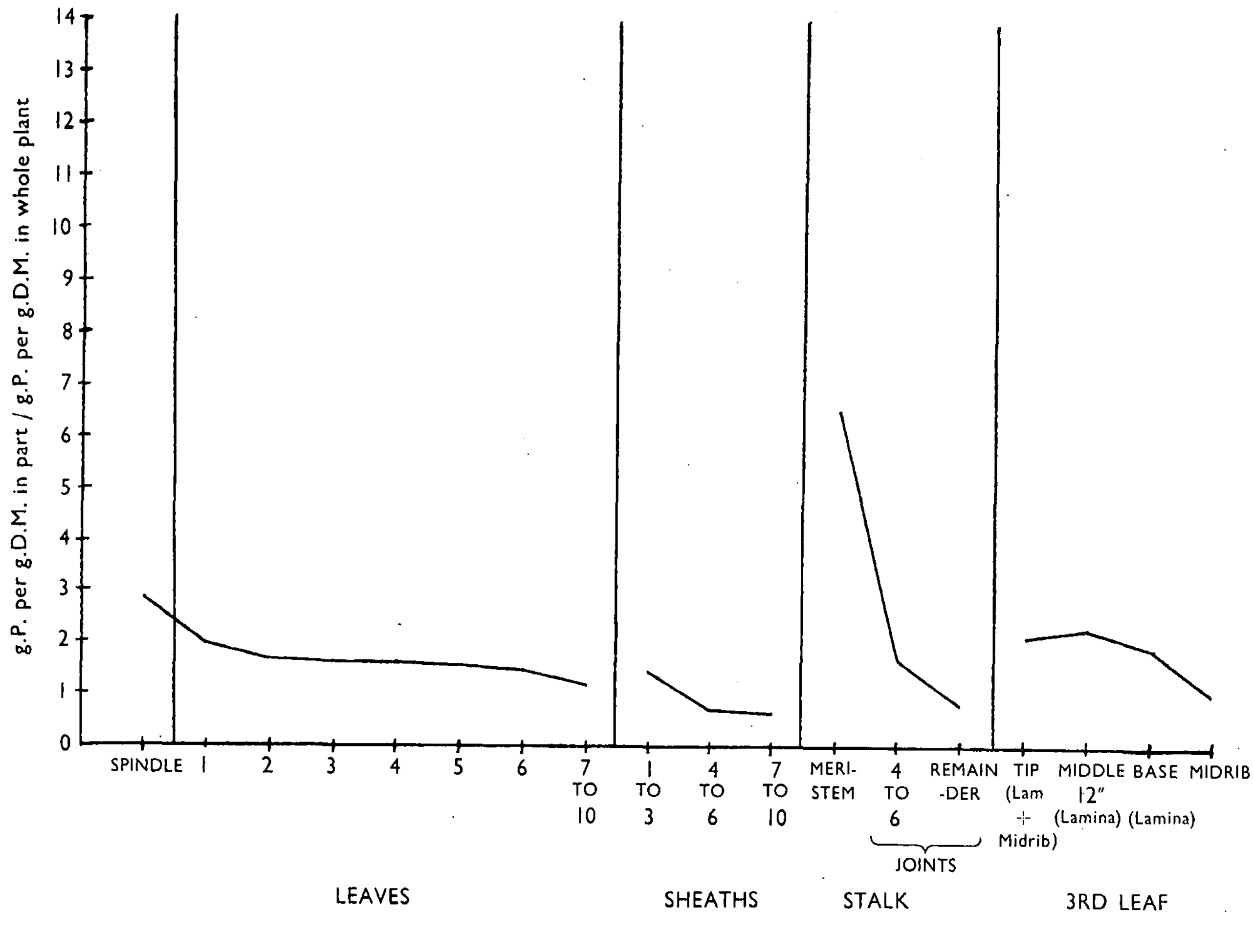
