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Soil Fertility Studies in Tamil Nadu Using Radiotracer Technique II – Phosphorus Uptake by Sunnhemp in Different Paddy Soils

by

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Introduction: Phosphorus is one of the most important nutrients essential for growth of leguminous green manure crops. Since most of the Indian soils are deficient in phosphorus, much attention is paid to phosphate manuring of legumes in recent years.

The application of phosphatic fertilizers has been reported to increase the yield of green manure crops by Taylor and Ghose (1923), Ramachandra Rao (1923), Parr and Bose (1944, 1945, 1947), Parr and Sen (1948), Desai and Parr (1949), Russel (1962), Sen and Bains (1951) and Sanyasi Raju (1953). However, the results of experiments conducted in the Agricultural Research Stations at Tirurkuppam and Coimbatore of Tamil Nadu (Anon 1952 to 1953) and the work done under the I.C.A.R. Scheme on the uptake of phosphate by legumes at the same stations during the years 1958 to 1963 (Anon 1962–63) have shown no significant increase in green manure yields. Similar conclusions have been reported by Krishna Rao *et al* (1962) in Andhra State and by Soundararajan (1965) with certain paddy soils from Maharashtra, Madhya Pradesh, West Bengal and Assam. From the foregoing, it is seen that the results regarding the response of green manures to phosphate application are much varied. There is therefore the need to understand better, the utilisation of soil and fertiliser phosphate by green manures and their relationship to soil properties with reference to the soils of our State. The tracer technique using radioactive phosphorus (P^{32}) is of immense value in this respect and the results of the studies conducted on four important paddy soils of Tamil Nadu with sunnhemp *(Crotalaria juncea)* as the green manure crop, are reported in this paper.

Materials and Methods: The experiment was conducted in pots with 12 treatments which included three levels of P_2O_5, *viz.*, 0, 40 and 80 kg/ha, and four types of paddy soils of Tamil Nadu, *viz.*, from Aduthurai (Thanjavur District), Coimbatore, Kallidaikurichy (Tirunelveli District) and Tirurkuppam (Chingleput District). Each treatment was replicated four times. Six kilograms of soil were taken in each pot and after application of P^{32} labelled superphosphate of known specific activity (0.16 millicurie/gm P_2O_5) as per treatments, 10 seeds of sunnhemp were sown in each pot. The phosphate was well mixed

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in the top 7.5 cm of the soil before sowing. Water was added once daily to a level of 75% maximum moisture holding capacity. The sunnhemp crop was harvested at 33 days, after sowing and dry matter yield was recorded. Samples of plant material were analysed for total phosphorus content by the Vanodomolybdate method (Koenig and Johnson. 1942) and the total phosphorus uptake by sunnhemp per pot was calculated. The plant samples were also analysed for radioactive phosphorus by the method of Mackenzie and Dean (1948) and the percentage of phosphorus in plant derived from the applied fertilizer phosphate was calculated therefrom. The original soils used in the studies were analysed for basic characteristics which are furnished in Table 1.

TABLE 1. *Basic Characteristics of soils used for pot culture studies on Sunnhemp*

	Paddy soils from			
	Aduthurai	Coimbatore	Tirurkuppam	Kallidai-kurichy
pH	7.0	8.5	8.0	7.0
E.C.	0.5	0.5	0.4	0.25
Maximum water holding capacity (%)	41.18	53.16	38.13	34.97
Texture	Clay	Clay	Loam	Loam
Available N (lb/ac)	168	140	126	154
Soil test classification for available N	Very low	Very low	Very low	Very low
Available P (lb/ac)	4.4	18.0	8.8	1.2
Soil test classification for available P	Very low	Medium	Low	Very low

Results: The results in Table 1 show that the available P status of Kallidaikurichi and Aduthurai soils is 'very low' while the Tirurkuppam falls under the category 'low' and the Coimbatore soil is 'medium'. The results for dry matter yield of sunnhemp are presented in Table 2, from which it is seen that the yield in general, significantly increases with the increase in dose of P_2O_5 except in Coimbatore soil.

