

Optimizing fertilizer doses for rice in alluvial soils through chemical fertilizers, farm yard manure and green manure using soil test values

S. Riazuddin Ahmed and P. V. Krishna Reddy

Agricultural Research Institute, Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad 500 030, India

Abstract

An attempt has been made in this paper to optimize fertilizer recommendation of N, P and K through chemical fertilizers, farm yard manure (FYM) and green manure using soil test values based on the Soil Test Crop Response (STCR) methodology. The study is based on two field experiments conducted during *kharif* 1999 and 2000 on alluvial soils of Nellore with fertilizer treatments based on the existing set of equations developed earlier in the project. Based on the study, the equations have been modified and a new set of equations have been developed for optimizing fertilizer requirement through FYM and green manuring, apart from inorganic fertilizer N, P and K nutrients for rice. Basic data viz., nutrient requirement, soil, fertilizer and organic nutrient efficiencies have been derived and examined over two seasons. A ready reckoner has been given in the paper for interpolating optimal fertilizer doses under 3 situations viz., inorganic fertilizers alone, inorganic + FYM and inorganic + green manure categories at varying soil test values for attaining 35 and 45 q/ha of rice yield in alluvial soils.

Additional keywords : Inorganic fertilizers and organic manures, soil fertility, targeted yield equations.

Introduction

There is a need to apply fertilizers in balanced quantitative proportions according to crop requirements and available nutrients. Further, there is a greater need to conjointly use organic manures like farm yard manure and green leaf manure along with inorganic fertilizers for not only attaining higher yield but also for maintaining soil fertility. This fact has been well recognized in India from the All India Coordinated Research Project for investigations under Soil Test Crop Response during the last 35 years (Ramamoorthy *et al.* 1967). Based on the findings of this project, resources can be effectively utilised and high yield and profits can be attained with judicious fertilizer application (Maruthi Sankar 1986). It is also important to replenish the soil after removing the nutrients (Velayutham 1979). Location specific fertilizer recommendations are possible for soils of varying fertility, resource conditions of farmers and levels of targeted yield for similar soil classes and environment. Soil test based optimal fertilizer doses have been examined for their accuracy in attaining yield targets of rice and also a new set of equations have been developed for better estimation of soil and fertilizer nutrient efficiencies (Maruthi Sankar *et al.* 1983). Based on two field experiments, an effort is made in this paper to modify the existing fertilizer adjustment equations of only inorganic and a new

set of equations with inorganic + FYM and inorganic + green manure have been developed for attaining yield targets of rice in alluvial soils of Nellore district in Andhra Pradesh.

Materials and methods

Two Soil Test Crop Response (STCR) field experiments with rice 'NLR-33651' variety have been conducted in kharif 1999 and 2000 seasons at Agricultural Research Station, Nellore on alluvial soils. In the first season, the nursery was sown on 9-9-1999; FYM and green manure treatments were superimposed on 30-9-1999; the transplanting was done on 18-10-1999 and the crop was harvested on 3-2-2000. In the second season, the nursery was sown on 11-9-2000, the FYM and green manure treatments were superimposed on 28-9-2000, the transplanting was done on 31-10-2000 and the crop was harvested on 19-2-2001. The layout was based on the approach developed by Ramamoorthy *et al.* (1967). The experiments were conducted with 9 treatments and 3 replications in Randomized Block Design. The 9 treatments experimented are as under :

