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TARGETED YIELD CONCEPT IN A RICE-RICE-RESIDUAL PULSE CROPPING SEQUENCE UNDER IPNS IN TYPIC USTROPEPTS OF LOWER BHAVANI PROJECT AREA OF TAMILNADU

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ABSTRACT

With a view to assess the extent of fertiliser requirement under Integrated Plant Nutrition System (IPNS) for rice-rice-residual pulse cropping sequence, field experiments were conducted in Typic Ustropept soils of Lower Bhavani Project area in Tamil Nadu. Making use of the data generated from the field experiments conducted on Inceptisol, targeted yield equations were developed for rice in *kharif* and *rabi* seasons. From these equations, the quantity of chemical fertilisers that could be adjusted to the levels and sources of organic manures was evaluated to be 38 kg N, 13 kg P_2O_5 and 33 kg K_2O/ha for fertilisers with GM ; 10-12 kg P_2O_5/ha for fertilisers with PB ; 40 kg N, 26 kg P_2O_5 and 33 kg K_2O/ha for fertilisers with GM plus PB.

KEY WORDS : Targeted yield concept, IPNS, fertiliser requirement

Table 1. Effect of application of graded levels of N_1,P_2,O_5 and K_2O on soil fertility status of gradient experiment

Strip	Fertiliser dose (kg/ha)			$KMnO_4$ - N(kg/ha)	Olsen-P (kg/ha)	NH_4 OAc-K (Kg/ha)
	N	P_2O_5	K_2O			
I	0	0	0	219	10.3	134
II	75	84	112	256	17.2	191
III	150	168	224	285	20.3	221
IV	300	336	448	296	26.2	244
'F' test				102.15**	63.32**	97.22**
SED				4.82	1.18	66.82
CD (1%)				16	3.8	22

** Significant at P = 0.01

To meet the ever-growing food demand in India, increasing productivity of intensive cropping systems is desirable through efficient fertiliser use without impairing soil health. Declining trend in productivity under continuous rice cropping due to depletion of soil fertility can be reversed by integrated use of chemical fertilisers, organic manures and biological sources of plant nutrients in the system. Rice based cropping sequences provide opportunities for practising Integrated Plant Nutrition System (IPNS). In view of the recent escalation in the cost of chemical fertilisers, it is imperative to increase their use efficiency through appropriate fertilisation practices. Hence, for practising the balanced, efficient and economic fertilisation, soil testing research should be directed to calibrate the soil test values for recommendation of chemical, organic and biofertilisers for targeted yield of crops in the rice based cropping sequence.

MATERIALS AND METHODS

Field experiments were conducted for four seasons in succession during 1993-94 and 1994-95 at the Agricultural Research Station, Bhavanisagar, Erode district, Tamil Nadu. The soil of the experimental site belongs to Irugur series which is a bench mark series of Tamil Nadu. Irugur soil series is classified as a fine loamy, mixed, Typic Ustropept. The surface soil texture was sandy clay loam and red non-calcareous, pH 7.2, E.C. 0.11 dS/m ; free $CaCO_3$ 0.35% ; $KMnO_4$-N 236 Kg/ha ; Organic carbon 0.405% ; Olsen-P 10.7 Kg/ha ; NH_4OAc-K 140 Kg/ha and deficient in available Zn (0.8 ppm). Phosphorus and potassium fixing capacities were 168 and 224 Kg/ha respectively. In the gradient experiment, the experimental field was divided into four equal strips viz., $N_0P_0K_0$, $N_{1/2}$, $P_{1/2}$, $K_{1/2}$, $N_1P_1K_1$ and $N_2P_2K_2$. P_1K_1 were fixed based on the phosphorus and potassium fixing capacities of the soil and N_1 is fixed based on the blanket recommendation for rice. Sixteen surface soil samples were collected before and after the rice crop for confirming the creation of fertility gradient.