TABLE 2. *Dry matter yield of Sunnhemp (at 33 days after sowing) (Expressed as g per pot)*

Dose of P_2O_5	Soils				
	Aduthurai (ADT)	Coimbatore (CBE)	Kallidaikurichy (KLD)	Tirurkuppam (TKM)	Means for doses of P_2O_5
0 kg P_2O_5/ha	2.26	4.62	2.22	5.56	3.66
40 kg P_2O_5/ha	4.44	5.13	5.16	6.27	5.25
80 kg P_2O_5/ha	4.58	5.81	5.96	7.98	6.08
Means for soils	3.76	5.19	4.45	6.60	—

Conclusions: (a) *For soil means :* S.E. : 0.36, C.D. (at 5%) : 0.73; TKM, CBE, KLD, ADT

(b) *For doses .* S.E. : 0.31, C.D. (at 5%) : 0.63; 80, 40, 0.

(c) *Interaction: Soils × Doses of P_2O_5* : S.E. : 0.62, C.D (at 5%) : 1.25 Significant.

However, in the interaction effects between soils and doses which are significant, it is observed that in the Aduthurai and Kallidaikurichy soils (which are 'very low' in Available phosphorus - *vide* Table I) there is no significant difference between the 40 and 80 kg P_2O_5 levels, although they are significantly better than 'no phosphate' treatment. In the Coimbatore soil ('Medium' available P status), however, no significant increase in yield for phosphate application is recorded for all the levels tried. The Tirurkuppam soil of a 'low' available P status registered significant increase in yield only at 80 kg P_2O_5 level, while there was no significant difference between 40 and 0 levels. In general, the dry matter yield was significantly more in the Tirukuppam soil, than in the Coimbatore, Kallidaikurichy and Aduthurai soils, which followed next in order. The interaction effects between doses of P_2O_5 and soils were significant. It is also seen that in the absence of phosphate, the yields from Tirurkuppam and Coimbatore soils were on a par and significantly better than those from Aduthurai and Kallidaikurichy which were almost similar. At 40 kg level, the Tirukuppam soil is better than the Aduthurai soil but on a par with Kallidaikurichy and Coimbatore soils. At the 80 kg P_2O_5 level the Tirurkuppam soil was significantly better than all the other three soils.

The results for phosphorus content in sunnhemp plant are given in Table 3.

TABLE 3. *Total phosphorus content in Sunnhemp (at 33 days after sowing) (Expressed as %)*

Treatments (Doses of P_2O_5)	Soils				Means for doses
	Aduthurai (ADT)	Coimbatore (CBE)	Kallidaikurichi (KLD)	Tirukuppam (TKM)	
0 kg P_2O_5/ha (No P)	0.22	0.28	0.17	0.21	0.22
40 kg P_2O_5/ha	0.24	0.30	0.17	0.23	0.24
80 kg P_2O_5/ha	0.29	0.29	0.19	0.25	0.26
Means for soils	0.25	0.29	0.18	0.23	—

The data indicate that the increase in levels of P_2O_5 increases the phosphorus content in plant to a small extent. The phosphorus content in the plant is more for the plants grown in the Coimbatore soil than in other soils. The Aduthurai, Tirurkuppam and Kallidaikurichy soils follow next in order in this respect.

The summary of results relating to the total phosphorus uptake by sunnhemp plant (calculated from the dry matter yield and the phosphorus content in plant) are presented in Table 4. The conclusions are more or less similar to those for dry matter yield.

TABLE 4. *Total Phosphorus uptake by Sunnhemp plant at 33 days after sowing (Expressed as mg P/pot)*

Doses of P_2O_5	Soils				
	Aduthurai (ADT)	Coimbatore (CBE)	Kallidaikurichy (KLD)	Tirurkuppam (TKM)	Means for doses of P_2O_5
0 kg P_2O_5/ha	5.03	13.05	3.78	11.80	8.41
40 kg P_2O_5/ha	10.77	15.34	8.83	14.56	12.38
80 kg P_2O_5/ha	11.09	16.23	10.99	19.89	14.55
Means for soils	8.96	14.87	7.87	15.42	—

Conclusions: (a) *For soil means:* S.E. : 0.72; C.D. at 5% : 1.45; TKM, CBE, ADT, KLD.

