Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7311

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **7 (1):** 260-266 (2019)

Research Article

International Journal of Pure & Applied Bioscience

Site Specific Nutrient Management for Rice in Alkali Soils of Tamil Nadu

S. Ravichandran[1] and S. Saravanakumar[2*]

[1]Scientist, HBSS, Rubber Board, Kabada, Karnataka

[2]Scientist (Agronomy), ICAR – KVK, MYRADA, Erode District

*Corresponding Author E-mail: agrisarwan@gmail.com

Received: 25.12.2018 | Revised: 29.01.2019 | Accepted: 7.02.2019

ABSTRACT

A field experiment was conducted in alkali soils of A.D. Agricultural College and Research Institute farm Tiruchirappalli, Tamil Nadu, in wet season (September to January) of 2006-07 and 2007-08 to study the effect of amendments viz., gypsum and distillery spentwash (DSW) and nutrient omission plots on yield, nutrient use efficiency and fertilizer N, P and K requirement of rice. In both years, reclamation of alkali soils with DSW recorded the highest grain yield of 6.58 Mg ha^{-1} followed by gypsum @ 50% GR (5.94 Mg ha^{-1}). Among the nutrient omission plots, application of recommended dose of NPK (RDN) recorded significantly higher rice grain yield of 6.98 Mg ha^{-1}. In DSW reclaimed alkali soils, N limiting yield was 6.79 and 6.33 Mg ha^{-1} during first and second year respectively which were 43 and 36 per cent higher than gypsum reclamation. But the effect of amendment on P limiting yield during the second year and K limiting yield on both years were not significant. The N, P and K requirement to produce one tonne of rice grain varied between 17. 3 to 25.5, 3.9 to 4.9 and 21.7 to 56.5 kg Mg^{-1} of grain respectively. For a yield target of 7.0 Mg ha^{-1}, the mean fertilizer N requirement was higher under no amendment followed by gypsum and DSW reclamation. The mean fertilizer P_2O_5 requirement was 30 per cent less than RDN while mean fertilizer K_2O requirement was 60 per cent higher than RDN.

Key words: *Distillery spent wash for reclamation, fertilizer requirement of rice, Site Specific Nutrient Management*

INTRODUCTION

In Tamil Nadu, about 0.47 million ha of salt affected soils are prevalent, of which 0.3 million ha are alkali soils. The excess Na in alkali soils (ESP >15 or SAR >13) destroys the soil structure, disperse the clay particles and clog the soil pores leading to ill drained condition. This unfavourable physical environment, poor soil fertility and low nutrient use efficiency affect the yield of agricultural crops grown in alkali soils. The alkali soils are generally kept fallow due to resource poor nature of farmers who own these lands and wherever irrigation facilities exist, single rice crop is grown during monsoon season with average yields of 2.5 to 3.0 Mg ha^{-1}.

Cite this article: Ravichandran, S. and Saravanakumar, S., Site Specific Nutrient Management for Rice in Alkali Soils of Tamil Nadu, *Int. J. Pure App. Biosci.* **7(1):** 260-266 (2019). doi: http://dx.doi.org/10.18782/2320-7051.7311

Technologies like tolerant cultivars, use of chemical amendments like gypsum ($CaSO_4$ $2H_2O$) or distillery spent wash (DSW) (industrial effluent from alcohol distillery unit, acidic with pH of 3.8, EC of 31 dSm^{-1}, BOD of 50,000 mg lit^{-1}) are available for reclamation of alkali soils.

In the onfarm trials conducted to demonstrate the efficacy of these amendments with recommended dose of nutrient (RDN), a yield gap of 0.4 to 1.5 Mg ha^{-1} was noticed between RDN and Farmer's Fertilizer practices (FFP). This yield gap was mainly attributed to imbalanced use of fertilizers and untimely application of N fertilizers. Hence to bridge this yield gap by improving nutrient use efficiencies, Site Specific Nutrient Management (SSNM) approach was used. SSNM, as conceptualised, aimed at dynamic field specific management of fertilizer N, P, and K to optimise the supply of supplemental nutrients with the plant's demand for nutrients. The plants need for fertilizer N, P or K was determined from the gap between the crops demand for sufficient nutrients to achieve a yield target and the supply of the nutrient from indigenous sources, including soil, crop residues, manures and irrigation water[2].

