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Soil Fertility Studies in Madras State Using Radio Tracer Technique - I. Placement of Phosphate to Hybrid Sorghum

by

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Introduction: Crops generally are unable to recover more than a relatively small proportion of the phosphate applied in fertilizers even under optimum conditions of soil reaction, soil structure, moisture, drainage and other factors. This is in marked contrast to the situation with nitrogen or potassium fertilizers where recovery is higher than 50%. Both fixation and positional unavailability have been regarded as the factors primarily accounting for low recovery of applied phosphorus by crops. Increased benefits have been obtained by placement of phosphate wherein extensive contact with the soil is reduced to an extent and the accessibility to roots has been increased (Stanford and Pierre, 1953). Early investigations by Coe (1926) with oats and wheat and by Duley (1930) on wheat clearly demonstrated the usefullness of drilling as compared to broadcast applications and as much as 50% reduction in dose to get a given yield increase have been reported (Reith, 1952; Smith, 1947). Further impetus has been given to research on placement methods as a result of developments in the use of radioisotopes. Until tagged phosphatic fertilizers came into use, it was not possible to evaluate clearly the relative or actual amounts of phosphorus obtained by the plant from various placements. This new development in research has greatly stimulated investigations along two main lines, 1) comparison of different types of placement for various crops and 2) evaluation of the factors or variables which may determine the relative value of different placements.

In general agreement with earlier evidence, the studies with radiophosphorus conducted during recent years have demonstrated that crops generally derive greater amounts of phosphorus from localised applications, such as banding or mixing with a restricted volume of soil than from broadcast application (Nelson *et al*, 1949). Using a technique involving injection of small quantities of radiophosphorus at various positions in the soil with respect to plant, Hall (1951) found that corn relies heavily on the top 3 inch layer of the soil during the first few weeks of growth but after 7 weeks, the 8 inch and 13 inch horizons contribute substantially to the growth of the plant.

Studies conducted in this country using radioisotope technique in small plot trials on paddy at the Indian Agricultural Research Institute, New Delhi, have shown maximum utilization of super phosphate from the surface broadcast

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application as compared to placement at 3" and 6" below surface. Similar experiments with wheat on the other hand showed that placement at 2 to 4 inches below surface was better than that applied at surface (Dutta, 1959).

The foregoing suggest the need for studying the value of placement with reference to different crops and probably soils since root development of crops are likely to be modified by soil characteristics as texture. The present study deals with placement of superphosphate at different depths to hybrid sorghum on a calcareous and a non-calcareous red soil of Coimbatore.

Material and Methods: Pot culture experiments were conducted using a calcareous (N.P.M. Field - Central Farm) and a non-calcareous red soil (Semmankuliyoor) with CSH1 hybrid sorghum as the test crop. The treatments were:— (1) Control (No phosphate) (2) 40 kg P_2O_5/ha at surface (3) 80 kg P_2O_5/ha at surface (4) 40 kg P_2O_5/ha at 5 cm depth (5) 80 kg P_2O_5/ha at 5 cm depth (6) 40 kg P_2O_5/ha at 10 cm depth and (7) 80 kg P_2O_5/ha at 10 cm depth, replicated four times.

Phosphate was applied as P^{32} labelled super phosphate at different levels and depths as per treatment schedule. The specific activity of the Superphosphate was 0.129 m.e./gm of P_2O_5. Nitrogen (N) and potash (K_2O) were applied at 60 and 40 kg/ha levels in the form of ammonium sulphate and muriate of potash respectively for all the treatments.

Hybrid sorghum CSH1 was sown at the rate of four seeds per pot. Plant samples were drawn after 35 days of sowing for analysis. The total phosphorus in plant samples was estimated by Vanadomolybdate method, after digestion of plant material in triacid. Radio active phosphorus in plants was determined by the method of McKenzie and Dean (1948). The percentage of P in plants derived from fertilizer was calculated and the data utilised for evaluating the placement effect on fertilizer P utilisation by the crop. The results are presented in Table 2. The available nutrient status of the soils used for the study was estimated and the data are presented in Table 1.