(b) *For doses:* S.E. : 0.62; C.D. at 5% : 1.25; 80, 40, 0.

(c) *Interaction:* Soils × Doses of P_2O_5, S.E. : 1.24; C.D. (at 5%) : 2.50 significant.

The results for the fraction of phosphorus in sunnhemp plant derived from the applied superphosphate (Fertilizer P in plant) are furnished in Table 5.

TABLE 5. *Phosphorus in Sunnhemp taken from the fertilizer as % of total P in plant (at 33 days after sowing)*

(N.B. Figures in parenthesis are values after sine inverse transformation for purpose of statistical analysis)

Doses of P_2O_5	Soils				
	Aduthurai (ADT)	Coimbatore (CBE)	Kallidaikurichy (KLD)	Tirurkuppam (TKM)	Means for doses of P_2O_5
40 kg P_2O_5/ha	47.8 (43.7)	18.2 (25.3)	72.4 (58.3)	34.5 (36.0)	43.2 (40.9)
80 kg P_2O_5/ha	65.1 (53.8)	30.2 (33.4)	90.1 (72.0)	51.6 (45.9)	59.3 (51.3)
Means for soils	56.5 (48.8)	24.2 (29.3)	81.3 (65.2)	43.1 (41.0)	

Conclusions: (after sine inverse transformation) (a) *For Soil means:* S.E. : 1.3; C.D. : 2.7; KLD, ADT, TKM, CBE.

(b) *For Doses means:* S.E. : 0.9; C.D. : 1.9 (at 5%) : 80, 40.

(c) *Interaction: Soils × doses of* P_2O_5: Not significant

Significant increase in fertilizer P is noticed with increase in P_2O_5 dosage from 40 to 80 kg. The values are significantly more in the Kallidaikurichy soil than in the other three soils which also significantly differ from one another and follow next in the following order, Aduthurai, Thirukuppam and Coimbatore. The results for interaction between soils and P_2O_5 doses are not significant for the fertilizer P uptake in plant.

Discussion: The comparison of the four paddy soils for total phosphorus uptake in sunnhemp plant (*vide* Table 4) shows that the uptake, in general, is significantly more for the Coimbatore and Tirukuppam soils than for the Aduthurai and Kallidaikurichy soils. The former two are 'medium' and 'low' respectively while the later two are both 'very low' in available phosphate status. Within the above groups the two soils of 'medium' and 'low' and the two soils of 'very low' available P status do not show significant differences for total phosphorus uptake. However, when the fraction of P in plant derived from fertilizer is considered (*vide* Table 5) all the four soils are significantly different from each other and fall in line in inverse order of their available P content. Thus, the available phosphorus contents of the Coimbatore, Tirurkuppam, Aduthurai and Kallidaikurichy soils are 18.0, 8.8, 4.4, and 1.2 lb/acre respectively and values for the fraction represented as % of total P in plant derived from fertilizer are 18.2, 34.5, 47.8 and 72.4 for the 40 kg/ha level and 30.2, 51.6, 65.1 and 90.1 for 80 kg/ha level respectively for the different soils. Similar results have been reported by Soundararajan (1965). The "A" values calculated from radiochemical data (*vide* Table 6) also reflect the same trend as for the soil test values for available phosphorus.