T₁ : Control

T₂ : FYM @ 10 t/ha

T₃ : Green manure (Dhaincha) @ 5 t/ha

T₄ : STCR dose for attaining 35 q/ha of yield target

T₅ : T₄+FYM @ 10 t/ha

T₆ : T₄+green manure (Dhaincha) @ 5 t/ha

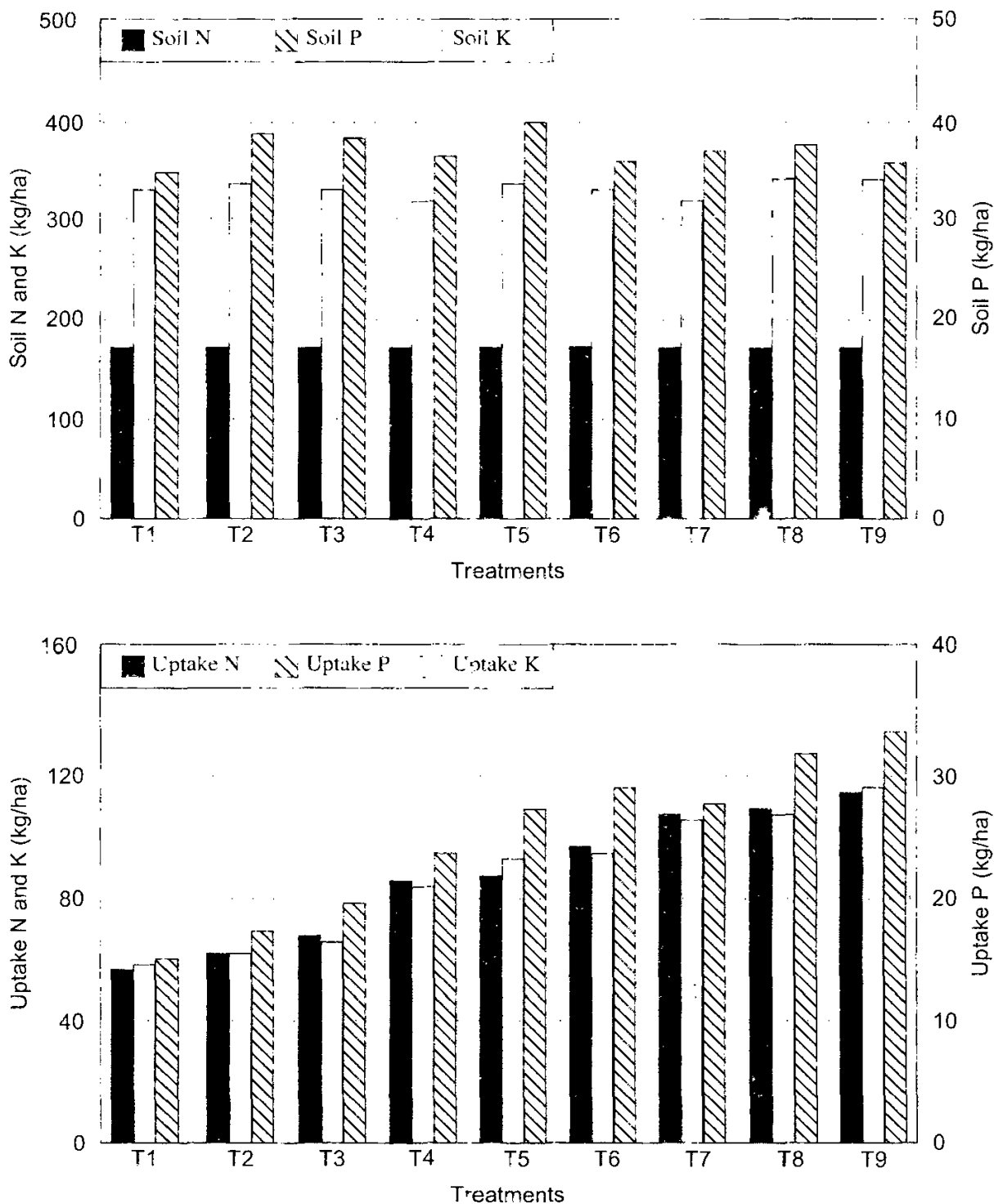
T₇ : STCR dose for attaining 45 q/ha of yield target

T₈ : T₇ + FYM @ 10 t/ha

T₉ : T₇+green manure (Dhaincha) @ 5 t/ha

Initial soil samples from 0-15 cm were collected from each plot and analysed for organic carbon, soil available N, P and K nutrients. The methodology adopted was based on organic carbon and alkaline permanganate method for nitrogen (Subbaiah and Asija 1955), Olsen's method for phosphorus (Olsen *et al.* 1954) and ammonium acetate method for potassium (Jackson 1973).

In *kharif* 1999, the organic carbon ranged between 0.78 and 0.97%, soil N between 181.0 and 186.5 kg/ha, soil P between 33.3 and 37.5 kg/ha and soil K between 255 and 289 kg/ha. The plant uptake N ranged between 54.6 and 98.2 kg/ha, uptake P between 15.4 and 29.6 kg/ha and uptake K between 66.8 and 119.2 kg/ha, and rice yield ranged from 2562 to 4839 kg/ha.



