

Site-specific nutrient management – a sustainable nutrient management option in rice, *Oryza sativa* L

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ABSTRACT

Field experiment was conducted on rice, *Oryza sativa* L consecutively for four years during Kharif season of 2005-06, 2006-07, 2007-08 and 2008-09 on Godavari alluvials (Vertic chromusters) at Andhra Pradesh Rice Research Institute, Maruteru, AP on clay loam soil with the treatments of NPKB in different ratios. Application of NPKB @ 100-90-90-5 kg/ha recorded the highest number of filled grains per panicle, panicle length, 1000-grain weight, dry matter production at harvest, grain yield, higher root biomass, highest N, P and K uptake at harvest, energy input and energy gross returns and showed more stability in production. Reduction of P and K from 90 to 60 kg/ha did not affect the growth, yield parameters and grain yield of rice markedly but further reduction in dose of P and K from fertiliser schedule reduced the grain yield conspicuously. Omission of P and K fertilisers resulted in reduction of grain yield to the tune of 17.3 and 17.6 per cent respectively. Boron application failed to influence the grain yield conspicuously. Maintenance of soil fertility at healthy levels by supplying all nutrients in proportion matching with crop needs is one of the key steps in safeguarding high productivity on sustainable basis.

Keywords: Rice; site-specific; nutrient management; grain yield; energetic; economics

INTRODUCTION

Rice, *Oryza sativa* L is one of the most important staple food crops in the world. To sustain present food self-sufficiency and to meet future food requirement India has to increase productivity by 3 per cent per annum (Meena et al 2014). This is a challenging task to achieve this targeted production

especially from shrinking resource base. Nutrient management practices determine the sustainability of the most intensively cropped systems. The practice of correct dose and timely application of fertilizer nutrients play an important role in efficient use of fertilizers (Hussain et al 2007). Site-specific nutrient management (SSNM) as developed in Asian rice producing countries provides an approach for feeding rice with

nutrients as and when needed (Anon 2006). SSNM strives to enable farmers to dynamically adjust fertilizer use to optimally fill the deficit between the nutrient needs of a high yielding crop and the nutrient supply from naturally occurring indigenous sources including soil, crop residues, manures and irrigation water. The SSNM approach advocates sufficient use of fertilizers P and K to overcome P and K deficiencies, to avoid the mining of soil P and K and to allow best N management. Keeping the above points in view the present study was undertaken to study the site-specific nutrient management on maximization of yield in rice-based cropping system.

MATERIAL and METHODS

Field experiments were conducted on rice, *Oryza sativa* L consecutively for four years during Kharif season of 2005-06, 2006-07, 2007-08 and 2008-09 on Godavari alluvials (Vertic chromusters) at Andhra Pradesh Rice Research Institute, Maruteru, AP (26.38° N, 84.44° E and 5 m amsl). The soil was clay loam having pH 7.1, organic carbon 0.9 per cent, available nitrogen 297 kg/ha, available P_2O_5 38 kg/ha, K_2O 344 kg/ha and CEC of 42 meq/100 g of soil. The trial consisted of ten treatments of NPKB (kg/ha) viz T_1 (100-90-90-5), T_2 (100-60-90-5), T_3 (100-30-90-5), T_4 (100-0-90-5), T_5 (100-90-60-50), T_6 (100-90-30-5), T_7 (100-90-0-5), T_8 (100-90-90-0), T_9 (90-50-40-0) and T_{10} (80-40-0-0) with four replications

conducted in randomised block design. The 24 to 26 days old seedlings of test variety MTU-3626 (135 days duration crop) were planted at a spacing of 20 x 15 cm during Kharif with 2-3 seedlings per hill. Weeds were controlled by application of pre-emergence herbicide Pretilachlore (0.75 kg ai/ha) 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. Manures and fertilizers were applied as per the treatment requirement through urea, SSP and MOP. Entire P and K and one third recommended N were applied as basal doses and remaining N was applied in two splits at active tillering and panicle initiation. The experiment was provided uniform plant protection and cultural management practices throughout the period of crop growth.