MATERIAL AND METHODS

An experiment is being conducted in alkali soils of A.D. Agricultural College and Research Institute farm, Tiruchirappalli, Tamil Nadu, for the past two years during wet season (September-January) of 2006-07 and 2007-08. The soil is sandy clay loam in texture with pH of 8.6, EC of 0.27 dSm^{-1} and ESP of 16. Taxonomically the soils are classified as fine, mixed, calcareous, isohypothermic, vertic ustropepts. The experiment was laid out in split plot design with three replications. The main plot treatments were different amendments *viz.*, no amendment, gypsum @ 50% GR and distillery spentwash (DSW) @ 0.5 M litres ha^{-1} and subplot treatments were different nutrient omission plots *viz.*, no fertilizer (-F), no nitrogen (PK), no phosphorus (NK), no potassium (NP), NPK and N alone. The experiment was continued during second year in the same layout. The amendment requirement of alkali soils *viz.*, gypsum through Schoonover[6] and DSW were calculated and applied at gypsum @ 50% GR and DSW @ 0.5 M litres ha^{-1} one week and one month before transplanting respectively and leached with good quality canal water before transplanting rice. The amendments were applied for the first crop only. As per the treatment schedule fertilizers were applied as follows: N in four splits (basal, 21, 42 and 63 DAT), full dose of P as basal and K in two splits (basal and 42 DAT). The $ZnSO_4$ @ 40 kg ha^{-1} was applied after last puddling. The rice cultivars BPT 5204 and TRY 1 were the test crop in 2006-07 and 2007-08 respectively. At harvest, grain and straw yields were recorded in 5 m^2 area and grain yield is expressed at 14% moisture content. The grain and straw samples were analysed for N, P and K content[3,5], and their uptake was computed.

The other nutrient use efficiencies were calculated as follows;

a) Total Factor Productivity (TFP) = (Grain yield (kg)/ Total nutrients applied (NPK) (kg))

b) Partial Factors Productivity (PFP) = kg grain per kg of nutrient applied

For N applied plot (PFP_N) = Grain yield in N applied plot/ Fertilizer N applied

c) Agronomic Efficiency (AE) = kg grain yield increase per kg of nutrient applied

For N applied plot (AE_N) = (Grain yield in N applied plot – Grain yield in N_0 plot) / fertilizer N applied

d) Recovery Efficiency (RE) = kg nutrient taken per kg of nutrient applied

For N applied plot (RE_N) = (Uptake of N in N applied plot - Uptake of N in N_0 plot) / Fertiliser N applied

Fertilizer N, P and K requirement were computed for a yield target of 7.0 Mg ha^{-1}. As per the SSNM approach, the N requirement of rice was computed as per Buresh *et al.*[1], and fertilizer P and K requirement were computed as per Witt *et al.*[7].

$$\text{Fertilizer N requirement} = \frac{(\text{Attainable yield} - \text{N limted yield})}{AE_N} \times 1000$$

Where, AE_N - Agronomic efficiency for nitrogen.

RESULTS AND DISCUSSION

Grain yield

The effect of different amendments and nutrient omission technique on rice grain yield during 2006-07 and 2007-08 is given in Table 1. In pooled analysis of two years data, there is no significant difference in rice grain yield in between the years. Among the different amendments, distillery spentwash (DSW) recorded the highest mean grain yield of 6.58 Mg ha^{-1} followed by gypsum @ 50% GR (5.94 Mg ha^{-1}) which was on par with no amendment. Hence in moderate alkali soils, growing alkali tolerant rice cultivars viz., TRY 1 or Andhra ponni (BPT 5204) recorded comparable yield with gypsum reclamation @ 50% GR. But distillery spent wash due to the addition of organic matter and potassium recorded the highest grain yield. With regard to the nutrient omission plots, in pooled analysis, application of recommended dose NPK (150:50:50 kg ha^{-1}) (RDN) recorded rice grain yield of 6.98 Mg ha^{-1}, which was significantly higher than the other nutrient omission treatment. The NP applied plot (-K) recorded next best higher yield, which was statistically on par with NK, and N alone applied plot. Based upon the two years data, the average response for N, P and K was 1.73, 0.46 and 0.33 Mg ha^{-1} respectively between RDN and respective omission plots. The N alone applied treatment recorded comparable yield with RDN during first year and significantly lower yield in second year.

