levels (Table 1). It was highest with eight irrigations. The extent of increase was 32.8 and 15.5 per cent over I_1 and I_2 irrigation levels respectively. Similar results were reported earlier by Rao and Bharadwaj (1982). Significantly higher total dry weight was recorded by HD 4502.

Yield

Eight irrigations given at different physiological stages (I_3) recorded 71.0 and 19.0 per cent over four (I_1) and six irrigations (I_2) respectively. The response obtained was 11 kg, 10.6 kg and 14 kg per mm of applied water with 4, 6 and 8 irrigations given at different physiological stages. The increase in grain yields due to increasing levels of irrigation in the present study is in complete agreement with the findings of Tomar *et al.* (1993). Among the varieties HD 2189, NI 5439 were on par with each other and were superior to other two varieties. The increase in grain yield may be due to favourable increase in all growth characters (Girothia *et al.* 1987).

Nutrient uptake

The nutrient harvest both in grain and straw increased with increase in number of irrigations. The increase in uptake of these nutrients might be due to availability of moisture at active root zone which might have enhanced the uptake and translocation of nutrients. This increased uptake and translocation of nutrients might have also increased the metabolic activities. The protein content of grain increased upto six irrigations and decreased at eight irrigations. These are in agreement with the findings of Soni *et al.* (1986). Among the varieties, HD 2189 recorded higher nutrient uptake over other varieties. This may be attributed to higher root dry weight.

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PHOSPHORUS USE EFFICIENCY AND ITS RECOVERY IN LEGUME - PADDY CROPPING SEQUENCE

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ABSTRACT

Field experiments conducted to study the Phosphorus (P) use efficiency and its recovery in a legume - paddy cropping sequence in red soils of Thambirabarani river basin indicated a marked influence of P application in increasing the yield and yield attributes of irrigated pulse as well as *Pisanam* rice crop. Split application of P was not found advantageous over full basal application on rice crop. The P use efficiency and apparent P recovery in rice were found to be higher under soil-test based fertilization over that of the blanket recommendation. The P recovery in rice was higher (13.24%) when both the crops in the legume-paddy sequence were fertilized with P than the P application to rice alone (7.63%).

KEY WORDS : Phosphorus, Recovery, Cropping Sequence

Phosphorus, (P) one of the major nutrient elements of crop plants, is being used only around 3 Kg P_2O_5/ha of cultivated lands in India. The crop recovery of added P seldom exceeds 20 per cent

Table 1. Influence of phosphorus on yield and yield components of irrigated pulse (ADT 3 black gram)

Treatments	Grain yield (kg/ha)	Drymatter yield (kg/ha)	No. of pods/plant	1000 grain weight (g)
Control	536	1243	21	46.5
50 kg P_2O_5/ha	755	1957	38	48.6
Percentage increase over control	40.8	57.4	81.0	4.5
't' value	63.8**	109.0**	22.19**	4.57**

** Significant at 1 percent level.

(Kanwar *et al.*, 1982; Marwaha, 1983) and this warrants to sustain the efficiency of applied P. Responses to P are not common as to nitrogen because under submergence, solubility of native P is higher due to reduced conditions. Variations in the efficiency and utilisation of applied P under different soils, cropping situations, methods of application have been reported (Mahapatra, 1969). Similarly, the utilisation of the applied P in cereals was found to be higher if it followed a legume crop (Khanna and Chaudhary, 1979; Krishnappa *et al.*, 1979). In the Thambirabarani river basin, an irrigated pulse crop is generally grown during *kar* season followed by the *Pisanam* rice under the situations of late release of canal water and limited availability of irrigation water. In the light of meagre information available on the aspect of P fertilization for a legume - rice cropping pattern, an attempt was made to study the efficiency of applied P in red soils with broader perspective of increasing P utility by rice following a legume crop.

MATERIALS AND METHODS

The P use efficiency was evaluated in a sequence of legume (irrigated black gram ADT 3 during June-Aug.,) followed by *Pisanam* paddy crop (IR 20 rice during Sept. - Jan.) during 1989-90 crop seasons. The soil of the experimental field was a sandy clay textured soil of Manakkarai series (Typic Ustropept) with high lime status having a pH 8.0, EC 0.2 m mhos/cm and an organic carbon content of 0.6 per cent. The soil was low in available N (171 kg/ha), medium in available P (20kg/ha) medium in available K (260kg/ha), moderate permeability, and irrigated with canal/well waters of good quality.

I Crop The irrigated pulse Crop (ADT 3 black gram) was raised with the following two treatments:

(i) Control (no phosphorus application)
(ii) P application @ 50 kg P_2O_5/ha (equivalent to 21.5 kg p/ha as single superphosphate)

There were 15 plots under treatment (i) and 30 plots under treatment (ii), making a total of 45 plots (4.8 x 3.6 m^2 each). The 30 plots under treatment (ii) were grouped into two of 15 each to accommodate the subplot treatments T_1 and T_3 for the Succeeding rice crop (Table 3). A uniform dose of 25 kg N/ha as urea was applied to all treatments. Both N and P were applied as basal at the time of dibbling the seeds. The data on the parameters studied at the harvest of the crop were statistically analysed following non-paired 't' test method and the results are presented in Tables 1 and 2.