Data on tillers/m² was collected from ten randomly marked hills at active tillering stage. Root biomass and weed biomass were estimated at flowering duly following standard procedure. Dry matter production at harvest was recorded from ten randomly marked hills. Samples were air-dried and then oven-dried at 60°C to a constant weight and expressed as kg/ha. The number of ear bearing tillers were counted from tagged plants, averaged to compute productive tillers/hill and

expressed as panicles/m². Panicle weight and panicle length were recorded following standard procedures from 10 randomly marked hills. Ten marked hills were counted, averaged and expressed as number of grains per panicle and filled grains per panicle at maturity stage. Grain from the net plot was thoroughly sun-dried to 14 per cent moisture content, weighed and expressed in kg/ha.

Energy use efficiency was calculated by dividing energy input by energy output as per the procedure given by Panesar and Bhatnagar (1994). The quality parameters were assessed as per the procedure given by Ghosh (1971). A sample of five hundred grams of paddy was taken from each plot and milled with Satake grain testing husker and then polished to one minute. Nitrogen was estimated by modified microkjeldahl method and crude protein was estimated by multiplying total N with factor 5.95; phosphorus was estimated by calorimetric method using a Technicon autoanalyser and potassium by flame photometry (Jakson 1973). The uptake of N, P and K in kg/ha at harvest was calculated by multiplying the nutritional content with the respective dry matter production. The nutrient content of grain and straw was analysed separately and then multiplied with respective weights of grain and straw which were summed up to present nutrient uptake at harvest. The available P was estimated by the method of Olsen et al (1954). The available K was

estimated by flame photometer (Jakson 1973). The organic carbon in the soil was estimated by the chromic acid digestion method of Walkley and Black (1934). The quality parameters were assessed as per the procedure given by Ghosh (1971). Economic parameters like gross returns, net returns and rupee returned/rupee invested were worked out treatment-wise taking prevailing market rates for different inputs and outputs. Sustainability index was calculated using formula given by Gangwar et al (2004). Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference ($p=0.05$) by pooling four years data.

RESULTS and DISCUSSION

The four years pooled data revealed that different site specific nutrient management packages significantly influenced the growth, yield attributes, yield, root biomass, weed biomass, nutrient uptake, grain quality, energy, economics and post-soil nutrient status. Application of site specific nutrient management package ie NPKB (100-90-90-0 kg/ha) resulted in the highest number of tillers as well as panicles per square meter whereas application of NPKB (100-90-90-5 kg/ha) recorded the highest number of filled grains per panicle, panicle length, 1000-grain weight, dry matter production at harvest and grain yield however these were on par with application of NPKB 100-60-90-5, 100-90-60-5 and 60-40-40-0 kg/ha

(Table 1). Significant yield advantage under site specific nutrient management may be due to application of higher amounts which in turn increased the availability of nutrients in rhizosphere of the crop and consequently greater uptake of nutrients by crop resulted in higher grain production. Sharma et al (2007) also reported significant increase in yield of rice through site specific nutrient management over existing and local management practices. Reduction of P and K from 90 to 60 kg/ha did not affect the growth, yield parameters and grain yield of rice markedly but further reduction in dose of P and K from fertiliser schedule reduced the grain yield conspicuously. Omission of P and K fertilisers resulted in reduction of grain yield to the tune of 17.3 and 17.6 per cent respectively. Similar results were reported by Raju and Reddy (1994). The possible reason for conspicuous yield decline with reduced phosphorus application might be due to the fact that P plays a key role in root development. Increase in root biomass might have improved the nutrient uptake by exploiting greater volume of soil resulting in better physiological and metabolic function inside the plant body which in turn laid down the foundation for higher yields. Farmers practices recorded the lowest yields probably due to excluding of potassium fertilization in this practice. Noticeable yield improvement with potassium application could be ascribed to increasing photosynthates activity as K stimulates vital biochemical properties like

oxidative photo phosphorelation that results in higher production of photosynthates and their translocation to sink which might have directly contributed towards better yield (Mengel 1976). The results are in agreement with the findings of Singh et al (2001) who reported that to increase and stabilize the production of rice in Andhra Pradesh there was a need to adopt appropriate P and K nutritional strategy. Boron application failed to influence the grain yields conspicuously. Application of NPKB 100-60-90-5 kg/ha showed more stability in production which was closely followed by application of NPKB 100-30-90-5 and 100-90-0-5 kg/ha. Maintenance of soil fertility at healthy levels by supplying of all nutrients in proportion matching with crop needs is one of the key steps in safeguarding high productivity on sustainable basis.