Nutrient efficiency

The effect of different amendments on efficiency factors viz., Total factor productivity (TFP), Partial factor productivity (PFP) is given in fig 1. The TFP varied between 27.1 to 28.6 and 27.4 to 29.1 kg grain per kg of nutrient applied in I and II year respectively. During I year, DSW reclamation recorded higher TFP while gypsum @ 50% GR recorded higher TFP during II year. Similarly PFP_N varied between 45.1 to 47.6 and 45.7 to 48.5 kg grain per kg of N applied in I and II year respectively. Also partial factor productivity for P and K varied between 135.6 to 142.8 and 137.2 to 145.4 kg grain per kg of P and K applied during I and II year respectively. In first year DSW application and in second year gypsum application recorded higher TFP and PFP.

The agronomic efficiency (AE_N) and recovery efficiency (RE) of N, P and K in both years of experimentation is given in table 2. In both years, AE_N varied between 17.9 and 13.7; 17.1 and 17.5; 3.4 and 5.1 kg grain increase per kg of N applied under no amendment, gypsum and DSW reclaimed alkali soils respectively. Based upon AE_N values, it is referred that DSW added lot of organic matter, hence the response to applied N is less as indicated by low AE_N values. As summarized by Buresh *et al.*[1], AE_N of about 20 to 25 and 18 to 20 kg grain increase per kg of N applied was recorded in dry and wet seasons respectively under good management conditions. But the low AE_N values under reclaimed alkali soils indicated the occurrence of either biotic or abiotic stress which is to be overcome to increase yield further for the same level of nutrient management.

In both years, Agronomic efficiency for P (AE_P) and K (AE_K) varied between 2.8 to 17.8 and 2.2 to 11.0 kg increase in grain yield per kg of nutrient applied respectively. In both years DSW application recorded the lower AE_P than gypsum and no amendment. In first year, the AE_K values were higher under no amendment while gypsum application recorded higher AE_K in second year.

In first year, rice (BPT 5204) recorded recovery efficiency of 0.32 to 0.51; 0.20 to 0.22 and 0.34 to 0.46 for N, P and K respectively. In second year rice (TRY 1) recorded recovery efficiency of 0.14 to 0.45; 0.09 to 0.34 and 0.06 to 0.30 of N, P and K respectively. In DSW reclaimed soils, the recovery efficiency of P and K were lower than gypsum reclaimed alkali soils.

Nutrient Uptake

The N, P and K uptake by rice under RDN in differently amended alkali soils varied between 118 to 181, 27 to 35, 143 to 301 kg ha^{-1} respectively (Table 3). During first year of reclamation of alkali soils, DSW recorded significantly higher N uptake than gypsum or no amendments while N uptake during II year and P and K uptake during both the years were not significant.

Nutrient requirement

The N, P and K requirement to produce one tonne of rice grain varied between 17.3 to 25.5, 3.9 to 4.9 and 21.7 to 56.5 kg per tonne of grain respectively (Table 3). In first year, the DSW reclaimed alkali soils recorded higher NPK requirement which might be due to luxury consumption. Comparing the K requirement of both the crops, the K requirement of second crop (rice- TRY 1) was less may be due to varietal influence and one time application of DSW during first year only. Compared to normal soils where NPK requirement are 14.7, 2.6 and 14.5 kg t^{-1} of grain[8], the nutrient requirement of rice are higher under reclaimed alkali soils.

Nutrient limiting yield

The N - limiting yield under no amendment was 4.09 and 4.81 Mg ha^{-1}during first and second year respectively which increased significantly during first year but on par with gypsum reclamation during second year (Table 4). But DSW reclamation recorded N-limiting yield of 6.79 and 6.33 Mg ha^{-1} during first and second year respectively, which is 43 and 36 per cent higher than gypsum reclamation. Hence DSW apart from reclamation of alkali soils, increased the rice yield due to addition of organic matter and potassium.