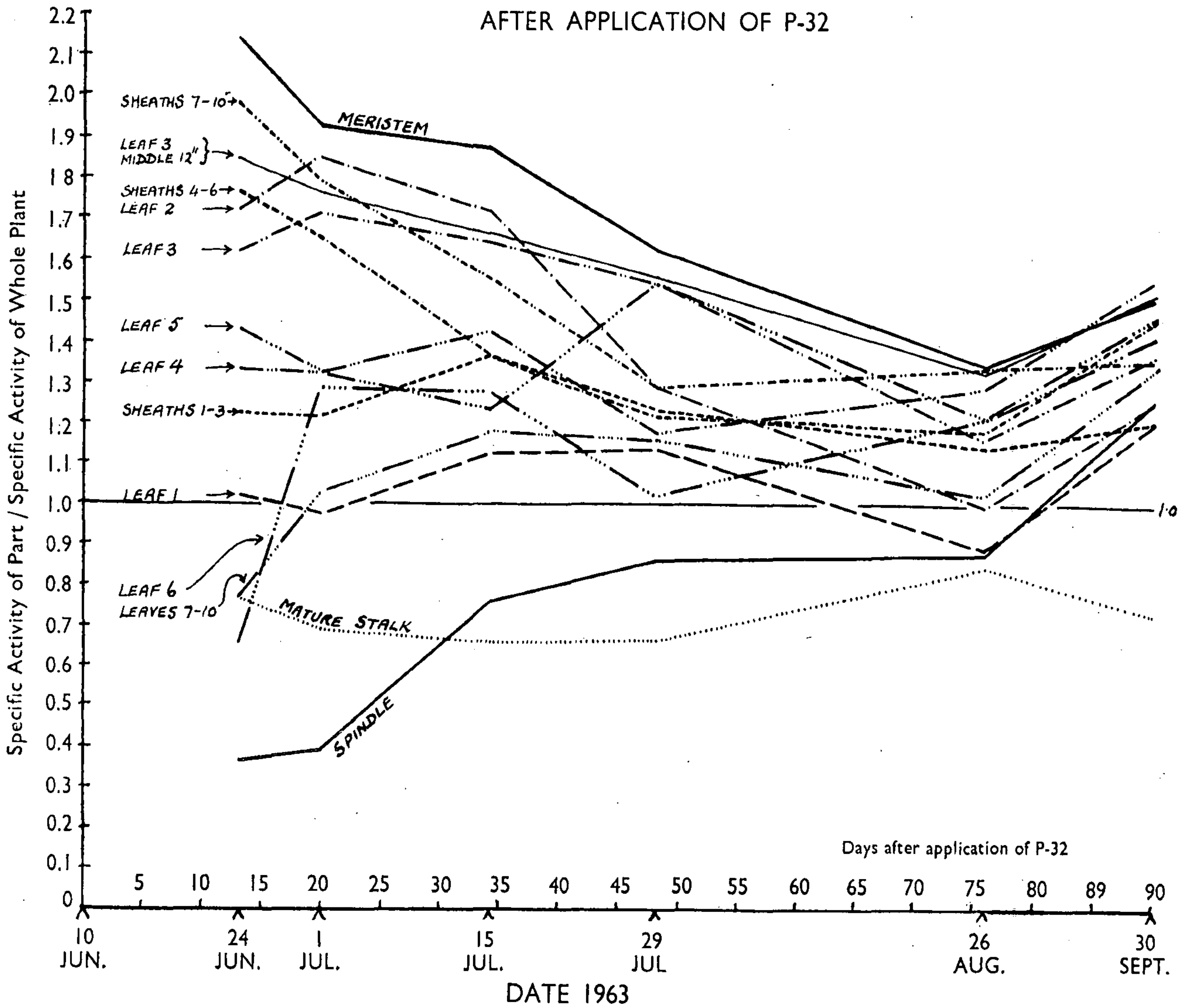