T 1 : Control T 2 : FYM @ 10 t/ha T 3 : GM @ 5 t/ha T 4 : STCR dose for 35 q/ha
 T 5 : STCR dose for 35 q/ha + FYM @ 10 t/ha T 6 : STCR dose for 35 q/ha + GM @ 5 t/ha
 T 7 : STCR dose for 45 q/ha T 8 : STCR dose for 45 q/ha + FYM @ 10 t/ha
 T 9 : STCR dose for 45 q/ha + GM @ 5 t/ha

Fig. 1. Soil test and plant uptake values of N, P and K nutrients in rice at Nellore

In *kharif* 2000, the organic carbon ranged between 0.79 and 0.89%, soil N between 156.3 and 193.7 kg/ha, soil P between 35.2 and 47.9 kg/ha and soil K between 373 and 417 kg/ha. The plant uptake N ranged from 59.7 to 132.4 kg/ha, uptake P from 14.4 to 36.5 and uptake K from 49.7 to 110.0 kg/ha, and rice yield ranged from 2309 to 5193 kg/ha.

The treatment wise mean soil and plant uptake of N, P and K nutrients are given in Figure 1. Soil available N, P and K amounts were maximum in the plot where STCR dose for 35 q/ha yield target+FYM @ 10 t/ha was applied (T5 treatment), while the plant uptake of N, P and K nutrients were maximum in the plot where STCR dose for 45 q/ha yield target+green manure (Dhaincha) @ 5 t/ha was applied (T9 treatment). Maximum yield was attained in the plot where STCR dose for 45 q/ha yield target+green manure (Dhaincha) @ 5 t/ha was applied (T9 treatment), while minimum yield was recorded in control plot. Higher crop yields resulted in higher N, P and K uptake and vice versa in both seasons as indicated in Figure 2.