After the creation of fertility gradients in the experimental site, two test crop experiments with

Table 2. Effect of application of graded levels of N_1,P_2,O_5 and K_2O on yield and nutrient uptake of rice (kg/ha)

Strip	Fertiliser dose (kg/ha)			Yield		Nutrient uptake		
	N	P_2O_5	K_2O	Grain	Straw	N	P	K
I	0	0	0	2480	3820	44.48	10.13	53.68
II	75	84	112	4150	5920	72.54	17.19	89.75
III	150	168	224	5180	6780	88.20	21.53	110.18
IV	300	336	448	5580	7835	98.22	22.00	118.72
'F' test				3992**	7909**	76.09**	208.71**	261.12**
SED				7.73	6.77	0.96	0.14	0.63
CD (1%)				25	22	3.10	0.46	2.10

** Significant at P = 0.01

Table 3. Nutrient requirement, per cent contribution from soil and fertilizer nutrients for *kharif* and *rabi* rice

Crop	Item	Basic Data			Response yardstick kg/ha
		N	P_2O_5	K_2O	
	i	1.79	1.02	2.61	
Kharif rice	ii	20.35	66.06	29.12	9.75
	iii	36.31	54.37	75.62	
	i	1.75	0.92	2.59	
Rabi rice	ii	17.15	49.81	26.12	9.23
	iii	35.75	44.87	66.42	

i. Nutrient requirement kg/q of grain
ii. Per cent contribution from soil available nutrients
iii. Per cent contribution from fertiliser nutrients

rice and one residual experiment with black gram were conducted. In the test crop experiments, there were 24 treatments with N at 5 levels *viz.*, 0, 50, 100, 150 and 200 Kg/ha ; P_2O_5 at 4 levels *viz.*, 0, 60, 120 and 180 Kg/ha. Green manure (*Sesbania rostrata*) at two levels 0 and 6.25 t/ha and phosphobacteria (*Bacillus megaterium* var. *Phosphaticum*) at two levels *viz.*, 0 and 2 Kg/ha. The design adopted was fractional factorial. Sources of fertiliser N, P_2O_5 and K_2O were urea, Udaipur Rock Phosphate (URP) and Muriate of Potash. These 24 treatments were superimposed randomly in each strip and were randomised in such a way that they occurred in four consecutive sub-blocks whether taken in the north to south or east to west directions. The fertilisers also, fertilisers + GM, fertilisers + PB and fertilisers + GM + PB were applied across each strip. In each experiment, the initial and post harvest soil samples were collected, processed and analysed for $KMnO_4$-N, Olsen-P and NH_4OAc-K. Grain and straw yields were recorded ; grain and straw samples were analysed for N, P and K contents and making use of this analytical data N, P and K uptake were computed.

The data on grain yield, uptake of nutrients pre sowing soil available nutrients and fertiliser doses were made use to compute the basic parameters *viz.*, nutrient requirement, soil, fertiliser and organic efficiencies. Fertiliser prescription equations were formulated using these basic parameters.

RESULTS AND DISCUSSION

Creation of fertility gradient

The soil fertility status with respect to available N, P and K was assessed in this experiment by analysing the pre sowing and post-harvest soil samples of gradient crop experiment. When the pre- sowing and post-harvest soil test

Table 4. Efficiency of green manure (GM), phosphobacteria (PB) and green manure plus phosphobacteria (GM plus PB) for *kharif* and *rabi* rice.

Parameter	N	P	K
Kharif rice			
Efficiency of green manure (Cg) per cent	25.40	17.26	29.74
Efficiency of phosphobacteria (Cp) per cent	-	31.51	-
Efficiency of green manure plus phosphobacteria (Cgp) per cent	26.00	22.79	31.11
Rabi rice			
Efficiency of green manure (Cg) per cent	24.15	14.17	26.49
Efficiency of phosphobacteria (Cp) percent	-	28.13	-
Efficiency of green manue plus phosphobacteria (Cgp) per cent	25.60	19.43	26.89

Table 5. Fertiliser requirements of rice for different yield targets and soil test values during *kharif* season (kg/ha)