FIGURE 5

RELATIVE SPECIFIC ACTIVITIES OF DIFFERENT PARTS OF CANE PLANT vs TIME AFTER APPLICATION OF P-32



relatively steady increase of the specific activity of all the samples with time, compared with the large fluctuations obtained for application 1.

It is noteworthy, that in the period 10th June, 1963 to 3rd February, 1964 there was virtually no significant uptake of applied P-32 from treatments at distances greater than 3 ft. from the cane row. Application 4 (3rd February, 1964 onwards) has so far shown significant uptake at 3.3 ft., but not at 4.2 ft. and beyond.

All the application 2 samplings gave graphs of *Specific activity* vs. *distance of* treatment of similar shape except that the uptake of P-32 at 0.5 ft., initially considerably lower than at 0 ft., gradually became equal with and exceeded it slightly. The results for two representative samplings on 15th July, 1963 and 9th September, 1963 are quoted in Table 5 and depicted in figure 6.

The samples taken 1 ft. and 2.2 ft. along the row from treatment 7 yielded consistently results of similar magnitude to those from treatment 5, 2.3 ft. and treatment 3, 3 ft. respectively.

Table 5

Specific activity of lg. samples.* (uc. P-3/2gP.)

Treatment	Row No.	Distance (Ft.)	15.7.63	9.9.63
1	6	0	2.53	6.87
2	5	0.5	1.77	7.23
3	6	1.0	0.19	1.64
4	5	1.5	1.77	6.17
5	6	2.0	0.23	1.20
5	5	2.3	0.89	4.06
3	5	3.0	0.16	0.92
4	6	3.0	0.03	0.30

* Corrected for divergence of treatments from 0.75 mc.

(The pronounced zig-zag shape of these curves is not due to sampling variance, as this shape is reproduced consistently with each sampling. The reason for it is obscure at the moment, but it is noteworthy that the minima all coincide with samplings in row 6.)

FIGURE 6

VARIATION OF P-32 UPTAKE WITH DISTANCE FROM TREATMENT (APPLICATION 2)

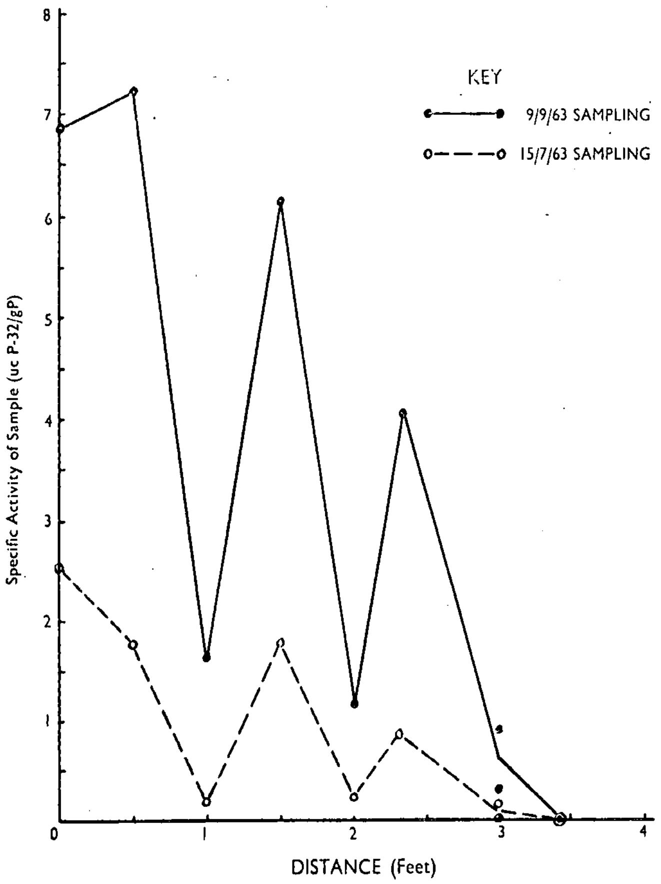


FIGURE 7

VARIATION OF P-32 UPTAKE WITH DISTANCE FROM TREATMENT (APPLICATION 3)