Root biomass at flowering was significantly influenced by different site specific nutrient management practices. Application of NPKB 100-90-90-5 kg/ha followed by application of NPKB 100-90-90-0 kg/ha recorded higher root biomass and it was conspicuously reduced with reduction in phosphorus level to 30 kg/ha and potassium level to zero. Weed dry weight was also markedly low in zonal recommendation, farmers practice, zero phosphorus potassium application and farmers practice than application of NPKB 100-90-90-5 kg/ha. Among grain quality parameters protein content, per cent grain

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Table 1. Effect of site specific nutrient management on growth yield attributes, yield and sustainable yield index of rice (pooled data of four years)

Treatment NPKB (kg/ha)	Tillers /m ²	DMPH (kg/ha)	Panicles /m ²	Filled grains/ panicle	Panicle weight (g)	Panicle length (cm)	Grain yield (kg/ha)	SYI
100-90-90-5	404	10632	323	123	3.42	24.9	4916	0.60
100-60-90-5	387	10421	319	120	3.27	24.7	4795	0.66
100-30-90-5	361	9612	306	113	3.06	24.4	4415	0.65
100-0-90-5	332	9071	293	107	2.92	24.0	4063	0.64
100-90-60-5	386	9954	316	118	3.21	24.5	4640	0.58
100-90-30-5	377	9276	317	111	2.94	23.9	4254	0.61
100-90-0-5	346	8843	298	104	2.77	23.2	4049	0.62
100-90-90-0	410	10527	328	121	3.25	23.5	4882	0.61
60-40-40-0	365	10422	310	120	3.29	23.1	4788	0.64
80-40-0-0	335	8533	298	101	2.81	22.7	3855	0.64
SEm±	6.9	234	5.52	3.77	0.13	0.19	133	-
CD _{0.05}	20	678	16.02	10.93	0.38	0.57	385	-

Table 2. Effect of site specific nutrient management on root biomass, weed dry weight, milling turnout and grain quality of rice (pooled data of four years)

Treatment NPKB (kg/ha)	Root bio-mass (g)	Weed dry weight (g)	Hulling (%)	Milling (%)	HRR (%)	L/B ratio	Amylase content (%)	Protein content (%)
100-90-90-5	8.98	26.94	75.4	69.8	62.9	3.05	24.5	8.01
100-60-90-5	8.17	26.73	75.1	69.0	61.6	3.05	24.1	7.95
100-30-90-5	7.22	25.71	74.9	67.7	61.2	3.04	23.7	7.88
100-0-90-5	6.42	24.04	74.0	66.5	60.0	3.03	23.1	7.82
100-90-60-5	8.48	26.10	75.2	68.6	61.5	3.05	23.9	7.99
100-90-30-5	8.29	25.40	74.8	66.2	59.7	3.03	23.2	7.96
100-90-0-5	8.07	24.24	73.1	65.4	58.4	3.02	22.5	7.84
100-90-90-0	8.91	25.36	74.5	69.7	61.9	3.04	24.0	7.99
60-40-40-0	7.90	21.03	74.3	70.0	61.2	3.03	23.5	7.85
80-40-0-0	7.47	22.75	73.0	65.9	58.9	3.03	22.6	7.83
SEm±	0.29	0.92	2.16	1.08	0.97	0.13	0.79	0.31
CD _{0.05}	0.84	2.68	NS	3.13	2.81	NS	NS	NS

HRR= Head rice recovery

amylase, L/B ratio and hulling percentage were unaffected by different site specific nutrient management practices whereas milling turnout and per cent head rice recovery were significantly reduced by reducing potassium level to 30 kg/ha, phosphorus level to zero and with farmers practice.