TABLE 6. *Comparison of soils with respect to responses in dry matter yield, total and fertiliser P uptake and A values in relation to soil test values for available P*

	Doses of P_2O_5	Soils			
		Coimbatore	Tirur-kuppam	Aduthurai	Kallidai-kurichi
Available Phosphorus in soil by Olsen's Method (lb/ac)	—	18.0	8.8	4.4	1.2
Phosphorus in plant derived from fertilizer as %	40 kg/ha	18.2	34.5	47.8	72.4
	80 kg/ha	30.2	51.6	65.1	90.1
Utilisation of applied fertilizer phosphorus %	40 kg/ha	5.7	10.3	10.5	13.1
	80 kg/ha	5.0	10.5	7.4	10.1
"A" value (lb P/acre by radiochemical data)	40 kg/ha	70.7	29.8	17.2	6.0
	80 kg/ha	72.7	29.5	16.9	3.5
Mean	—	71.7	29.7	17.1	4.8
Dry matter yield responses (as % over '0' P_2O_5 level due to phosphate)	40 kg/ha	11.4	12.77	96.47	132.40
	80 kg/ha	25.75	43.72	102.7	168.5
Responses in total phosphorus uptake in plant due to phosphate(as% over '0' P_2O_5 level)	40 kg/ha	17.55	23.39	94.2	133.6
	80 kg/ha	43.7	68.6	119.9	190.8

The mean "A" values are 71.7, 29.7, 17.1, 4.8 (lb/acre) for the four soils in the order given above. Thus, the radiochemical data have provided the true picture of the soil status of phosphorus while the absolute values of total P uptake has not. The better usefulness of the radio chemical data over the yield and total uptake figures have been observed by Ensminger and Pearson

(1957), Fried (1957) and Mistry (1962) for assessing the soil P status and phosphatic fertilizer utilisation in soils. Whereas the yield and total P uptake are influenced by other environmental factors, the radiochemical data are not. In the present study, for example, the Tirurkuppam soil and the Kallidaykurichi soil (which are more open textured than the other two soils) have produced relatively better yields (sunnhemp being better suited to well drained soils) than would otherwise be expected from their soil P status.

The "A" values for the four soils are more or less the same at the two levels of P applied. This is generally what can be expected, when the fertilizer is mixed with soil and not placed locally as bands. From Table 6 it is also seen that the dry matter yield and total P uptake, when represented as % response are falling in line in an inverse order with the soil test values showing thereby that the soil test values truly reflect the responsiveness of the soils to phosphate application.

The % utilisation of the applied phosphate by the sunnhemp crop calculated from the radioassay is also given in Table 6. It is seen that the crop has utilised only about 5 to 13 % of the super phosphate applied, the highest testing Coimbatore soil utilizing the least and the lowest testing Kallidaikurichy soil utilising the most. The value of tracer technique in obtaining this data and finding ways and means of improving the ability of the crop to utilise phosphatic fertilizers that are in short supply is well recognised.

Summary and Conclusions: A pot culture trial was conducted using tracer technique to study the phosphate uptake by sunnhemp under phosphate fertilization on four paddy soils of Tamil Nadu, *viz.*, from Coimbatore, Tirurkuppam, Aduthurai and Kallidaikurichy. The treatments included three levels of P_2O_5 *viz.*, 0, 40 and 80 kg/ha applied as P^{32} labelled superphosphate. The original soils were analysed for basic characteristics. The sunnhemp crop was harvested at 33 days after sowing and the yeild data were recorded. The plant samples drawn at harvest were analysed for total and radioactive phosphorus contents. The fraction of phosphorus in plant derived from fertilizer, the amount of fertilizer utilised by the crop and the "A" values were calculated. From the results the following conclusions were drawn:

1. The different paddy soils studied show differences in uptake of fertilizer phosphorus and this is in inverse order of their soil test values for available phosphorus.

2. The "A" values calculated from radiochemical data show the same trend as the soil test values for available P.

3. The response to applied P calculated as % over control are different for the different soils and the variations between soils follow an inverse trend

to that of soil test values. The yield and total phosphate uptake data as such do not give the correct picture of the relative behaviour of the soils.

4. The % utilization of applied superphosphate varied from 5 to 13% in the four soils, the Coimbatore soil with medium available P status (18 lb/ac) showing lowest utilization and the Kallidaikurichy soil testing very low (1.2 lb/ac) utilising the highest.

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