Soil nutrient (Kg/ha)	Fertilisers alone			Fertilisers + GM			Fertilisers + PB			Fertilisers + GM + PB		
	Yd target (q/ha)			Yd target (q/ha)			Yd target (q/ha)			Yd target (q/ha)		
	50	60	70	50	60	70	50	60	70	50	60	70
Nitrogen												
200	134	183	232	95	144	193	134	183	232	94	143	192
225	120	169	218	81	130	179	120	169	218	80	129	178
250	106	155	204	67	116	165	106	155	204	66	115	164
275	92	141	190	53	102	151	92	141	190	52	101	150
300	78	127	176	39	88	137	78	127	176	38	87	136
Phosphorus												
10	66	85	104	53	72	91	54	73	92	40	59	78
15	52	71	90	39	58	77	40	59	78	26	45	64
20	38	57	76	25	44	63	26	45	64	12	31	50
25	24	43	62	11	30	49	12	31	50	0	17	36
30	11	30	49	0	17	36	0	18	37	0	4	23
Potassium												
150	104	139	173	71	107	141	104	139	173	70	105	139
175	92	127	161	59	95	129	92	127	161	58	93	127
200	81	116	150	48	84	118	81	116	150	47	82	116
225	69	104	138	36	72	106	69	104	138	35	70	104
250	58	93	127	25	61	95	58	93	127	24	59	93

values were compared, a marked increase in all the three nutrients was observed (Table 1). The build-up of $KMnO_4$-N status may be due to the reduced loss of N through volatilisation on account of convergence of pH towards neutrality under submergence and better adsorption of NH4+ ions in the soil by virtue of sufficient quantities of organic and inorganic colloids (Tisdale *et al.*, 1990).

The increased availability of P may be attributed to the application of phosphatic fertilisers at graded levels over and above the P fixing capacity of the soil and resultant increase in the concentration of orthophosphate ions. Since the application rates were high, more P would have remained in the solution (Dibb *et al.*, 1990). The increase in available K concentration might be due to the addition of K fertilisers in quantities higher than the K fixing capacity of the soil and the probable retent. ' of the added K in exchangeable form on exchange complexes of both organic and inorganic fractions of the soil. The grain and straw yields of gradient rice (var. ADT 36) increased with the increase in doses of fertiliser N, P_2O_5 and K_2O in all the strips. Similar trend of results was observed in the pattern of uptake of NPK by rice (Table 2).

Calibration of soil tests

Fertilisers are to be used economically for crops in the cropping sequence. According the concept of fertiliser prescription for specified yield targets, the fertiliser use in optimum amounts and proportions mainly depends on the ability of the soil to supply the native nutrients, the efficacy of the applied nutrients and the crop needs (Randhawa and Velayutham, 1982). The basic parameters *viz.*, nutrient requirement (NR), soil nutrient efficiency (Cs) and fertiliser nutrient efficiency (Cf) were estimated (Table 3). Using these basic parameters, fertiliser adjustment equations for chemical fertilisers alone were developed for *kharif* and *rabi* rice crops.

Table 6. Fertiliser requirements of rice for different yield targets and soil test values during *rabi* season (kg/ha)

Soil nutrient (Kg/ha)	Fertilisers alone			Fertilisers + GM			Fertilisers + PB			Fertilisers + GM + PB		
	Yd target (q/ha)			Yd target (q/ha)			Yd target (q/ha)			Yd target (q/ha)		
	50	60	70	50	60	70	50	60	70	50	60	70
Nitrogen												
200	148	197	246	110	159	208	148	197	246	108	157	206
225	136	185	234	98	147	196	136	185	234	96	145	194
250	124	173	222	86	135	184	124	173	222	84	133	182
275	112	161	210	74	123	172	112	161	210	72	121	170
300	100	149	198	62	111	160	100	149	198	60	109	158
Phosphorus												
10	78	99	119	65	86	106	68	89	109	53	74	94
15	65	86	106	52	73	93	55	76	96	40	61	81
20	52	73	93	39	60	80	42	63	83	27	48	68
25	40	60	80	27	54	67	30	55	70	15	45	55
30	27	48	68	14	42	54	17	43	58	2	33	43
Potassium												
150	124	162	201	91	129	168	124	162	201	91	129	168
175	113	151	190	80	118	157	113	151	190	80	118	157
200	101	139	178	68	106	145	101	139	178	68	106	145
225	89	127	166	56	94	133	89	127	166	56	94	133
250	77	115	154	44	82	121	77	115	154	44	82	121

Optimisation of fertiliser doses and yield targeting under Integrated Plant Nutrition System (IPNS)