The existing basic data viz., nutrient requirement, soil and fertilizer nutrient

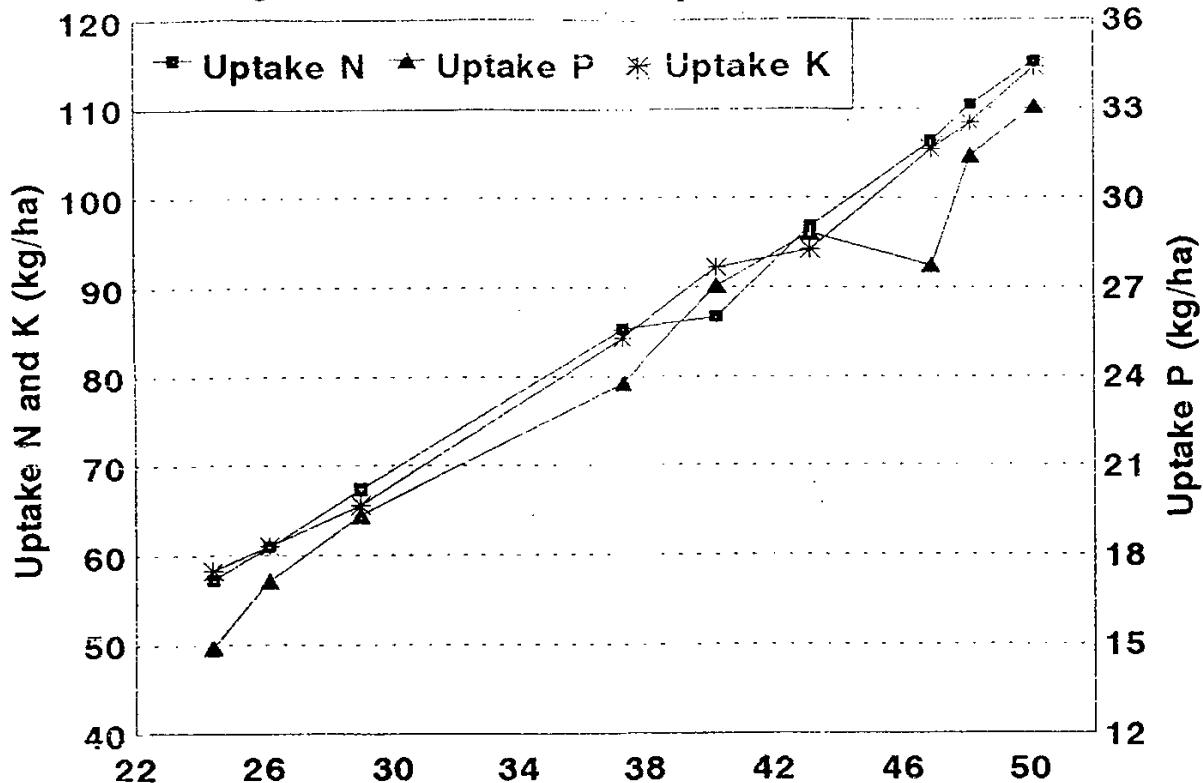


Fig. 2. Relation between grain yield and plant uptake of N, P and K nutrients in rice

efficiencies of N, P and K nutrients and fertilizer adjustment equations from the inorganic fertilizer set of data calculated by the procedure discussed by Velayutham

(1979) are given in Table 1. Based on the two field experiments, a modified set of basic data and targeted yield equations using FYM and green manure (Dhaincha) nutrient efficiencies have been calibrated and are given in Table 1. Using the fertilizer adjustment equations, a ready reckoner has been developed for interpolating optimal fertilizer doses at varying soil test values for attaining different yield targets of rice in alluvial soils. The composition of FYM was 0.351% N, 0.371% P₂O₅ and 1.20% K₂O. Green manure (Dhaincha) used contained 0.401% N, 0.26% P₂O₅, 0.34% K₂O.

Table 1. Basic data and targeted yield equations for rice in alluvial soils of Nellore

Category of equations	Nutrient	NR	SE	FE	OE (FYM/GM)	Targeted yield equations
Original	N	1.88	20	54		FN = 3.47 T-0.37 SN
	P	1.09	40	43		FP = 2.53 T-2.12 SP
	K	2.79	24	148		FK = 1.89 T-0.20 SK
Modified (FYM)	N	1.88	20	54	10.2	FN = 3.47 T-0.37 SN-0.19 FYM
	P	1.09	40	43	16.6	FP=2.53 T-2.12 SP-0.31 FYM
	K	2.79	24	148	11.3	FK= 1.89 T-0.20 SK-0.21 FYM
Modified (GM)	N	1.88	20	54	43.5	FN=3.47 T-0.37 SN-0.81 GM
	P	1.09	40	43	64.7	FP= 2.53 T-3.43 SP WITH GM
	K	2.79	24	148	25.0	FK = 1.89 T-0.21 SK WITH GM

SN, SP & SK : Soil test values of N, P and K nutrients (kg/ha)

FN, FP & FK are fertilizer N, P & K nutrients (kg/ha)

NR : Nutrient requirement (kg/q)

SE : Soil nutrient efficiency (%)

FE : Fertilizer nutrient efficiency (%)

OE : Organic nutrient efficiency (%)

FYM : Farm yard manure

GM : Green manure (Daincha)

T : Target (q/ha)

Results and discussion

The existing estimates of basic data as given in Table 1 indicated a N requirement of 1.88, P requirement of 1.09 and K requirement of 2.79 kg/q; soil nutrient efficiency of 20% for N, 40% for P and 24% for K; and fertilizer nutrient efficiency of 54% for N, 43% for P and 148% for K. Based on the two field experiments, the basic data and targeted yield equations have been modified and the organic nutrient use efficiencies for FYM and green manure (Dhaincha) have been

estimated. Under modified method, organic nutrient efficiency using FYM as source was found to be 10.2% for N, 16.6% for P and 11.3% for K. The estimates were 43.5% for N, 64.7% for P and 25% for K when green manure (Dhaincha) was used as source. Using the organic nutrient efficiencies of FYM and green manure (Dhaincha), the fertilizer adjustment equations have been recalibrated and are given in Table 1.