TABLE 1. *Analysis of initial soil samples used for placement studies*

Locality	Type	lbs / acre (Av.)	
		N	P
New permanent Manurials	Calcareous red	154	2.4
Semmankuliyur	Non-calcareous red	168	2.8

Results: The soils used had very low available nitrogen and phosphorus (Table 1). The fraction of phosphorus in plants derived from fertilizer was significantly more for placement at 5 cm or 10 cm depth than for surface appli

cation in the case of non-calcareous red soils, whereas in the case of calcareous red soil the surface application and placement at 5 cm depth were at par and significantly better than the placement at 10 cm depth. As regards the effect of levels on the percentage of P derived from fertilizer, the 80 kg P_2O_5/ha was significantly better than 40 kg P_2O_5/ha level in the case of calcareous red soil, while in the non-calcareous red soil, the results were not significant. (Vide Table 2).

TABLE 2. *Fraction of phosphorus in plant derived from fertilizer (%)*

Calcareous red soil				Non-calcareous red soil		
Levels of P_2O_5	40 kg/ha	80 kg/ha	Mean for methods	40 kg/ha	80 kg/ha	Mean for methods
Methods of application						
Surface	53.50	70.55	62.02	44.21	55.21	49.71
5 cm depth	53.04	56.44	54.73	64.83	70.46	67.64
10 cm depth	38.22	49.48	43.85	63.47	62.06	62 77
Means for levels	48.25	58.82	53.53	57.50	62.58	60.04

(i) *Results for levels of P*
S.E.=2.45, C.D. (P=0.05)=7.27,
Conclusion : 80, 40

(ii) *Results for levels of P*
Not significant

(iii) *Results for placement (Methods)*
S.E.=2.99, C.D. (P=0.05)=8.88,
Conclusion : Surface, 5 cm, 10 cm

(iv) *Results for placement (Methods)*
S.E.=3.41, C.D. (P=0.05)=10 13,
Conclusion : 5 cm, 10 cm, Surface

Tables 3 and 4 show the summary of results of total P uptake, the phosphorus derived from the soil and fertilizer, the efficiency of the utilisation of applied fertilizer as % of total applied P and the 'A' value (available phosphorus in the soil as calculated from radiochemical data).

TABLE 3. *Phosphorus uptake by sorghum from the calcareous soil and superphosphate*

Treatment	Uptake of P mg/pot	P from soil mg/pot	P from fertilizer mg/pot	% utilisation of fertilizer applied	"A" value kg/ha P_2O_5	Mean "A" value kg/ha P_2O_5
i) *Dose of P_2O_5*						
0 P_2O_5	1.28	—	—	—	—	
40 kg P_2O_5/ha	5.10	2.67	2.43	3.3	45.0	52.0
80 kg P_2O_5/ha	7.84	3.20	4.64	2.7	58.9	
ii) *Placement*						
Surface	6.68	2.38	4.30	3.9	34.1	
5 cm depth	5.67	2.53	3.14	2.9	48.7	52 0
10 cm depth	7.08	3.91	3.17	2.9	73.2	

TABLE 4. *Phosphorus uptake by sorghum from the non-calcareous soil and superphosphate*

Treatment	Uptake of P mg/pot	P from soil mg/pot	P from fertilizer mg/pot	% utilization of fertilizer applied	"A" value kg/ha P_2O_5	Mean "A" value
i) *Dose of P_2O_5*						
0 P_2O_5	4.34	—	—	—	—	
40 kg P_2O_5/ha	11.87	5.01	6.86	9.3	33.4	41.3
80 kg P_2O_5/ha	17.73	6.58	11.15	7.6	49.1	
ii) *Placement*						
Surface	13.05	6.45	6.60	6.2	60.0	
5 cm depth	14.70	4.69	10.01	9.4	27.9	41.3
10 cm depth	16.65	6.23	10.42	9.8	35.9	

1. *Total P uptake:* Both the soils responded to applied phosphate very well at the two levels of 40 and 80 kg/ha P_2O_5. As for the method of application, the differences in total P uptake were not significant.