The DSW reclamation recorded significantly higher P limiting yield of 6.7 Mg ha^{-1} followed by no amendment (6.58 Mg ha^{-1}) and reclamation with gypsum (6.1 Mg ha^{-1}). In second year, the P- limiting yield ranged between 6.27 to 6.76 Mg ha^{-1} and in both years, K limiting yield varied between 6.45 to 6.73 Mg ha^{-1} which were not statistically significant among the different amendments used.

Response to nutrient applied

The response for N, P and K in differently amended alkali soil is given in fig 2. In both years, the response for N varied between 2.05 to 2.69 and 2.25 to 2.62 Mg ha^{-1} under no amendment and gypsum reclamation while the response was 0.05 to 0.77 Mg ha^{-1} only under DSW reclamation. During first year, reclamation with gypsum recorded higher response for P (0.89 Mg ha^{-1}) while no amendment recorded higher response for P (0.59 Mg ha) in second year.

But the response to K varied between 0.11 to 0.32 and 0.38 to 0.55 Mg ha^{-1} in first and second year respectively. In first year, no amendment recorded the highest response to K (0.32 Mg ha^{-1}) while gypsum reclamation recorded the highest response to K (0.55 Mg ha^{-1}) during second year.

Fertilizer N, P_2O_5 and K_2O requirement

The fertilizer N, P_2O_5 and K_2O requirement of rice computed based on SSNM approach is given in table 4. The N requirement of rice for a yield target of 7.0 t ha^{-1} was 163 and 160 kg ha^{-1} during first and second year respectively under no amendment. As the soils are moderately alkali, the N requirement was close to recommended dose of 150 kg N ha^{-1}. But the fertilizer N requirement of gypsum reclaimed alkali soil was 150 and 135 kg N ha^{-1} during first and second year respectively. But under DSW reclamation, the N requirement could not be computed for first year as the response for added N in terms of AE_N is negligible. But during second year the N requirement for DSW reclaimed alkali soils was 131 kg N ha^{-1}.

For a yield target of 7.0 Mg ha^{-1}, the P requirement of rice varied between 30 to 35 kg P_2O_5 ha^{-1}. This P requirement was less than the recommended dose of 50 kg P_2O_5 ha^{-1} for rice. Hence it can be concluded that the P requirement of alkali soils as per SSNM approach is not dependant on amendment used.

For a yield target of 7.0 Mg ha^{-1} the fertilizer K requirement varied between 75 to

90 kg K_2O ha^{-1} in both years. In general, reclamation with gypsum or DSW, reduced the fertilizer K requirement of rice. But this fertilizer K requirement is 50 per cent higher than recommended dose of K (50 kg K_2O ha^{-1}). The high K_2O requirement in DSW reclaimed soils need further study as the DSW itself added lot of K to soils.

Table 1. Effect of different amendments and nutrient omission technique on rice grain yield (Mg ha^{-1})

Amendment/ Nutrient	No amendment			Gypsum			DSW			Mean		
	I	II	Pooled	I	II	Pooled	I	II	Pooled	I	II	Pooled
No fertilizer	4.14	4.68	4.41	3.99	3.96	3.98	6.76	5.18	5.97	4.96	4.61	4.78
PK	4.09	4.81	4.45	4.75	4.65	4.70	6.79	6.33	6.56	5.21	5.26	5.24
NK	6.58	6.27	6.43	6.10	6.76	6.43	6.70	6.69	6.70	6.46	6.57	6.52
NP	6.46	6.45	6.46	6.80	6.72	6.76	6.73	6.72	6.73	6.66	6.63	6.65
NPK	6.78	6.86	6.82	6.99	7.27	7.13	6.84	7.10	6.97	6.87	7.08	6.98
N alone	6.80	6.52	6.66	7.04	6.28	6.66	6.19	6.86	6.53	6.67	6.55	6.62
Mean	5.80	5.93	5.87	5.95	5.94	5.94	6.67	6.48	6.58			

	I			II			Pooled		
	M	T	MxT	M	T	MxT	M	T	MxT
SE.d	0.118	0.105	0.203	0.131	0.186	0.322	0.075	0.141	0.245
CD (P=0.05)	0.328	0.213	0.465	0.363	0.380	0.697	0.174	0.283	0.491