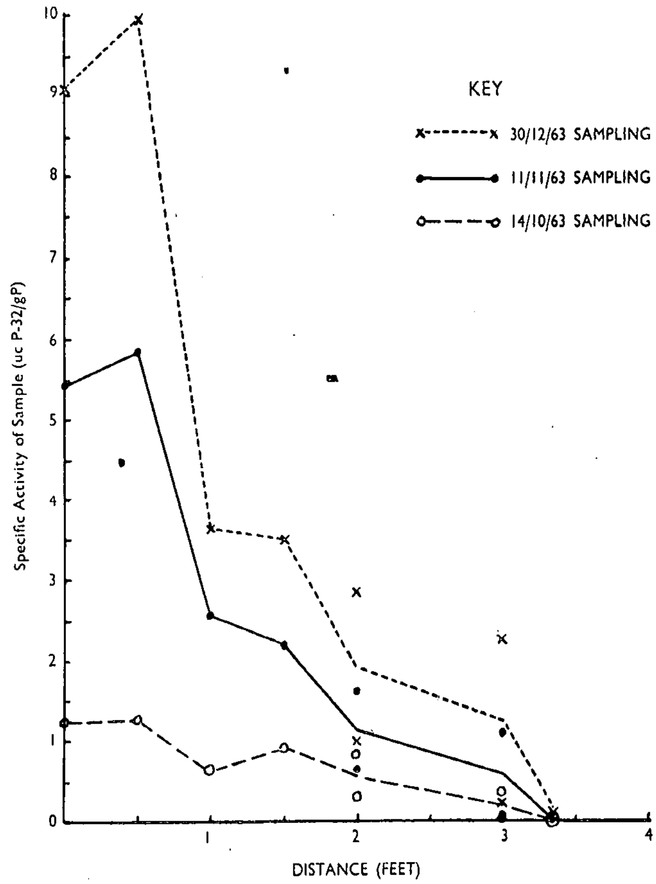


Table 6 (together with figure 7) shows results from three representative samplings from application 3.

Table 6

Specific activity of lg samples

Treat-ment	Row No.	Dist. (ft.)	Depth (ins.)	14.10.63	11.11.63	30.12.64
1	6	0	6	1.24	5.46	9.08
2	6	0.5	6	1.27	5.84	9.94
3	7	1.0	6	0.67	2.55	3.65
4	6	1.5	6	0.92	2.21	3.50
5	6	2.0	6	0.30	0.64	1.01
5	7	2.0	6	0.81	1.62	2.87
3	6	3.0	6	0.36	1.12	2.27
4	7	3.0	6	0.02	0.07	0.26*
6	6	0.5	9	1.43	4.19	8.43
7	6	0.5	3	3.83	13.58	21.10
8	6	0.5	½	2.94	9.35	11.87

* Insignificant at 95% level

The pronounced zig-zag shape of the specific activity vs. distance curve for application 2 has not been reproduced here, although the result for treatment 3, row 6 is surprisingly high.

The uptake from ½in. depth was initially slightly higher than from 3 ins., but was soon overtaken by the latter.

Variation of P-32 uptake with time

Since P-32 is chemically identical to P-31 (stable phosphorus) it is valid to assume that, if applied as orthophosphate, it is taken up in an identical manner to the ordinary phosphate ion. It can therefore be used as a measure of the rate of uptake of ordinary phosphate.

For any particular P-32 application, the variation of the rate of uptake of P-32 from each individual treatment with time showed approximately the same trend, as has already been inferred above, although the gradients of the curves differ markedly for different treatment distances.

In order to obtain a picture of the variation of the rate of phosphate uptake by N:Co.376 plant cane throughout the year (i.e. from its 5th to 17th month of growth), the mean of the specific activities of the samples taken at distances 0, 0.5, 1.0, 1.5 and 2.0 ft. was plotted against time (Fig. 8). Continuity of the curve was obtained by allowing the samplings from successive applications to overlap, and adding the new results onto the value for the date of the new application interpolated from the previous curve.