II Crop

The second crop of *Pisanam* rice (IR 20) was raised succeeding the irrigated pulse, superim posing the treatment schedule with five main plot treatments and three sub plot treatments (Table 3) replicated thrice in split plot design over the same experimental plots (4.8 x 3.6 m^2)of irrigated pulse crop. Nitrogen was applied as urea in three splits (50% basal, + 25% at tillering+ 25% at panicle

Table 2. Influence of phosphorus on nutrient uptake and its use efficiency in irrigated pulse (ADT 3 black gram)

Treatments	Nutrient uptake (kg/ha)			Apparent recovery % of applied P	P use efficiency (kg grain/ kg P applied)
	N	P	K		
Control	40.2	7.01	17.6	..	..
50 kg P_2O_5/ha	64.9	10.85	28.4	17.59%	10.1
Percentage increase over control	61.4	54.8	61.4		
't' value	5.9**	3.20**	3.7**		

** Significant at 1 percent level.

Table 3. Yield of pisanum rice (IR 20) under various 'P' fertilization practices

Main plot / Sub plot	Grain yield (kg/ha)				Straw yield (kg/ha)			
	T1	T2	T3	Mean	T1	T2	T3	Mean
M1 Absolute control	1807	2297	2193	2099	2887	3163	3668	3240
M2 Blanket NPK (P - all basal)	4382	4565	4604	4517	7581	7697	7855	7711
M3 STL based NPK (P - all basal)	4452	4691	4780	4641	7822	8848	8856	8509
M4 Blanket NPK (P - in splits)	4083	4278	4582	4314	7328	7629	7648	7513
M5 STL based NPK (P - in splits)	4539	5038	4669	4749	7833	8087	8628	8182
Mean	3852	4174	4166	4064	6690	7085	7331	7031
Statistical results :		SE		CD (5%)		SE		CD (5%)
(1) Main plots (M)		190		440		417		962
(2) Sub plots (T)		113		236		108		225
(3) M x T interaction		253		NS		242		504

Sub-plots : T1 : P_2O_5 application to irrigated pulse alone
T2 : P_2O_5 application to *Pisanam* rice alone
T3 : P_2O_5 application to both the crops.

Main plots : Blanket NPK : 120 : 60 : 60 kg N, P_2O_5, K_2O/ha
STL based NPK : 167 : 47.5 : 220 kg N, P_2O_5, K_2O/ha

initiation stages). Phosphorus was applied as single superphosphate in full basal or in two splits (50% basal + 50% at tillering) as per treatment schedule. potash was applied basally as muriate of potash. The data on the yield, uptake of nutrients, P use efficiency and apparent P recovery percentage are reported in Tables 3, 4 and 5. The analysis of plant samples for their N, P and K contents was done following standard analytical procedures (Piper, 1966). The P use efficiency and apparent P

Table 4. Uptake of nutrients by *Pisanam* rice (IR 20) under various P fertilization practices

Treatments	Nutrient uptake (kg/ha)		
	N	P	K
MAIN PLOTS			
M1 Absolute control	53.2	10.9	50.8
M2 Blanket NPK (P - all basal)	127.9	24.2	114.9
M3 STL based NPK (P - all basal)	125.4	27.0	123.9
M4 Blanket NPK (P - in splits)	121.0	31.6	112.0
M5 STL based NPK (P - in splits)	138.4	27.3	120.1
Mean	113.2	24.2	104.3
SE	2.9	3.1	7.8
CD (5%)	8.1	8.7	21.7
SUB-PLOTS			
T1 : P_2O_5 to irrigated pulse alone	105.5	22.4	100.0
T2 : P_2O_5 to *Pisanam* rice alone	115.2	24.6	105.7
T3 : P_2O_5 to both the crops.	119.0	25.6	107.3
Mean	113.2	24.2	104.3
SE	4.7	1.0	3.2
CD (5%)	10.5	2.3	NS
Main x Sub interaction			
SE	10.6	2.3	7.2
CD (5%)	NS	NS	NS

able 5. **Efficiency of applied 'P' under varying 'P' fertilization practices in *pisanam* rice (IR 20)**

Main plot / Sub plot	Phosphorus use efficiency				Apparant P recovery (%) (incremental P uptake/kg P applied)			
	T1	T2	T3	Mean	T1	T2	T3	Mean
1 Absolute control	-	-	-	-	-	-	-	-
2 Blanket NPK (P - all basal)	-	6.98	8.47	7.73	-	8.78	14.50	11.64
3 STL based NPK (P - all basal)	-	11.52	15.81	13.67	-	5.79	23.14	14.47
4 Blanket NPK (P - in splits)	-	7.44	19.05	13.25	-	7.25	3.44	5.35
5 STL based NPK (P - in splits)	-	24.06	6.27	15.17	-	8.68	11.89	10.39
lean	-	12.50	12.40	12.45	-	7.63	13.24	10.43

b-plots : T1 : P_2O_5 application to irrigated pulse alone
T2 : P_2O_5 application to *Pisanam* rice alone
T3 : P_2O_5 application to both the crops.

in plots : Blanket NPK : 120 : 60 : 60 kg N, P_2O_5, K_2O/ha
STL based NPK : 167 : 47.5 : 220 kg N, P_2O_5, K_2O/ha

covery per cent were worked out as per methods uggested by Manickam and Ramaswami (1985).

