International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(2): 36-38

Received: 19-01-2019
Accepted: 23-02-2019

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Indigenous nutrient supply and nutrient requirement of rice in reclaimed alkali soils

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Abstract
Field experiments were conducted during samba (September-February) season of 2004 and 2005 in alkali soils with pH 8.6 and ESP 16 with amendments like gypsum @50% GR or distillery spentwash (DSW)@ 5 lakh litres /ha. By adopting the recommended DSW technology for the reclamation of alkali soils ie., one month time gap after application and leaching with good quality water, DSW apart from reclaiming alkali soils also recorded significantly higher rice grain yield of 6.58 Mg /ha over gypsum @50%GR. In moderately alkali soils (pH <8.7 and ESP<20) growing alkali tolerant rice cultivars *viz,* TRY-1 or BPT5204 recorded average rice yield of 5.87 Mg/ ha. The total factor productivity and partial factor productivity for N, P and K of rice increased by reclamation of alkali soils either with DSW or gypsum @50%GR. Reclaiming alkali soils using gypsum @50%GR, improved the recovery efficiency of N and P and decreased the recovery efficiency of K. Reclaiming through DSW application recorded significantly higher N and Na uptake. Reclaiming alkali soil with gypsum increased the N and P requirement of rice to produce one tonne of grain while decreased K requirement. But DSW reclamation increased the N,P, and K requirement of rice. The nutrient requirement to produce one tonne of rice is higher in reclaimed alkali soils than normal soil. The indigenous nutrient supply *viz*., INS, IPS and IKS increased with DSW application while it is almost comparable with no amendment in gypsum reclaimed alkali soil.

Keywords: Reclamation of sodic soil, irrigated lowland rice, nutrient requirement of rice, indigenous nutrient supply

1. 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 t ha^{-1}. 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. An attempt has been made to study the nutrient requirement of rice after reclamation with commonly used amendments using site specific nutrient management (SSNM) techniques

The potential supply of a nutrient can be defined as the accumulative amount of that nutrient originating from all indigenous and exogenous sources that circulates through the soil solution surrounding the entire root system during one complete life cycle (Janssen *et al.*, 1990) [7]. Like wise, the proportion of potential supply of a nutrient derived from all indigenous (no fertilizers) nutrient sources is then defined as the effective indigenous supply (IS) and knowledge of IS would allow the calculation of fertilizer rates based on the general equation (Dobermann and Cassman, 2002) [3] In an irrigated system, IS includes plant available nutrients derived from sources such as (i) chemical and biological transformations of soil solids, (ii) biological N_2 fixation in the floodwater–soil system, (iii) atmospheric deposition, and (iv) solutes and sediments deposited by irrigation and/or naturally occurring flooding (Cassman *et al.*, 1998; Dobermann *et al.*, 1998) [1, 4]. Indigenous supply can also be approximated by only measuring plant nutrient accumulation with the above ground biomass in a nutrient omission plot. This approach was successfully used in site specific nutrient management (SSNM) in irrigated rice (Wang *et al.,* 2001; Dobermann *et al.,* 2002) [8, 3, 6]. 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 (Dobermann *et al*, 2004) [2].

Material and Methods

An experiment is being conducted in alkali soils of A.D. Agricultural College and Research Institute farm for the part of two years during samba season (September-February) of 2004 and 2005. The soil is sandy clay loam in texture with pH of 8.6, EC of 0.27 d Sm^{-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 amendment *viz.,* no amendment, gypsum @ 50% GR and distillery spentwash (DSW) @ 5 lakh 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 is continued during second year in the same layout. The amendments gypsum @ 50% GR and DSW @ 5 lakh litres ha^{-1} were applied 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 N was applied in four splits (basal, 21, 42 and 63 DAT), full dose of P was applied as basal and K was applied in two splits. 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 samba (September to February) 2004-05 and 2005-06 years respectively. The straw and grain samples were collected at harvest, dried and grain yield is expressed at 14% moisture content. The grain and straw samples were analysed for nutrient content, NPK uptake was computed. The nutrient uptake in its respective omission plot is taken as its indigenous nutrient uptake and various 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 (PFPN) = 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 (AEN) = (Grain yield in N applied plot – Grain yield in N0 plot) / fertilizer N applied
d. Recovery Efficiency (RE) = kg nutrient taken per kg of nutrient applied
   For N applied plot (REN) = (Uptake of N in N applied plot - Uptake of N in N0 plot) / Fertiliser N applied

Results and Discussion

Grain yield

The effect of different amendments and nutrient omission technique on rice grain yield during 2004-05 and 2005-06 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 is 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 yield. With regard to the nutrient omission plots, application of recommended dose NPK (150:50:50 kg ha^{-1}) (RDN) recorded rice grain yield of 6.98 Mg ha^{-1}, which is significantly higher than the other nutrient omission treatment. The NP applied plot (-K) recorded next best higher yield, which is 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 while significantly lower yield in second year.

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

	Rice grain yield (Mg ha^{-1})		
Treatment	**2004-05**	**2005-06**	**Pooled**
I. Amendment			
No amendment	5.81	5.93	5.87
Gypsum @ 50% GR	5.95	5.94	5.94
DSW	6.67	6.48	6.58
II. Nutrient omission plots			
No fertilizer (-F)	4.96	4.61	4.78
No nitrogen (PK)	5.21	5.26	5.24
No phosphorus (NK)	6.46	6.57	6.52
No potassium (NP)	6.66	6.63	6.65
(NPK)	6.87	7.08	6.98
N alone	6.68	6.55	6.62
	SE(d)	**CD (p=0.05)**	
Y	0.061	NS	
M	0.075	0.174	
T	0.141	0.283	
YxM	0.106	NS	
MxT	0.245	0.491	
YxT	0.200	NS	
YxMxT	346.9	694.2	

Nutrient efficiency

The effect of different amendments on efficiency factors *viz*., Total factor productivity (TFP), Partial factor productivity (PFP) and Agronomic Efficiency (AE) and Recovery Efficiency (RE) are given in table 2. 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. Among the amendments, in first year DSW application recorded higher efficiency while gypsum application recorded higher efficiency *viz*., TFP and PFP for P and K during II year.