Application of NPKB 100-90-90-5 kg/ha recorded the highest N, P and K uptake at harvest however it was at par to application of NPKB 100-90-90-0, 100-60-90-5, 100-90-60-5 and 60-40-40-0 kg/ha. Reduction of P and K from 90 to 60 kg/ha did not affect the N, P and K uptake by rice markedly but further reduction in dose of P and K from fertiliser schedule reduced the N, P and K uptake conspicuously. This might be due to application of higher amounts which in turn increased the availability of nutrients in rhizosphere of the crop and consequently greater uptake of nutrients by the crop. Dobermann and Singh (2007) also reported significant increase in N, P and K uptake of rice through site specific nutrient management. Soil chemical properties were unaltered by adoption of different site specific nutrient management practices over four years of experimentation. However post-soil available phosphorus and potassium were declined over four years of experimentation with the treatments associated with reduced phosphorus and potassium levels. Large scale nutrient depletion through crop harvest on one hand

and low level of nutrient replenishment through inadequate nutrient supply might be the probable reasons for this decline in status of phosphorus and potassium after four years of experimentation.

Both energy input as well as energy output were higher with application of NPKB 100-90-90-5 kg/ha followed by application of NPKB 100-90-90-0 kg/ha whereas energy ratio as well as energy productivity were highest in zonal recommendation ie application of NPKB 60-60-40-0 kg/ha. Both energy input and energy output were progressively decreased with decrease in P and K levels from 90 to zero. This shows the importance of site specific nutrient management to reap the maximum energy benefit in rice. Economics of the study reveals that during Kharif the highest gross returns were realised in application of NPKB 100-90-90-5 kg/ha followed by application of NPKB 100-90-90-0 kg/ha and were lowest in farmers practice (Table 4). Cost of cultivation was higher in application of NPKB 100-90-90-5 kg/ha followed by application of NPKB 100-90-60-5 kg/ha while it was lowest in farmers practice. The net returns were higher in application of NPKB 100-90-90-0 kg/ha followed by application of NPKB 100-90-90-5 kg/ha and zonal recommendation. Rupee returned per rupee invested was higher in zonal recommendation followed by application of NPKB 100-60-90-5 kg/ha. Crop yields and economics were appreciated

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Table 3. Effect of site specific nutrient management on N, P and K uptake at harvest of rice, soil chemical properties and post-soil available phosphorus and potassium status after four years of experimentaion

Treatment NPKB (kg/ha)	Uptake at harvest (kg/ha)			pH	EC ds/m	Organic carbon (%)	Available status (kg/ha)	
	N	P	K				P ₂ O ₅	K ₂ O
100-90-90-5	102.56	24.76	82.45	6.07	0.46	0.91	43.04	249
100-60-90-5	98.99	22.52	79.70	6.04	0.50	0.93	40.18	246
100-30-90-5	92.72	21.00	76.24	6.06	0.46	0.95	36.07	241
100-0-90-5	83.51	18.53	73.21	6.12	0.48	0.93	31.42	236
100-90-60-5	97.62	23.88	78.46	6.06	0.47	0.89	42.68	238
100-90-30-5	90.42	22.90	74.13	5.91	0.52	0.92	41.62	224
100-90-0-5	85.03	21.98	69.36	6.00	0.53	0.90	40.42	207
100-90-90-0	99.66	23.40	81.73	6.08	0.52	0.95	42.94	255
60-40-40-0	96.51	22.95	80.19	6.10	0.46	0.97	38.35	241
80-40-0-0	89.67	21.21	70.09	5.97	0.46	0.90	38.44	211
SEm±	2.49	0.74	1.78	0.58	0.08	0.09	1.02	3.91
CD _{0.05}	7.24	2.16	5.18	NS	NS	NS	2.96	11.33

Table 4. Effect of site specific nutrient management on energetic and economics of rice (pooled data of four years)