Table 2. Agronomic efficiency and recovery efficiency of rice in differently amended alkali soils

Amendment	Agronomic efficiency (kg grain yield increase per kg of nutrient applied)						Recovery efficiency (kg nutrient uptake per kg of nutrient applied)					
	AE_N		AE_P		AE_K		RE_N		RE_P		RE_K	
	I	II	I	II	I	II	I	II	I	II	I	II
No amendment	17.9	13.7	3.8	11.7	6.4	8.2	0.32	0.23	0.20	0.09	0.46	0.30
Gypsum @ 50% GR	17.1	17.5	17.8	10.2	3.9	11.0	0.40	0.45	0.22	0.34	0.34	0.23
DSW @ 0.5 M lit ha^{-1}	3.4	5.1	2.8	8.4	2.2	7.7	0.51	0.14	0.20	0.24	0.44	0.06

I- 2006-07; II- 2007-08

Table 3. Nutrient uptake under RDN and nutrient requirement by rice in differently amended alkali soils

Amendment	Nutrient uptake (kg ha^{-1})						Nutrient requirement (kg t^{-1})					
	N		P		K		N		P		K	
	I	II	I	II	I	II	I	II	I	II	I	II
No amendment	118	119	27	28	226	149	17.6	17.3	4.0	4.1	33.7	21.8
Gypsum @ 50% GR	134	139	27	34	220	143	19.4	19.1	3.9	4.6	31.9	18.8
DSW @ 0.5 M lit ha^{-1}	181	131	35	33	301	171	25.5	18.4	4.9	4.7	56.5	21.7
SE.d	9.5	10	4.5	3.4	35.5	16.8						
CD (P=0.05)	22.4	NS	NS	NS	NS	NS						

I- 2006-07; II- 2007-08

Table 4. Nutrient limiting yield and fertilizer N, P_2O_5 and K_2O requirement of rice

Amendment	Nutrient limiting yield (Mg ha^{-1})						*Fertilizer requirement (kg ha^{-1})					
	N		P		K		**N**		**P_2O_5**		**K_2O**	
	I	II	I	II	I	II	I	II	I	II	I	II
No amendment	4.09	4.81	6.58	6.27	6.45	6.45	163	160	30	35	90	90
Gypsum @ 50% GR	4.75	4.15	6.10	6.76	6.80	6.72	150	135	35	30	75	75
DSW @ 0.5 M lit ha^{-1}	6.79	6.33	6.70	6.69	6.73	6.72	NC	131	35	30	75	75
SE.d	0.20	0.32	0.20	0.32	0.20	0.32						
CD (P=0.05)	0.47	0.70	0.47	NS	0.47	NS						

*yield target 7.0 t ha^{-1}; I- 2006-07; II- 2007-08; NC- Not computed due to low AE_N

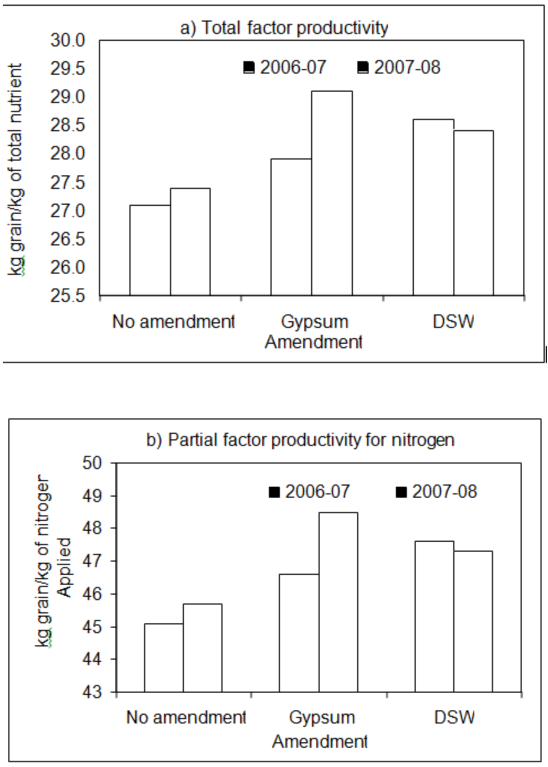

Fig. 1: Effect of different amendments on total factor productivity and partial factor productivity of rice

