

A Study of some Factors influencing the uptake of Phosphorus by Potato using P³²

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(Received August, 1966)

INTRODUCTION

THE uptake and utilization of fertilizer phosphorus is largely influenced by the phosphorus fertility status of the soil, crop variety, rate and method of application of phosphate fertilizers, (1) Potato which requires a fairly high amount of phosphorus prefers a concentrated supply of fertilizer phosphorus. This is considered to be due to the short vegetative period and the limited root system of the crop, (2) The importance of phosphate fertilizer in the cultivation of potato under local conditions (3, 4, 5) necessitates the evaluation of the most efficient method of using this fertilizer for larger profits. Nelson *et al* (6) found that different methods of placement of fertilizer affects the percentage of phosphorus taken up from the fertilizer by plants. Caesar and Ganeshan, (7) in a field experiment conducted at Sita Eliya found that on the basis of yield data, furrow application is superior to broadcasting of the fertilizers. It has now become an established procedure to estimate the efficiency of usage of P fertilizers directly by using P³² labelled fertilizers and isotope detection techniques.

The objective of this study was to investigate the efficiency of utilization of phosphorus in two soils by potato using P³² labelled potassium dihydrogen phosphate under (a) different methods of placement of phosphorus and nitrogen fertilizers, and (b) the application of two forms of (coral and dolomitic) lime.

MATERIALS AND METHODS

Two soils, one a sandy loam from Sita Eliya and the other a humic silt loam from Meepilimana, were used in this study. These soils have been referred to as jungle soils and wet patana black soils by Kathirgamathaiyah and Caesar (5). The soils were sampled from areas which were fallow for more than two years. The chemical analysis of these soils are given in table 1.

TABLE I.—Chemical Analysis of Soils

	<i>Sita Eliya</i>	<i>Meepilimana</i>
pH ..	4.1	4.5
Total nitrogen % ..	0.53	0.79
Organic matter % ..	10.56	18.96
Available phosphorus (Olsen's) lb. P ₂ O ₅ /acre ..	77.5	57.0
Exchangeable		
1. Calcium m.e. % ..	1.39	0.52
2. Magnesium m.e. % ..	0.35	0.26
3. Potassium m.e. % ..	0.30	0.33

The experiment was of 3 × 3 factorial design consisting of three methods of fertilizer placement combined with no lime, coral lime and dolomitic lime. The treatments were replicated three times and the experiment was conducted under glass-house conditions at the Potato Research Station, Sita Eliya. The treatments are as shown in table 2.

TABLE 2.—Treatments

No.	Fertilizer placement	Lime
1	A*	No lime
2	A*	Coral lime
3	A*	Dolomitic lime
4	B†	No lime
5	B†	Coral lime
6	B†	Dolomitic lime
7	C‡	No lime
8	C‡	Coral lime
9	C‡	Dolomitic lime

A*—Nitrogen and Phosphate fertilizers broadcasted

B†—Nitrogen and Phosphate fertilizers banded

C‡—Nitrogen fertilizer broadcasted and Phosphate fertilizer banded.

Twenty pounds of air dried soils were placed in polythene lined cylindrical metal pots. The pots receiving lime were treated with the respective lime at the rate of one ton per acre at two weeks before planting of the tubers. The soils were thoroughly mixed with the lime and then placed in the pots. All treatments received 80 lb. N per acre in the form of Urea and 200 lb. P₂O₅ per acre in the form of labelled potassium dihydrogen phosphate containing 0.12 m.c. P³² per gram

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P_2O_5 . The potassium dihydrogen phosphate was labelled using P^{32} in the form of phosphoric acid obtained from Radiochemical Centre, Amersham, England.

The soils for the three methods of fertilizer placement were prepared as follows :

Placement A

The calculated volume of the active solution was added to a small quantity of soil in an evaporating dish. This was dried in an oven for about 2-3 hours, ground thoroughly with weighed amount of Urea, mixed with twenty pounds of soil in a double shell blender and transferred into the pots.

Placement B

The method was the same as in the case of placement A, except that the fertilizers were applied in a band at a depth of five inches.

Placement C

Here, urea was first mixed with the top six inches of the soil and the phosphate was banded as in the case of placement B.

Three potato tubers of the variety Arka were planted in each pot at a depth of four inches, so that the three tubers were approximately situated at the vertices of an equilateral triangle. The pots were watered whenever necessary, using a specially devised water can. Plant samples were taken at 32 and 72 days from planting and the whole plant was analysed for P^{32} , P^{33} , calcium and magnesium. The plant samples were dried at $70^\circ C$ for 24 hours, ground and wet digested as described by Jackson (8). P^{32} was determined by liquid counting, using a halogen quenched G.M. tube of the Type MX 124/01, on an EKCO automatic scaler N 530G. The standard corrections for background, resolution and decay were made. P^{32} was estimated colorimetrically by the Vanadomolybdo-phosphoric acid method (8). Calcium and magnesium were determined by the versenate titrimetric method using Patton and Reeder's reagent and Erichroms Black T as indicators (9). Soil pH was measured with a Beckman Zeromatic pH meter using a glass electrode in conjunction with a reference Calomel electrode. A 1 : 1 soil-water ratio was used.

