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Fertilizer recommendation based on soil test crop response for high targeted yield

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ABSTRACT

Soil test crop responses (STCR) studies were conducted with rice cv. ADT 43 at the Experimental Farm, Annamalai University, Annamalainagar. The field consisted of four strips(I, II, III, IV) and received $N_0P_0K_0$,$N_{1/2}$,$P_{1/2}$,$K_{1/2}$, $N_1P_1K_1$,N_2,P_2K_2 fertilizers, respectively. The results indicated that the grain yield in strip I (2.36 tha^{-1}) increased to strip IV (5.69 tha^{-1}) with graded levels of NPK fertilizers due to better nutrient uptake. Followed by test crop (STCR) experiment was carried out with rice cv. ADT 36 in the same field during wet season. By using grain yield, initial soil test values, uptake of nutrients and fertilizer doses applied, the three basic parameters viz., NR,CS,CF were worked out, Fertilizer adjustment equations(FAEs) were formulated. Finally the fertilizer recommendations were worked. The results of this STCR experiment revealed that when the initial soil available NPK status were 200, 10, 250 kgha^{-1}, the FN,FP_2O_5,FK_2O recommendations to get 60 t ha^{-1} were 233:100:107 kgha^{-1} for fertilizers alone application. The fertilizer recommendations for the application of fertilizers + FYM + Azospirillum, for the same yield target were 185:86:82 kgha^{-1} due to balanced fertilization.

Key words: *rice, STCR, fertilizer recommendations, yield target*

Self-sufficiency in rice has been a major goal of agricultural research and development in India. In Tamil Nadu, rice is grown in an area of 2.79 million hectares with the production of 7.2 million tonnes with an average of 3.4 t ha^{-1}. Rice yield obtained from one hectare could sustain 5.7 persons in a year (Budhar and Palaniappan,1996). Soil test crop response (STCR) studies help to generate fertilizer adjustment equations and calibration charts for recommending fertilizers on the basis of soil tests and achieving targeted yield of crops (Singh and Biswas, 2000). The need to apply fertilizers in balanced quantitative proportions according to crop requirements and soil available nutrients for targeted yields has been well recognized as a better approach than the existing practice of general fertilizer recommendation. Therefore, the present investigation was carried out to establish the relation between soil test values uptake of NPK on yield.

MATERIALS AND METHODS

The crop experiment with rice cv. ADT 43 was carried out in the Experimental Farm, Annamalai University. The soil of the experimental site was black in colour with clay loam texture, pH-7.70, EC (dSm^{-1})-0.48 and CEC- 29.70 cmol(p$^+$) kg^{-1}. The available N, P and K status were 196, 9.14 and 270 kgha^{-1}, respectively. Phosphorus and potassium fixation capacity of the initial soil were 82 and 70 kgha^{-1}, respectively. The field was divided into four equal strips like I, II, III and IV. Fertilizer levels $N_0P_0K_0$, $N_{½}P_{½}K_{½}$, $N_1P_1K_1$ and $N_2P_2K_2$ were given to strip I, II,III &IV, respectively. N was applied through urea as per blanket recommendation. P and K were applied based on their fixing capacity through SSP and MOP, respectively. Plant, soil samples from each strip were taken and analysed for available NPK content and status, respectively. At maturity, rice crop was harvested and yield from each strip was also recorded. After harvesting of the gradient crop experiment, a test crop experiment (STCR) was carried out in the same field with rice cv.ADT 36 during wet season. It consisted four strips and four blocks laid in fractional factorial design based on targeted yield model (Ramamoorthy *et al.,* 1967). Each gradient strip was sub divided into 24 plots, out which 20 NPK treatments

and 4 controls were super imposed at random in each strip. Treatment consisted of 5 levels of N(0, 50, 100, 150 and 200 kg ha^{-1}), 4 levels of P_2O_5(0, 30, 60 and 90 kg ha^{-1}), 3 levels of K_2O kg ha^{-1}), 2 levels of FYM were 0, 12.5 t ha^{-1}, 2 levels of *Azospirillum*, were 0, 2 kg ha^{-1}. Block like I, II, III and IV received NPK, NPK+FYM, NPK+*Azospirillum* and NPK+FYM + *Azospirillum*, respectively. Initial soil samples were collected and analysed for available NPK status. Rice cv. ADT 36 was grown with the recommended cultural practices. At maturity, plant samples were collected and analysed for NPK content and uptake. Grain yield from each strip was also recorded. By using grain yield, NPK uptake, soil NPK availability, fertilizer doses applied, three basic parameters viz., nutrient requirement (NR)-kg ha^{-1}, contribution of soil nutrients (CS)-%, Contribution of fertilizer nutrients (CF) were worked out and fertilizer adjustment equations (FAEs) were developed to recommend fertilizers for the targeted yield of 60 t ha^{-1} of rice.