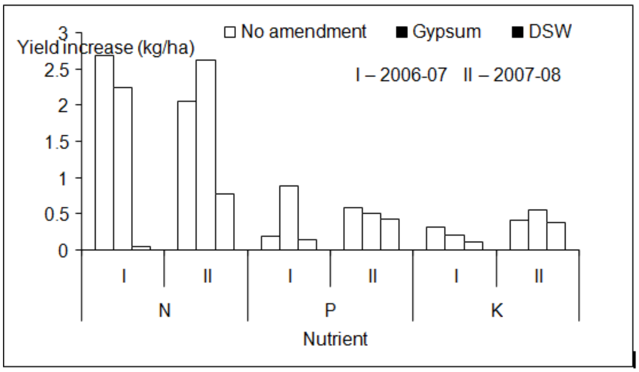

Fig. 2: Response to N, P and K in differently amended alkali soils

CONCLUSIONS

In moderate alkali soils, alkali tolerant rice cultvars themselves sustained higher rice yields of 5.87 Mg ha^{-1}. In the case of chemical amendments, distillery spentwash performed better than gypsum interms of higher grain yield and high nutrient limiting yield. But the DSW can be used as an amendment for alkali soils by following the recommended technologies[4], only. The fertilizer N requirement of rice computed by using SSNM approach is dependant on the amendment used. In the first year after DSW application, fertilizer N requirement of rice could not be computed by using SSNM approach due to the low response to added N but worked well in the second year. The fertilizer P_2O_5 and K_2O requirement of rice computed using SSNM approach were not dependant on the amendment used.

Acknowledgement

The financial support given by Indian Council of Agricultural Research, New Delhi through ICAR adhoc scheme is gratefully acknowledged.

REFERENCES

1. Buresh, R.J, Ramanathan, S., Chandrasekharan, B., Jayaraj, T., Rajendran, R., Witt, C., Stalin, P. and Valliappan, K., Site Specific Nutrient Management (SSNM) for rice: Progress and opportunities for Tamil Nadu. In (Eds. C.Ramasamy, S. Ramanathan and M. Dakshinamoorthy). Perspectives of Agricultural Research and Development, Tamil Nadu Agrl. *University, Coimbatore. pp*. 318 -342 (2005).
2. Dobermann, A., Simbahan, G.C., Moya, P.F., Adviento, M.A.A., Tiongco, M., Witt, C. and Dawe, D., Methodology for socioeconomic and agronomic onfarm research in the RTDP project.. In A. Dobermann (ed) Increasing productivity of intensive rice systems through site-specific nutrient management. Science PublishersInc. Enfield, NH and International rice Research Institute) IRRI), Los Banos, Philippines. pp 11-27 (2004).
3. Jackson, M.L., Soil and Plant Analysis. Prentice Hall of India Private limited, New Delhi. (1973).
4. Mohamed Haroon, A.R. and Bose, S.C., Use of distillery spentwash for alkali soil reclamation, treated distillery effluent for fertigation of crops. *Indian Farming*, **53(11):** 48-51 (2004).
5. Piper, C.S., Soil and Plant Analysis. *Inter Science Publications. New York*. (1966).
6. Schoonover, W.R., Examination of soil for alkali. University of California service, Berkeley, California. (1952).
7. Witt, C., Balasubramanian, V., Dobermann, A. and Buresh, R.J., Nutrient Management. P. 1-45 *In* T. Fairhurst and C.Witt (ed). Rice- a practical guide to nutrient management. Potash and Phosphate Institute (PPI) and Potash and Phosphate Institute of Canada (PPIC). *Singapore and International Rice Research Institute (IRRI), Los Bafios, Phillippines* (2002).
8. Witt, C., Dobermann, A., Abdulrachman, S., Gines, H.C., Wang, G.H., Nagarajan, R., Satawathananont, S., Son, T.T., Tan, P.S., Tiem, L.V., Simbahan, G.C. and Olk, D.C., Internal nutrient efficiencies of irrigated lowland rice in tropical and subtropical Asia. *Field Crops Res*. **63:** 113–138 (1999).