OBSERVATIONS

There were very distinct differences in growth between the treatments at the initial stages. Placements B and C showed quicker growth than placement A. These differences were less marked during

the later stages. The limed treatments were better in growth than the unlimed ones but there was not much difference between the two forms of lime except that the coral lime treated ones (and the unlimed ones) showed premature yellowing of the lower leaves. No incidence of disease or pest was observed.

RESULTS

(i) *Phosphorus*

The percentage of phosphorus in plants derived from the fertilizer was estimated using the isotopic dilution technique (10). Table 3 shows that the percentage phosphorus derived from the fertilizer increases during the period of vegetative growth for both soils under the different methods of fertilizer placement. Placements B and C resulted in higher phosphorus uptake from fertilizer than placement A, at both times of sampling, even though the values for placement A increased considerably at 72 days after planting (table 3).

TABLE 3.—Percentage of Phosphorus in the Plants derived from fertilizer
(Mean of three replicates)

Treatment		32 days after planting				72 days after planting			
Place- ment	Lime	Sita Eliya Soil		Meepilimana Soil		Sita Eliya Soil		Meepilimana Soil	
A	.. No lime	..	3.7	..	5.7	..	19.1	..	28.2
A	.. Coral lime	..	4.4	..	3.5	..	16.1	..	20.2
A	.. Dol. lime	..	5.2	..	4.3	..	22.0	..	20.4
B	.. No lime	..	28.5	..	19.2	..	31.8	..	28.7
B	.. Coral lime	..	21.4	..	23.4	..	30.4	..	30.1
B	.. Dol. lime	..	30.0	..	29.5	..	31.8	..	27.1
C	.. No lime	..	20.0	..	20.6	..	28.6	..	23.3
C	.. Coral lime	..	36.2	..	26.9	..	33.9	..	22.6
C	.. Dol. lime	..	30.8	..	34.1	..	32.3	..	25.0

Statistical analysis of variance by angular transformation revealed that placements B and C are significantly superior to placement A at both times for Sita Eliya soil. For the Meepilimana soil, however, placements B and C were significantly superior to placement A only at 32 days after planting. No significant differences were found between placements B and C for both soils, which shows that the percentage uptake of fertilizer phosphorus is not influenced by the method of placement of nitrogen.

Application of lime (both forms) increase the phosphorus uptake in the initial stages.

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(ii) Calcium

Percentage calcium in the plant samples are presented in table 4.

TABLE 4.—Percentage Calcium in the Plant Samples (Oven Dry)
(Mean of three replicates)

Treatment		32 days after planting				72 days after planting			
Place- ment	Lime	Sita Eliya Soil		Meepilimana Soil		Sita Eliya Soil		Meepilimana Soil	
		A ..	No lime	..	0.46	..	0.44	..	0.83
A ..	Coral lime	..	0.46	..	0.46	..	0.85	..	0.70
A ..	Dol. lime	..	0.61	..	0.38	..	0.96	..	0.61
B ..	No lime	..	0.51	..	0.74	..	0.96	..	0.93
B ..	Coral lime	..	0.68	..	0.76	..	0.94	..	1.10
B ..	Dol. lime	..	0.59	..	0.66	..	1.22	..	1.07
C ..	No lime	..	0.42	..	0.53	..	0.86	..	0.90
C ..	Coral lime	..	0.61	..	0.97	..	0.84	..	1.18
C ..	Dol. lime	..	0.57	..	0.76	..	1.14	..	1.08

The percentage of calcium in the plants is not significantly different for the different forms of lime at 32 days after planting. Dolomitic lime gave significantly higher calcium values than coral lime for both Meepilimana and Sita Eliya soils at the latter stage of sampling.

(iii) Magnesium

The magnesium percentages as shown in table 5 are significantly higher for dolomitic lime than coral lime for both soils at 32 days and 72 days after planting.

TABLE 5.—Percentage Magnesium in the Plant Samples (Oven Dry)
(Mean of three replicates)

Treatment		32 days after planting				72 days after planting			
Placement	Lime	Sita Eliya Soil		Meepilimana Soil		Sita Eliya Soil		Meepilimana Soil	
		A	No lime	..	0.68	..	0.46	..	0.63
A	Coral lime	..	0.86	..	0.59	..	0.66	..	0.48
A	Dol. lime	..	1.20	..	0.89	..	1.11	..	0.98
B	No lime	..	0.82	..	0.61	..	0.66	..	0.44
B	Coral lime	..	0.83	..	0.77	..	0.81	..	0.73
B	Dol. lime	..	1.12	..	1.30	..	1.90	..	1.60
C	No lime	..	0.64	..	0.64	..	0.81	..	0.56
C	Coral lime	..	0.92	..	0.68	..	0.66	..	0.61
C	Dol. lime	..	1.16	..	1.23	..	1.78	..	1.37

(iv) Soil pH

The pH for the different treatments at final sampling are shown in table 6.