The specific activity was chosen in preference to the P-32 concentration (uc P-32/g. dry matter) as a measure of phosphate accumulation by the plant, because of the variation of P concentration (gP./g. dry matter) with time. (Dotted line in fig. 8.) For instance, if the P-32 concentration should remain the same at two successive samplings and the P concentration decrease. this does not mean there has been no further phosphate uptake or that the plant has lost phosphate (assuming the distribution of P-32 in the plant to remain reasonably constant). On the contrary, it indicates that the plant has taken up phosphate, including P-32, thereby increasing the specific activity, but this uptake has not kept pace with the accumulation of dry matter, hence the P concentration has dropped.

The height vs. time curve of the cane in the Growth Analysis Experiment at the S.A.S.A. Chaka's Kraal Experimental Farm has been included in figure 8 for comparison together with the rainfall data at Mount Edgecombe during the experimental period. It is to be noted that the Growth Analysis Experiment was planted on Dwyka soil at the same time as the cane used for the P-32 experiment, the variety also being N:Co.376.

Discussion

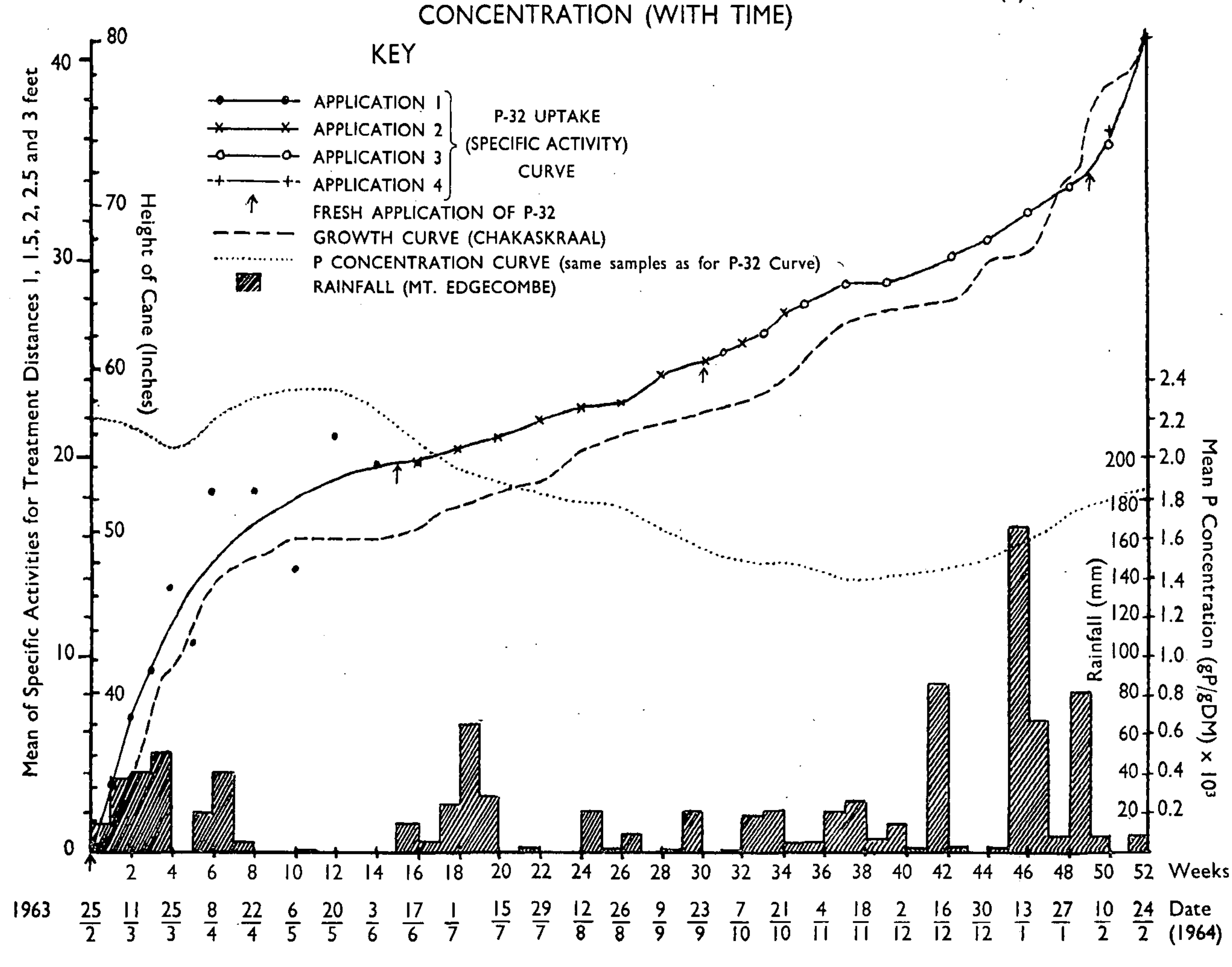
Figures 3 and 4 show clearly that, within the experimental period of 90 days, the P-32 distribution curve tended to assume the same shape as the average total phosphate distribution curve, the curve for the spindle and leaves gradually being inverted with time. Although the general shape of the sheath, stalk and 3rd leaf curves remained the same, the gradients of these tended to become more similar to the total phosphate curves. This is further illustrated by the convergence to unity of the relative specific activity curves with time (figure 5). The upswing of all the curves for the sampling on the 9th September is due solely to one determination viz. total P concentration in the mature stalk.