ESULTSAND DISCUSSION

The results on the yield and yield attributes of rrigated pulse crop (Table 1) indicated that there vas significant response for the application of P.Phosphorus application @ 50 KgP_2O_5/ ha had ecorded markedly higher grain yield of 755 kg/ha which was 40.8 per cent increase over control (536 Kg/ha) with a net profit of approximately Rs.2000/- within a period of 65 days. A marked ncrease in the dry matter (haulms) yield was also bserved due to P application. In addition to the grain and haulm yield of pulse, P application has also favourably increased the yield attributes *viz.*, number of pods per plant and 1000 grain weight over control indicating the role of P in the pulse production. A marked increase (55- 61%) in the uptake of N,P and K by the pulse crop (Table 2) was observed for the application of P due to the ncreased grain yield and dry matter production. The apparent recovery per cent of applied P in the pulse crop worked out to 17.59 per cent. The P use efficiency was found to be 10.1 kg pulse grain per kg of P applied.

The results on the yield and uptake of nutrients in the *Pisanam* rice crop are reported in Table 3. With regard to the grain yield of rice, among the sub-plot treatments, application of P_2O_5 for rice alone or both for the irrigated pulse and the succeeding rice crop, being on a par among themselves, were found to be superior in recording an increased grain yield of 8.4 per cent over the P_2O_5 application for the irrigated pulse alone (no P for rice). It is evident that there is no residual effect of P applied to pulse on the succeeding rice crop and emphasised the need for the application of full dose of P for *pisanam* rice even though the preceeding irrigated pulse received 50 kg P_2O_5/ha. In the main plot treatments, application of P_2O_5 either by all basal or in split were found on a par. Similarly the grain yields under blanket recommendation (120:60:60) as well as soil test based recommendation (167:47.5:220) were comparable. The straw yield of rice was increased by the application of P_2O_5 as in the case of grain yield. Application of P_2O_5 both to the preceeding pulse as well as the succeeding rice crop had an additive effect in increasing the straw yield of rice over P application to rice alone. Soil test based fertilizer recommendation favoured more straw yield over blanket recommendation and the effect was more pronounced when the P was applied all basal as could be observed from the interaction effect of main plots with sub plot treatments.

Application of P_2O_5 both to the irrigated pulse and *Pisanam* rice, increased the N and P uptake by rice while its influence on the uptake of K was found non-significant (Table 4). P use efficiency (Table 5) in rice varied from 6.27 to 24.06 with an over all average of 12.45. P use efficiency recorded for the application of P either to rice alone or both for the irrigated pulse and rice was comparable under sub plots. In the main plots, STL based NPK recommendation registered higher P use efficiency than that of the blanket recommendation.

The apparent recovery per cent of the applied P in *Pisanam* rice (Table 5) varied from 3.44 to 23.14 with an average of 10.43 per cent. Application of P to both the crops in the legume-paddy sequence had registered a higher P recovery in rice crop (13.24%) than the P application to rice alone (7.63%). Under main plots, the STL based NPK application had recorded a higher P recovery than that of the blanket recommendation. The increased P use efficiency as well as P recovery in rice under STL based fertilization in this experiment was due to the lower level of P applied through STL recommen dation than that of the blanket and that the recovery of nutrients was found always higher under lower levels than that of the higher levels as reported by Velu (1989). Similarly the all- basal application of P favoured more P recovery in rice than that of the split. This is in agreement with the reports of Mahapatra (1969), who was of the view that rice responded well to basal application of P because of its poor ability to utilise soil P in early stages.

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EFFECT OF NITROGEN SOURCES ON THE AVAILABILITY OF INORGANIC NITROGEN FORMS IN SANDY CLAY WETLAND RICE SOIL

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ABSTRACT

Field experiments were conducted during *Kharif* and *rabi* seasons of 1991-92 to study the effect of nitrogen (N) sources on the availability of different inorganic N forms in Typic Ustropept Wetland rice soil. The results indicated that the NH_4 - N, NO_3 - N and available N content of the soil declined with crop growth during both the seasons. Increasing levels of N application up to 175 kg N ha_{-1} increased the NH_4-N, NO_3-N and available N content of the soil. Application of neem cake coated urea (NCU) recorded the lowest content of NO_3-N in the soil during both the seasons. Among the applied N sources, NCU followed by urea gypsum, prilled urea + green leaf manure recorded the highest NH_4-N and available N content of the soil in both the seasons.

KEY WORDS : Inorganic Nitrogen Forms, Neem Cake Coated Urea, Urea gypsum, Wetland Rice.

The soil contains nitrogen (N) as organic compounds, NH_4-N and NO_3- N forms. The amount of N availability in soil is small. Application of suitable and effective N source will