Table 2. Ready reckoner of soil test based fertilizer doses (with and without organics) for attaining yield targets of rice

Soil test values (kg/ha)			Original equation (without organics)			Modified equation (with FYM)			Modified equation (with GM)		
SN	SP	SK	FN	FP	FK	FN	FP	FK	FN	FP	FK
Fertilizer doses for attaining a yield target of 35 q/ha											
150	5	250	66	78	16	64	75	14	62	71	14
155	10	270	64	67	12	62	64	10	60	54	9
160	15	290	62	57	8	60	54	6	58	37	5
165	20	310	60	46	4	59	43	2	56	20	1
170	25	330	59	36	0	57	32	0	55	3	0
175	30	350	57	25	-	55	22	-	53	0	-
180	35	370	55	14	-	53	1	-	51	-	-
185	40	390	53	4	-	51	1	-	49	-	-
190	45	410	51	0	-	49	0	-	47	-	-
195	50	430	49	-	-	47	-	-	45	-	-
200	55	450	47	-	-	46	-	-	43	-	-
Fertilizer doses for attaining a yield target of 45 q/ha											
150	5	250	101	103	35	99	100	33	97	97	33
155	10	270	99	93	31	97	90	29	95	80	28
160	15	290	97	82	27	95	79	25	93	62	24
165	20	310	95	71	23	93	68	21	91	45	20
170	25	330	93	61	19	91	58	17	89	28	16
175	30	350	91	50	15	90	47	13	87	11	12
180	35	370	90	40	11	88	37	9	86	0	7
185	40	390	88	29	7	86	26	5	84	-	3
190	45	410	86	18	3	84	15	1	82	-	0
195	50	430	84	8	0	82	5	0	80	-	-
200	55	450	82	0	-	80	0	-	78	-	-

Based on the existing (inorganic) and modified (inorganic+organic) fertilizer adjustment equations, a ready reckoner has been developed for interpolating optimal fertilizer doses based on soil test values for attaining different yield targets of rice in alluvial soils and is given in Table 2. Based on the existing equations, fertilizer N recommendation was found to range between 47 and 66 kg/ha, fertilizer P between 4 and 78 and fertilizer K between 4 and 16 kg/ha for attaining a yield target of 35 q/ha when the soil N ranged between 200 to 150 kg/ha, soil P between 55 to 5 kg/ha and soil K between 450 to 250 kg/ha. Based on the modified equations using FYM efficiency, fertilizer N, P and K ranged between 46 and 64, 1 and 75 and 2 and 14 kg/ha respectively at the same level of soil test values. There was a further decrease in the fertilizer doses when green manure nutrient efficiency was used and the doses were varying between 43 and 62 for N, 3 and 71 for P and 1 and 14 kg/ha for K for attaining a yield target of 35 q/ha. However, for attaining 45 q/ha of rice yield, the doses ranged from 82 to 101 for N, 8 to 103 for P and 3 to 35 kg/ha for K employing existing method; 80 to 99 for N, 5 to 100 for P and 1 to 33 kg/ha for K employing modified method using FYM as source; and 78 to 97 for N, 11 to 97 for P and 3 to 33 kg/ha for K employing modified method using green manure.

The study indicated that fertilizer N, P and K requirement is the lowest when green manure is used followed by FYM and only inorganic source of fertilizer. However, this should be verified under farmer's field conditions before large scale fertilizer recommendations are made for attaining yield targets of rice under alluvial soils of Nellore in Andhra Pradesh.

References

- Jackson, M.L. (1973). "Soil Chemical Analysis". (Prentice Hall of India Pvt. Ltd.: New Delhi.)
- Maruti Sankar, G. R., Velayutham, M., Reddy, K.C.K., and Singh, K. D. (1983). A new method for better estimation of soil and fertilizer efficiencies. *Indian Journal of Agricultural Science*, **53**, : 314-319.
- Maruthi Sankar, G.R. (1986). On screening of regression models for selection of optimal variable subsets. *Journal of Indian Society of Agricultural Statistics*, **38**, : 161-168.
- Olsen S.R., Cole, C.V., Watanabe, F.S., and Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circ. U S Dept. Agric. 939.
- Ramamoorthy, B., Narasimham, R. L., and Dinesh, R. S. (1967). Fertiliser application for specific yield target of sonora-64 wheat. *Indian Farming*, **17**, 43-45.

Subbaiah, B. V., and Asija G. L. (1956). A rapid procedure for determination of available nitrogen in soil. *Current Science* **25**, 259-260.

Velayutham, M (1979). Fertiliser recommendation based on targetted yield concept problems and prospects. *Fertilizer News* **24**, 12-20.

Received : July, 2002; Accepted : February, 2003