RESULTS AND DISCUSSION

The results of the gradient crop experiment revealed that the grain yield in strip I, II, III and IV were 2.36, 3.35, 4.77 and 5.69 kg ha^{-1}, respectively. This might be due to better nutrient uptake by the crop which favourably influenced the growth and yield of rice as reported by Santhi and Selvakumari (1999). The mean N uptake in strip I, II, III and IV was 36.31, 52.15, 78.63 and 92.26 kg ha^{-1}, respectively. The P uptake values were 10.84 kg ha^{-1} (strip I), 20.25 kg ha^{-1} (strip II), 29.37 kg ha^{-1} (Strip III) and 35.61 kg ha^{-1} (strip IV) while the mean K uptake was 31.21 kg ha^{-1} in strip I, 52.28 kg ha^{-1} in strip II, 69.10 kg ha^{-1} in strip III and 81.54 kg ha^{-1} in strip IV. It was inferred from the STCR gradient crop experiment that an application of graded levels of NPK fertilizers significantly influenced the grain yield, NPK uptake and NPK availability. It is very much essential to simulate different fertility status in one and the same field for STCR fertilizer recommendation.

The range and mean values of initial soil available, in the test crop rice cv. ADT 36 ranged 202 - 384 kg ha^{-1} with a mean of 270 kg ha^{-1}. The available P values ranged from 8.61 to 40.60 with a mean of 22.03 kg ha^{-1}, while the available K varied from 273- 439 kg ha^{-1} with a mean value of 352 kg ha^{-1} (Table 2). The N, P and K uptake ranges were 43.01- 97.15, 13.88-43.12 and 40.35-80.14 kg ha^{-1}, respectively. The grain yield of rice recorded a range of 3.46-6.43 t ha^{-1} with a mean of 4700 kg ha^{-1}.

It is evident from the above data that a wide variability existed in the grain yield and soil test values.

There are three basic parameters namely nutrient requirement (NR), contribution of soil nutrients (CS) and contribution of fertilizers (CF) are required to develop FAEs for recommending fertilizers for the specific yield target of rice. NR values for N, P_2O_5, K_2O were 1.40, 1.36 and 1.50 $kgha^{-1}$, respectively. The CS values for Nitrogen, phosphorus and potassium were 12.53, 61.07 and 10.67 percent, respectively. While the fertilizer N, P_2O_5, K_2O efficiencies were 25.42, 67.52 and 54.05 percent, respectively. Nutrient efficiencies of FYM, *Azospirillum* and FYM+*Azospirillum* were also worked out and are given in table 3.

By using the NR,CS,CF values along with the nutrient efficiencies of FYM, *Azospirillum* and FYM + *Azospirillum*, fertilizer adjustment equations (FAE) were developed are presented in table 4.

Table 1. Effect of graded levels of NPK fertilizers on grain yield, NPK uptake and Post-harvest soil NPK availability of rice cv. ADT 43

Strip	FN ($kgha^{-1}$)	FP_2O_5 ($kgha^{-1}$)	FK_2O ($kgha^{-1}$)	Grain Yield (t ha^{-1})	NUptake ($kgha^{-1}$)	PUptake ($kgha^{-1}$)	KUptake ($kgha^{-1}$)	SN ($kgha^{-1}$)	SP ($kgha^{-1}$)	SK ($kgha^{-1}$)
I	0	0	0	2.36	36.31	10.84	31.27	217	9.57	285
II	60	41	35	3.35	52.15	20.25	52.28	258	17.60	332
III	120	82	70	4.77	78.63	29.37	69.10	290	25.10	374
IV	240	164	140	5.69	92.26	35.61	81.54	325	34.23	425
SEd				0.04	1.28	0.61	5.60	4.17	1.48	5.31
CD (0.05)				0.08	2.79	1.32	12.19	9.08	3.43	11.57

Table 2. Initial soil available NPK nutrients status, NPK Uptake and Grain yield of rice cv. ADT36

S.No	Parameters	Range	Mean
1	Soil available Nitrogen(kgha^{-1})	202-334	270
2	Soil available Phosphorus(kgha^{-1})	8.61-40.60	22.03
3	Soil available Potassium(kgha^{-1})	273-439	352
4	N Uptake (kgha^{-1})	43.01-97.15	66.00
5	P Uptake(kgha^{-1})	13.88-43.12	28.10
6	K Uptake (kgha^{-1})	40.37-80.14	58.84
7	GrainYield (kgha^{-1})	3462-6438	4700

On the basis of FAEs a ready reckoner was prepared for a yield target of 6.0 t ha^{-1} of rice with varying soil test values. The results indicated that when the soil available N status was 200 kg ha^{-1} , the sole fertilizer N recommendation was 233 kgha^{-1}. when fertilizer + FYM applied, the FN dose was 202 kgha^{-1}. For combined application of fertilizer with *Azospirillum* the FN requirement was 220 kg ha^{-1}. To obtain a similar yield target at the same available N status, when the conjoint application of fertilizer + FYM + *Azospirillum*, the FN dose was 185 kg ha^{-1}.