TABLE 6.—Soil pH

	Treatment		pH after 72 days	
	Placement	Lime	Sita Eliya Soil	Meepilimana Soil
A	No lime	..	4.15	4.40
A	Coral lime	..	4.50	4.90
A	Dol. lime	..	4.75	4.95
B	No lime	..	4.30	4.60
B	Coral lime	..	4.70	4.90
B	Dol. lime	..	4.30	5.00
C	No lime	..	4.20	4.50
C	Coral lime	..	4.40	4.80
C	Dol. lime	..	4.30	4.90

There does not seem to be any appreciable difference in the pH values for the two forms of lime used in this experiment.

DISCUSSION

Field experiments conducted earlier at Sita Eliya (7) showed that furrow application of fertilizers resulted in higher potato yields than broadcasting of the fertilizers. Nelson *et al* (6) in an experiment with corn concluded that placement of phosphorus fertilizers close to the seed results in higher total uptake than broadcasting. The high acidity of the two soils used in this investigation and probably their high phosphate fixing capacity would be some of the factors that contribute to the higher uptake of phosphorus when the fertilizer is applied in furrows. The higher potato yields as reported by Caesar *et al* (7) is due to the higher usage of fertilizer phosphorus by the plant when the fertilizer is applied in furrows.

The supply of more magnesium by dolomitic lime is due to its higher magnesium content. It is not possible to offer any satisfactory explanation as to why dolomitic lime has given more calcium than coral lime at the later stages. The reported result (5) that dolomitic

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lime corrects the often experienced magnesium deficiency on the wet patana black soil is due to the larger supply of magnesium by dolomitic lime. This investigation too shows that there is hardly any pH difference between the application of dolomitic and coral lime as found by the earlier workers (5) on these soils.

SUMMARY AND CONCLUSIONS

The uptake of phosphorus by the potato plant was studied under glass house conditions, under different methods of placement and different forms of lime on two soils. The results could be summarised as follows :

- (1) Banding of phosphate fertilizer results in higher phosphorus uptake than broadcasting.
- (2) Phosphorus uptake is increased by the application of lime.
- (3) Placement of nitrogen does not influence the uptake of phosphorus.
- (4) Dolomitic lime supplies more calcium and magnesium than coral lime.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the technical assistance of Messrs. M. M. M. Jauffer and S. M. Willenberg, Laboratory Assistants, in the radiochemical analysis and glass house operations. They also thank Mr. M. M. M. Jauffer for the preparation of the typescript.

The authors also wish to express their sincere thanks to Mr. V. Navaratnam, Statistician, for his help in the design and analysis of the experiment.

REFERENCES

- (1) DEAN, L. A., *et al.*—Application of Radioactive Tracer Technique to Studies of Phosphate Fertilizer Utilization by Crops: 1. Greenhouse Experiments. *Soil Sci. Soc. Amer. Proc.*, 12 : 107-112, 1947.
- (2) KRANTZ, B. A., *et al.*—A Comparison of Phosphorus Utilization by Crops. *Soil Sci.* 68 : 171-178, 1949.
- (3) PONNAMPERUMA, F. N.—Response of Potato to Fertilizers, Manure, Lime and Trace Elements. *Tropical Agriculturist*, CXIV, 99-111, 1958.
- (4) KANDIAH, S. and RODRIGO, D. M.—Manurial Experiment with Potato at Rahangala. *Tropical Agriculturist*, CX, 190-200, 1954.
- (5) KATHIRGAMATHAIYAH, S. and CAESAR, K.—Fertilizer Response Studies on Potato. *Tropical Agriculturist*, CXX, 87-118, 1964.

- (6) NELSON, W. L., *et al.*—Utilization of Phosphorus as Affected by Placement. II Cotton and Corn in North Carolina. *Soil Sci.* 68, 137-144, 1949.
- (7) CAESAR, K. and GANESHAN, S.—Fertilizer Application in Potato. *Tropical Agriculturist*—CXX, 119-124, 1964.
- (8) JACKSON, M. L.—Soil Chemical Analysis. Constable and Co. Ltd., London, 1958.
- (9) VOGEL, AURTHUR, I.—A Text Book of Quantative Inorganic Analysis, Longmans, 1961.
- (10) FRIED, M.—Atomic Energy in Agriculture, pp 1-18, *Amer. Assoc. for the Advancement of Science*, Washington D. C., 1957.