Treatment NPKB (kg/ha)	Energy in (MJ)	Energy out (MJ)	Energy ratio (MJ/MJ)	Net return of energy (kg/MJ)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	Rupee returned/ rupee invested
100-90-90-5	17429	143712	8.25	126283	39833	22122	17711	0.82
100-60-90-5	17096	140804	8.24	123709	38697	21333	17364	0.85
100-30-90-5	16763	129867	7.75	113104	35544	20546	14998	0.79
100-0-90-5	16430	122317	7.44	105888	32826	19762	13064	0.73
100-90-60-5	17228	134626	7.81	117398	37534	21826	15708	0.75
100-90-30-5	17027	125301	7.36	108275	34397	21418	12980	0.63
100-90-0-5	16826	119445	7.10	102620	32547	21106	11441	0.59
100-90-90-0	17324	142328	8.22	125004	39561	21698	17864	0.84
60-40-40-0	14010	139364	9.95	125354	38687	20549	18138	0.93
80-40-0-0	14954	118649	7.93	103695	30952	19825	11127	0.64
SEm±	-	-	-	-	1081	463	402	0.027
CD _{0.05}	-	-	-	-	3138	1344	1166	0.079

considerably with application of P which were improved further by inclusion of K (Nandaram 2007).

CONCLUSION

Site-specific nutrient management (SSNM) provides maintenance of soil fertility at healthy levels by supplying all nutrients in proportion matching with crop needs and is one of the key steps in safeguarding high productivity on sustainable basis.

REFERENCES

- Anonymous 2006. Site-specific nutrient management. International Rice Research Institute Research Findings Optimizing Crop Nutrition (IRRI) 2006.
- Dobermann A and Singh RK 2007. Performance of site specific nutrient management for irrigated transplanted rice in northeast India. *Agronomy Journal* **1999(6)**: 1436-1447.
- Gangwar B, Katyal JC and Anand KV 2004. Stability and efficiency of cropping systems in Chattishgarh and Madhya Pradesh. *Indian Journal of Agricultural Science* **74(10)**: 521-528.
- Ghosh AK 1971. Influence of nitrogen on physico-chemical characteristics of rice grain. *Oryza* **8(1)**: 81-98.
- Hussain AT, Manzoor MZ, Safdar E and Ahmad M 2007. Yield response of rice to dynamic use of potassium in traditional rice growing area of Punjab. *Pakistan Journal of Agricultural Sciences* **44(1)**: 130-135.
- Jackson ML 1973. Soil chemical analysis. Prentice Hall of India Pvt Ltd, New Delhi, India.
- Meena BP, Dasharath Prasad, Dotaniya ML and Meena VD 2014. Modern techniques of rice production– a key for ecosystem sustainability in changing climate. *Indian Farming* **64(3)**: 11-14.
- Mengel K 1976. Potassium in plant physiology and yield promotion. *Society of Soil Science Bulletin* **10**: 23-40.
- Nandaram 2007. Long term experiments for precise nutrient management. *Proceedings, Precision in Agronomy for Sustainable Crop Production*, pp 40-43.
- Olsen SR, Cole CL, Watanabe FS and Dean DA 1954. Estimation of available phosphorus soils by extraction with sodium bicarbonate. *USDA Circular #939*.
- Panesar BS and Bhatnagar AP 1994. Energy norms for inputs and outputs of agricultural sector. In: *Energy management and conservation in Agricultural production and food processing* (SR Verma, JP Mittal and S Singh eds). USG Publishers and Distributors, Ludhiana, Punjab, India, pp 5-16.
- Raju RA and Reddy MN 1994. Potassium fertilization in rice on vertisols of Godavari flood plains. *Indian Journal of Agronomy* **39(1)**: 99-101.
- Sharma RP, Pathak SK, Chatopadyaya N and Raman KR 2007. Effect of SSNM on productivity, profitability and nutrient removal of rice-wheat system. *3rd National Symposium on Integrated Farming Systems*, pp 172-174.
- Singh HP, Sarma KL, Ramesh V and Mandal UK 2001. Nutrient mining in different agro climatic zones of Andhra Pradesh. *Fertiliser News* **46(8)**: 29-42.
- Walkley A and Black CA 1934. An examination of Degtjaroff method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Science* **37**: 29-34.

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