Table 3. Basic parameters, Efficiencies of organics, bio-fertilizer in test crop experiment of rice

S.No	Parameters	N	P_2O_5	K_2O
1	Nutrient Requirement (NR kgha^{-1})	1.40	1.36	1.50
2	Contribution of Soil Nutrients (CS %)	12.53	61.07	10.67
3	Contribution of Fertilizer Nutrients (CF %)	25.42	67.52	54.05
4	Contribution of FYM (C_{FYM} %)	19.50	16.48	28.79
5	Contribution of *Azospirillum* ($C_{Azos.}$ %)	21.30	-	-
6	Contribution of FYM+ *Azospirillum* ($C_{FYM+Azos.}$ %)	22.26	17.45	29.72

When the initial soil available P status was 10 kgha^{-1}, the fertilizer P_2O_5 requirement for sole fertilizer application was 100 kg ha^{-1}, when the fertilizers were applied along with FYM, the P_2O_5 dose was 87 kgha^{-1}. When the fertilizers + FYM +*Azospirillum* applied, the quantity of fertilizer P_2O_5 requirement was 86 kgha^{-1}.

Table 4. Fertilizer adjustment equations(FAEs) under targeted yield model for rice cv. ADT 36.

Fertilization	Fertilizer Adjustment Equations
NPK alone	FN=5.51T-0.49 SN F P_2O_5= 2.02T – 2.07 SP F K_2O = 2.78 T – 0.24 SK
NPK+FYM	FN=5.51T-0.49 SN- 0.77 ON F P_2O_5= 2.02T – 2.07 SP-0.56 OP F K_2O = 2.78 T – 0.24 SK- 0.65 OK
NPK+*Azospirillum*	FN=5.51T-0.49 SN-0.84 ON F P_2O_5= 2.02T – 2.07 SP F K_2O = 2.78 T – 0.24 SK
NPK+FYM+*Azospirillum*	FN=5.51T-0.49 SN-0.88 ON F P_2O_5= 2.02T – 2.07 SP-0.59 OP F K_2O = 2.78 T – 0.24 SK-0.67 OK

Where, FN, FP_2O_5, FK_2O- Fertilizer N, P_2O_5, K_2O(kgha^{-1}) : SN,SP ans SK – soil available N,P and K status (kgha^{-1}) :ON,OP and OK- organic nitrogen, phosphorus and potassium (kgha^{-1})
T- targeted yield(qha^{-1})

With sole fertilizer application for a soil available potassium status was 250 kgha^{-1}, the FK_2O dose required for an yield target of 6.0 t ha^{-1} of rice yield was 107 kgha^{-1}. The quantity of FK_2O reduced to 83 kg ha^{-1} and 82 kg ha^{-1} with the application of fertilizers +FYM and fertilizers+FYM+*Azospirillum,* respectively.

Table 4. Fertilizer recommendations under STCR for an yield target of 6.0 t ha^{-1} of rice cv. ADT 36

Soil available Nutrients	Fertilizer alone	Fertilizers+ FYM	Fertilizers+ *Azospirillum*	Fertilizers+ FYM *Azospirillum*
Nitrogen (kgha^{-1})				
200	233	202	220	185
225	221	190	208	173
250	208	177	195	160
275	196	165	183	148
300	184	153	171	136
Phosphorus (kgha^{-1})				
10	100	87	100	86
15	90	77	90	76
20	80	67	80	66
25	69	56	69	55
30	59	46	59	45
Potassium (kgha^{-1})				
250	107	83	107	82
300	95	71	95	70
350	83	59	83	58
400	71	47	71	46
450	59	35	59	34

Similar results have been reported by Santhi *et al* (2002).

It is evident from the data that the fertilizer N, P_2O_5, K_2O doses decreased with increase in soil test values. The results also revealed that the FN,FP_2O_5 and FK_2O doses were high when fertilizer alone were applied. The fertilizer requirement decreased with the conjoint application of fertilizers + FYM+*Azospirillum* for a specific yield target at the same soil test value.Hence there will be a balanced supply of nutrients coupled with organics and bio-fertilizers avoiding either under or over usage of fertilizers.

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