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Optimization of fertilizer doses for Kharif rice, *Oryza sativa* L on deltaic soils of Andhra Pradesh

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ABSTRACT

Field experiments were conducted on rice, *Oryza sativa* L for three consecutive Kharif seasons viz 2006, 2007 and 2008 on Godavari alluvials (Vertic chromusters) at Andhra Pradesh Rice Research Institute, Maruteru with an objective to revise the existing fertilizer doses of major nutrients for Kharif rice in Krishna Godavari delta regions of AP. There was increase in grain yield by 13.1 and 6.3 per cent due to increase in recommended dose of N from 100 to 125 and 125 to 150 per cent respectively. Increase in P and K doses from 100 to 125 per cent improved grain yield significantly. Higher agronomic efficiency and energy use efficiency of K and P were observed with first incremental dose (125%). Increase in levels of N, P and K by 50 per cent resulted in an additional net income of ₹6987, 2260 and 3567 respectively. Study showed that 50 per cent increase of N, P and K over the existing doses of 60, 40 and 40 kg/ha respectively appeared to be the optimum doses for Kharif rice in deltaic alluvial soils of Andhra Pradesh.

Keywords: Rice; incremental doses; yield; economics

INTRODUCTION

Nutrient management must be sound for achieving production targets on sustainable basis. With the advent of modern production technology the usage of higher doses of fertilizers in balanced manner is inevitable to exploit their full potential particularly under irrigated conditions. Application of inadequate and imbalanced fertilization to crops not only results in low crop yields but also deteriorate the soil health (Sharma et al 2003). The existing fertilizer recommendation for major nutrients in rice during Kharif *(*N, P and K @ 60, 40 and 40 kg/ha) particularly for deltaic soils of Andhra Pradesh are proving to be sub-optimal for attaining higher productivity levels and need a fresh look to revise them to optimum and more balanced levels. In view of the above a study was conducted to revise the existing major nutrient recommendations of Kharif rice for delta soils of Andhra Pradesh to an optimum level.

MATERIAL AND METHODS

Field experiments were conducted on rice, *Oryza sativa* L for three consecutive Kharif seasons of 2006, 2007

and 2008 on Godavari alluvials (Vertic chromusters) at Andhra Pradesh Rice Research Institute, Maruteru, Andhra Pradesh, India (26.38^0 N, 84. 44^0 E and 5 m above mean sea level). The soil was clay loam having pH 7.1, CEC of 42 meq/100g of soil, organic carbon 0.9 per cent, available nitrogen 297 kg/ha, available P 16.3 kg/ha and K 227 kg/ha. The trial was conducted in randomized block design with three replications and ten treatments consisting of different levels of NPK (kg/ha) viz 60-40-40, 75-40-40, 90-40-40, 105-40-40, 60-50-40, 60-60-40, 60-70-40, 60-40-50, 60-40-60 and 60-40-70. The 26 days old seedlings of variety MTU 1061 (145 days duration) were planted at a spacing of 20 x 15 cm with 2-3 seedlings per hill. Weeds were controlled by application of pre-emergence herbicide Pretilachlore @ 0.75 kg ai per hectare followed by one hand weeding at 40 days after transplanting. Water was maintained at a depth of 2 cm up to panicle initiation and 5 cm thereafter up to one week before harvest. The field was drained before application of fertilizers and one week before harvest. Fertilizers were applied as per the requirement treatment through urea, SSP and MOP. Entire doses of P and K and 1/3 recommended dose of N were applied as basal dose and remaining N was applied in two splits at active tillering and panicle initiation. The experiments received uniform plant protection and cultural management practices throughout the period of crop growth. Data on growth, yield attributes and yield were collected following standard procedures from 10 randomly marked hills. The surface soil samples from 0 to 15 cm depth before and after the harvest of the crop were collected and analyzed for the physico-chemical properties. The quality parameters were assessed following standard procedures. Economic parameters like gross returns, net returns and rupee returned per rupee invested were worked out treatment-wise taking prevailing market rates for different inputs and outputs. Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference (p= 0.05) by pooling three years data.

RESULTS AND DISCUSSION

Growth and yield attributes

Significant response in growth parameters like tillers/m^2 and dry matter production per hectare was observed with incremental doses of N up to 90 kg/ha and further increase was not significant (Table 1). Increased levels of N favours greater absorption of nutrients resulting in rapid expansion of foliage, better accumulation of photosynthates and eventually resulting in increased growth structure. There was significant increase in tiller production by enhancing the doses P and K by 25 per cent over the recommended doses whereas dry matter production was significantly different at 50 per cent increment only.

Conspicuous differences in yield attributing characters were also found with incremental doses of N, P and K. Though the panicle production was highest at 105 kg N/ha the differences among N levels were significant up to 90 kg/ha. Adequate N content in rice plant stimulates the production of panicles with increased number of filled grains of higher weight. The panicle production was significantly different at 50 per cent increment of P and K only. Marked increase in number of filled grains per panicle was recorded due to 25 per cent increase in N and K and 50 per cent increase in P doses. Measurable improvement in test weight was noticed with 75 per cent increase in N and K levels only. Spikelet sterility increased progressively with incremental doses of N and it was highest in case of 105 kg N/ha while it decreased progressively with incremental doses of K and recorded the lowest values at 70kg K /ha (Table 1). Potassium has been found to improve germination of pollens in the floret and that might be the reason for high spikelet fertility in rice due to incremental levels of K. Harvest index was unaffected by incremental doses of N, P and K in spite of marked influence on dry matter content and this could be ascribed to better carbon assimilation and effective translocation of assimilates to reproductive parts. Incremental levels of nutrients did not influence the harvest index of rice conspicuously was also reported by Singh and Bharadwaj (2008).