At the first sampling (14th June, 1963), not shown in the figures, only the meristem showed significant uptake of P-32. It is clear from this fact and from figure 5 that phosphate (as. P-32) applied at this stage of growth was initially deposited preferentially in the meristem tissue, while the spindle was the least favoured. Of the leaves, the 2nd and 3rd initially showed preferential uptake, while the 1st and 6th to 10th were least favoured. An unexpected result was that the older sheaths took preference over the younger sheaths in P-32 uptake.

An important point emerging from this experiment is that sampling the 3rd leaf tends initially to give an

FIGURE 8

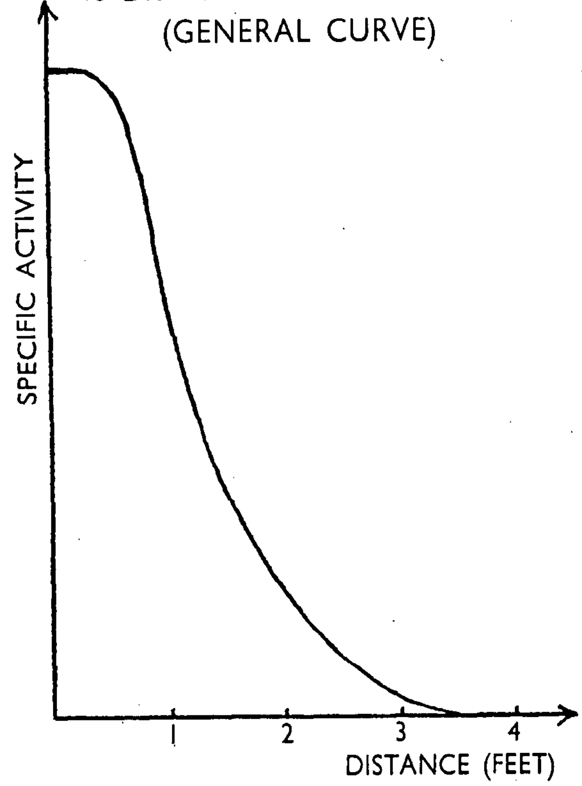
VARIATION OF UPTAKE OF P-32, GROWTH OF CANE & PHOSPHATE(P) CONCENTRATION (WITH TIME)



overestimate of the specific activity of the whole plant, although further investigation would be necessary to determine precise corrections to apply, as the magnitude of this initial overestimate could depend on the stage of growth of the cane when the P-32 is applied.