2. *Phosphorus uptake from soil and from fertilizer:* With increase in levels of application of phosphate, the uptake increased from both the sources of supply *viz.* the soil and the fertilizer. However, relatively the increase was far greater in the case of uptake from the fertilizer than from the soil. It was about double in the case of fertilizer P uptake, while from the soil the increase was only about 25%. As regards method of application, there was a general trend of soil phosphorus uptake decreasing with increase in fertilizer P uptake.

3. *Amount of fertilizer utilised by the crop:* The utilization of applied fertilizer was in general very low and varies from about 3% in the case of calcareous soil to about 6–9% for the noncalcareous soil. With reference to effect of levels of P application, the utilisation % was lower for higher levels of application. The placement effect varied according to soil in line with the fraction of P in plant derived from fertilizer already mentioned above.

4. *"A" Value:* The "A" value was more for the calcareous soil than for the non-calcareous soil. The level of application of P affected the value, increased doses of P applications showing higher "A" values. The "A" value was more where fertilizer utilization is less.

Discussion: The results indicated that the superiority or otherwise of placement over broadcast application is dependent on the nature of the soil. Thus on the non-calcareous red soil which is more open textured than calcareous red soil, placement at 5 and 10 cm depths are superior to broadcast

application at surface while for the calcareous soil, surface application is as good as placement at 5 cm depth both of these being superior to 10 cm placement. This seems to suggest that 1) the soil texture which affects the pattern of root distribution may be of importance in determining the superiority or otherwise of placement and 2) the mobility of phosphate ions may be different in the two soils. Hall (1951) has indicated that among the many factors which may determine the superiority of the particular system of placement over another, the kind of crop and its pattern of root distribution appear to be of particular importance. The distribution of the root system of the crop under study was found to be different in the two different soils studied. In the case of the non calcareous soil which was a sandy loam the roots penetrated deeper especially the younger ones whereas in the calcareous soil which was a clay loam wherein the drainage was somewhat poor the younger roots were more in the top 3 inch layer. This probably explains why surface and shallow placement were more beneficial in the latter than in the former.

With reference to the movement of applied phosphate it is well known that it does not take place to any great extent in soils. Sell and Olsen (1947) reviewing the subject have shown that there is no detectable movement below one inch in a sandy loam soil during a period of 3 years when 80 lb of P_2O_5 as superphosphate was applied as a top dressing. With heavier soils, silt loams and clay loams, the movement is even slower. Therefore it seems to be clear that the differences in the mobility of the applied phosphate is not likely to have contributed to the observed differences of the soils studied and the difference in the pattern of root distribution seems to have caused the differences in P utilisation. Therefore it may be said that while deciding the need or otherwise of placement of phosphate the nature of root distribution as existing under a given condition of soil and management practices has to be reckoned.

The results for phosphorus uptake from soil given in tables 3 and 4 show that with increase in level of application of phosphate the soil supplying power also increases. This is also reflected in the "A" values calculated from radio activity data. This is probably due to the fact that a larger volume of soil is explored by the comparatively bigger crop obtained with its increased root growth, at higher dose of phosphate. Similar results have been reported by Larsen (1952) and Strzemienski (1948).

It is known that the "A" value is not affected by level of application of the nutrient or the yield of crop when the fertilizer is thoroughly mixed with the soil. However when applied locally such as band placements, the "A" value is affected by the level of nutrient applied. Such results have been

reported by Fried and Dean (1952). The present study also shows that the "A" value varies with the method of placements of the phosphate.

Summary: The effect of placement of superphosphate to hybrid sorghum on a calcareous and non-calcareous red soil of Coimbatore on the utilisation of applied fertilizer by the crop was studied. Tagged superphosphate at two levels viz. 40 and 80 kg P_2O_5/ha was applied at surface, 5 cm and 10 cm below surface and the relative merits judged from the fraction of phosphorus in plant derived from fertilizer. The results showed the superiority of placement at 5 or 10 cm over surface application in the case of the non-calcareous red soil, whereas in the case of calcareous red soil surface application was as good as placement at 5 cm depth both being superior to placement at 10 cm depth.

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