Yield

Increase in recommended doses of N from 100 to 125 and 125 to 150 per cent resulted in significant yield improvement ie 11.6 and 6.3 per cent respectively (Table 2). Increase in recommended N doses from 100 to 150 per cent recorded 17.9 per cent higher grain yield (6,470 kg/ha) over recommended dose (5,486 kg/ha). Further increase of N beyond 150 per cent did not result in significant yield improvement. Increase in P and K doses from 100 to 125 per cent did not improve the yield significantly whereas increase in recommended P and K doses from 100 to 150 per cent improved the grain yield significantly. Increased grain yield associated with added fertilizer levels might be due to the cumulative effect of increased translocation of photosynthates to sink resulting in enhanced levels of yield components. Increase in rice yield by 5 per cent due to increase in N, P and K doses by 50 per cent was also reported by Rao et al (2004). Significant yield increase (8%) with 150 per cent recommended K over 100 per cent recommended K during Kharif was also reported by Bhaskar et al (2004).

Agronomic efficiency and energy use efficiency

Agronomic efficiency of N, P and K increased progressively with incremental doses of nutrients (Table 2). This may be due to better utilization of nutrients from the

Table 1. Effect of incremental doses of N, P and K on growth yield attributes, spikelet sterility and harvest index of rice (pooled data of three years)

Treatment N,P,K (kg/ha)	Tillers/ m^2	DMP	Panicle/ m^2 (kg/ha)	Filled grains/ panicle	1000 grain wt (g)	Spikelet sterility (%)	Harvest Index (%)
60-40-40	404	11700	318	134	20.12	14	46
75-40-40	445	13082	347	156	20.97	15	47
90-40-40	473	13880	364	163	21.21	21	47
105-40-40	497	14351	378	164	21.90	28	47
60-50-40	430	12160	330	145	20.40	15	46
60-60-40	436	12708	337	151	20.87	15	46
60-70-40	458	12965	342	151	20.80	14	46
60-40-50	433	12235	327	153	20.21	16	47
60-40-60	442	12751	332	162	21.14	14	47
60-40-70	459	13069	335	165	21.42	12	47
SEm ±	8.35	226.8	5.06	4.00	0.377	-	-
$CD_{0.05}$	24.81	674	15.04	12.00	1.12	-	-

Table 2. Effect of incremental doses of N, P and K on yield, agronomic efficiency, energy use efficiency and economics of rice (pooled data of three years)

Treatment N,P,K (kg/ha)	Grain yield (kg/ha)	Agronomic efficiency of NPK (kg/kg)	Energy use efficiency (MJ/ MJ)	Gross returns (₹/ha)	Net returns (/ha)	Rupee per invested (₹/ha)
60-40-40	5486	0.00	4.39	41325	18810	0.84
75-40-40	6121	4.10	4.67	46092	23405	1.03
90-40-40	6470	5.79	4.71	48657	25797	1.13
105-40-40	6681	6.46	4.66	50293	27261	1.18
60-50-40	5620	0.89	4.47	42268	19470	0.85
60-60-40	5875	2.43	4.65	44152	21070	0.91
60-70-40	5968	2.84	4.69	44868	21503	0.92
60-40-50	5742	1.71	4.58	43261	20666	0.91
60-40-60	5981	3.09	4.75	45052	22377	0.99
60-40-70	6149	3.90	4.87	46262	23507	1.03
SEm ±	128	-	0.11	659	657	0.03
$CD_{0.05}$	382	-	0.33	1958	1952	0.09

available pool and consequent improvement in growth, yield attributes and yield. Higher agronomic efficiency of N and K was observed particularly with first two incremental doses (150%). This is an indication of the fact that recovery efficiency of the incremental doses is good at initial increments. The highest energy use efficiency was recorded with application of highest dose of K (4.87). The energy use efficiency progressively increased with increased doses of K and P up to highest level whereas with regard to N the higher energy use efficiency was realized at second increment and decreased with further increase in N level (Table 2). This shows the importance of incremental doses of K and P along with N to reap the maximum energy benefit.

Economics

Economic analysis of three years data showed that the highest gross returns, net returns and rupee per rupee invested were higher with application of N,P and K @ 105, 40 and 40 kg /ha (Table 2). The gross returns, net returns and rupee per rupee invested increased progressively with incremental doses of N and the increase was statistically measurable up to additional dose of N @ 30 kg/ha (50% increase) with respect to gross returns, net returns and rupee per rupee invested. Increase in P and K doses by 50 per cent over existing doses resulted in significant improvement in gross returns, net returns and rupee per rupee invested. At 50 per cent N increase by spending ₹ 346 an additional net income of ₹ 6,987 per hectare was realized. Similarly there was an additional net income of ₹ 2,260 by spending ₹ 567 at 50 per cent P increment and ₹ 3,567 by spending ₹ 160 at 50 per cent K increment.

Based on the above results it can be inferred that the yield improvement was significant up to 50 per cent over present recommendation of N and 25 per cent increase in P and K. A 50 per cent increase of N, P and K (90, 60 and 60 kg/ha) over existing doses (60, 40 and 40 kg/ha) appears to be the optimum dose for Kharif rice in deltaic alluvial soils of Andhra Pradesh.

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