The IPNS using chemical fertilisers, organic manures and biofertilisers on scientific principles will not only enhance the nutrient use efficiency but also maintain soil productivity over long run. The basic parameters *viz.*, the efficiency of N, P and K nutrients from GM, PB and GM plus PB were worked out (Table 4). Fertiliser adjustment equation were developed and these equations adjust

Table 7. IPNS and fertilisers saving in rice

Treatments	Fertiliser requirement (kg/ha)			Quantity of fertilisers saved (kg/ha)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Kharif rice						
NPK alone	106	52	81	-	-	-
NPK + GM	67	39	48	39	13	33
NPK + PB	106	40	81	-	12	-
NPK + GM + PB	66	26	47	40	26	34
Rabi rice						
NPK alone	124	65	101	-	-	-
NPK + GM	86	52	68	38	13	33
NPK + PB	124	55	101	-	10	-
NPK + GM + PB	84	40	68	40	25	33

Initial soil test value : 250:15:200 kg NPK/ha
GM : Green manure ; PB - Phosphobacteria

the dose of chemical fertilisers for the levels of GM or PB or GM plus PB applied with chemical fertilisers for rice. The fertiliser prescription equations are as follows :

Kharif	*Rabi*
Fertilisers alone	
$FN = 4.92\ T - 0.56\ SN$	$FN = 4.88\ T - 0.48\ SN$
$FP_2O_5 = 1.88\ T - 2.78\ SP$	$FP_2O_5 = 2.06\ T - 2.54\ SP$
$FK_2O = 3.46\ T - 0.46\ SK$	$FK_2O = 3.89\ T - 0.47\ SK$
Fertilisers with GM	
$FN = 4.92\ T - 0.56\ SN - 0.70\ ON$	$FN = 4.88\ T - 0.48\ SN - 0.68\ ON$
$FP_2O_5 = 1.88\ T - 2.78\ SP - 1.66\ OP$	$FP_2O_5 = 2.06\ T - 2.54\ SP - 1.65\ OP$
$FK_2O = 3.46\ T - 0.46\ SK - 0.58\ OK$	$FK_2O = 3.89\ T - 0.47\ SK - 0.59\ OK$
Fertilisers with PB	
$FN = 4.92\ T - 0.56\ SN$	$FN = 4.88\ T - 0.48\ SN$
$FP_2O_5 = 1.88\ T - 2.78\ SP - 3.04\ OP$	$FP_2O_5 = 2.06\ T - 2.54\ SP - 3.29\ OP$
$FK_2O = 3.46\ T - 0.46\ SK$	$FK_2O = 3.89\ T - 0.47\ SK$
Fertilisers with GM plus PB	
$FN = 4.92\ T - 0.56\ SN - 0.72\ ON$	$FN = 4.88\ T - 0.48\ SN - 0.72\ ON$
$FP_2O_5 = 1.88\ T - 2.78\ SP - 2.20\ OP$	$FP_2O_5 = 2.06\ T - 2.54\ SP - 2.27\ OP$
$FK_2O = 3.46\ T - 0.46\ SK - 0.60\ OK$	$FK_2O = 3.89\ T - 0.47\ SK - 0.59\ OK$

Where FN, FP_2O_5 and FK_2O stand for fertiliser N, P_2O_5 and K_2O in Kg/ha respectively. ON, OP and OK stand for organic N,P and K in Kg/ha respectively. SN, SP and SK stand for soil available N, P and K in Kg/ha respectively. T denotes yield target in q/ha.

The ready reckoners constructed from the fertiliser adjustment equations to obtain fertiliser doses for varying soil test values are furnished in Table 5 & 6. Thus the basis developed would serve as a means to arrive at the actual quantity of fertiliser doses, when GM and PB were integrated with chemical fertilisers. There was considerable reduction in the quantities of fertiliser nutrients (NPK) under IPNS (Table 7). The extent of saving under IPNS also increased with increase in soil fertility levels and decline when the yield targets aimed at were increased.

It has been shown that 'Targeted yield concept' is highly applicable for rice-rice-residual pulse cropping sequence under IPNS. Soil test calibrations and the adjustment of fertiliser doses with green manure and biofertiliser is the best way of prescribing fertiliser requirement for Lower Bhavani Project area of Tamil Nadu.

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