FIGURE 9

SPECIFIC ACTIVITY OF SAMPLES vs DISTANCE OF TREATMENT (GENERAL CURVE)



Examination of figures 6 and 7 shows that, disregarding the zig-zag shape in figure 6 and the high value for 3 ft. in figure 7, the maximum uptake occurs in the 0—6 in. range (at 6" depth) and that it falls off rapidly with increasing distance from the plant. The general picture obtained is a smooth curve as in figure 9, falling to zero between 3 and 4 ft. from the centre of the row. The inference is that in this particular soil the majority of the feeding roots are concentrated directly beneath the stool, and although odd feeding roots may extend beyond 4 ft. laterally, they generally do not extend much beyond 3 ft. up to the present stage of development of the crop.

From the few results so far obtained regarding uptake at various depths it would appear that, at 6 in. lateral distance from the centre of the cane row, the greatest concentration of feeding roots is about 3 ins. from the surface at the particular stage of development of the crop (11½ to 16 months plant). The concentration on the surface was comparable to this at the beginning of this period but became considerably less as time went on. The decrease in the concentration of feeding roots from 3 to 6 in. depth ranged from 72 to 37 per cent during the period and the concentration at 9 in. depth was similar to that at 6 in. or perhaps slightly lower.

From figure 8 it can be clearly seen that the shape of the height vs. time curve for the Growth Analysis Experiment is almost identical to the phosphate uptake curve. The correlation coefficient between these two curves is 0.98 which is very highly significant. Although the two experiments are situated at some distance from each other, the general rainfall and weather conditions for the two places were the same. Hence it can be concluded that the plant takes up phosphate strictly in proportion to its growth. The phosphate accumulation and growth were rapid from the 25th February, 1963 to about 25th April, 1963 when rainfall and temperatures were high after which there was a levelling off followed by a slow, but steady, increase during winter and spring corresponding with low temperatures. An increase in the rate of accumulation and growth is again apparent at the beginning of 1964.

The scatter of the points corresponding to the first P-32 application can be clearly seen and is obviously due to the large sampling variance.

The results from the 2.0 mc. treatment in the first P-32 application are very variable and hence no conclusion can be drawn as to the effect on the P-32 uptake of a four-fold increase in the activity of the P-32 applied to the soil.

Useful information affecting future experiments with P-32 which has been accumulated from this preliminary experiment is summarized as follows:

(*a*) The optimum stage to take samples for radiometric analysis from a P-32 experiment is 3 to 5 weeks after treatment.

(*b*) The useful life of a single application of P-32 is about 120 days, after which the counts become too small.

(*c*) To reduce sampling variance and damage to the plant, the best sampling method is to take punch discs from the lamina in the field. This treatment does not kill the leaf, and it remains green and functioning for a similar time to undisturbed leaves. The technique is, however, laborious.

(*d*) 1 g. of dry material is the most convenient sample for ashing and radiometric assay.

(*e*) Sampling the third leaf tends initially to give an overestimate of the specific activity of the whole plant, due to preferential absorption by this as well as certain other plant parts.

(*f*) 0.5 mc. P-32 per treatment is adequate to give good counting rates under summer conditions (high temperature and rainfall) but with low temperature and growth the counting rates become rather low.

Acknowledgment

The author herewith acknowledges data from the Research Agronomy Department in connection with the Growth Analysis Experiment.

Mr. du Toit (in the chair): Radioisotope work is in its infancy at the Experiment Station, but is developing quickly. We have a moisture probe working on this principle. This paper describes a preliminary exercise in the handling of radioisotopes, but some results obtained are quite useful. On the site of this particular experiment the bulk of the roots seem to have been immediately under the cane, about three inches down, and up to six inches from the cane line.

The migration of the phosphate to the meristem first is not surprising. There is almost perfect correlation between phosphate up-take in this experiment and elongation in a growth experiment at Chaka's Kraal, indicating that phosphate is always taken up when growth takes place.

Mr. Hill: Could early fertilization of the cane have influenced the roots in such a way as to give these results?

Mr. Wood: As the experiment was not directed to this particular purpose we had no exact idea of previous treatment. Fertilizer must have been placed in the row at planting but how much is not known. Future experiments will be properly controlled.