In both years Agronomic efficiency for N (AE_N), P (AE_P) and K (AE_K) varied between 3.4 to 17.9, 8.4 to 17.8 and 3.8 to 11.0 kg increase in grain yield per kg of nutrient applied respectively. In both the years DSW application recorded the lower AE_N and AE_P than gypsum and no amendments. The AE_K values were higher under DSW in first year while gypsum application recorded higher AE_K in second year. In first year rice (BPT 5204) recorded recovery efficiency of N, P and K which varied between 0.32 to 0.51; 0.20 to 0.22 and 0.34 to 0.46 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 NPK respectively. In DSW reclaimed soils, the recovery efficiency of N and K were lower than gypsum reclaimed alkali soils.

Table 2: Nutrient use efficiency by rice in differently amended alkali soils

	Total factor productivity		Partial Factor Productivity (kg grain per kg of nutrient applied)					
Amendment	TFP		PFP_N		PFP_P		PFP_K	
	I	II	I	II	I	II	I	II
No amendment	27.1	27.4	45.1	45.7	135.6	137.2	135.6	137.2
Gypsum	27.9	29.1	46.6	48.5	139.8	145.4	135.8	145.4
DSW	28.6	28.4	47.6	47.3	142.8	142.1	142.8	142.1
Agronomic efficiency (kg grain yield increase per kg of nutrient applied)								
			AE_N		AE_P		AE_K	
			I	II	I	II	I	II
No amendment			17.9	13.7	10.6	11.7	6.4	8.2
Gypsum			17.1	17.5	17.8	10.2	3.8	11.0
DSW			3.4	5.1	8.8	8.4	8.2	7.7
Recovery Efficiency (kg nutrient uptake per kg of nutrient applied)								
			RE_N		RE_P		RE_K	
			I	II	I	II	I	II
No amendment			0.32	0.23	0.20	0.09	0.46	0.30
Gypsum			0.40	0.45	0.22	0.34	0.34	0.23
DSW			0.51	0.14	0.20	0.24	0.44	0.06

I crop (2004-05), II crop (2005-06)

Nutrient Uptake

The N, P, K and Na uptake by rice under RDN in differently amended alkali soils varied between 118 to 181, 27 to 35, 143 to 301 and 92 to 359 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. The Na uptake was higher under DSW reclamation during first year while it was not significant during II year. Comparing K and Na uptake during first year, rice variety (BPT 5204) recorded higher Na uptake than K uptake while during second year, rice variety TRY 1 recorded higher K uptake than Na uptake. Comparing the two rice cultivars, BPT 5204 recorded higher K and Na uptake than rice cultivars TRY 1. Hence alkali tolerant rice cultivar, TRY 1 could counteract sodicity by absorbing more K than Na.

Table 3: Nutrient uptake under RDN in differently amended alkali soils

Amendment	N uptake		P uptake		K uptake		Na uptake	
	I	II	I	II	I	II	I	II
No amendment	118	119	27	28	226	149	267	113
Gypsum @ 50% GR	134	139	27	34	220	143	271	98
DSW @ 5 lakh litres ha^{-1}	181	131	35	33	301	171	359	92
S.Ed	9.5	10	4.5	3.4	35.5	16.8	26.1	14.2
CD (P=0.05)	22.4	NS	NS	NS	NS	NS	53.3	NS

I crop (2004-05), II crop (2005-06)

Nutrient requirement

The nutrient requirement of rice grown in reclaimed alkali soils with different amendment with RDN is given in table 4. 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. 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 (Witt *et al.*, 1999) [9], the nutrient requirement of rice are higher under reclaimed alkali soils.

Table 4: Effect of different amendments with RDN on nutrient requirements of rice

Nutrient requirement (kg t^{-1})						
Amendment	N		P		K	
	I	II	I	II	I	II
No amendment	17.6	17.3	4.0	4.1	33.7	21.8
Gypsum	19.4	19.1	3.9	4.6	31.9	18.8
DSW	25.5	18.4	4.9	4.7	56.5	21.7

I crop (2004-05), II crop (2005-06)

E) Indigenous nutrient supply

The indigenous nutrient supply of reclaimed alkali soil is given in table 5. In both years, indigenous nutrient supply varied between 69 to 84, 16 to 25 and 132 to 203 kg ha^{-1} for INS, IPS and IKS respectively in no amendment and gypsum reclamation. In DSW reclaimed soils, INS, IPS and IKS were higher, which is 104 to 110, 21 to 28 and 168 to 379 kg ha^{-1} respectively. Hence apart from the reclamation effects of DSW due to solubilization of native Ca through its acidity, also improves fertility status of soil by adding organic matter and potassium.

Table 5: Indigenous nutrient supply of reclaimed alkali soils

Amendment	INS		IPS		IKS	
	I	II	I	II	I	II
No amendment	69	84	17	23	203	134
Gypsum @ 50% GR	74	72	25	16	203	132
DSW	104	110	28	21	379	168

I crop – (2004-05), II crop –(2005-06)

Conclusions

In moderately alkali soils (pH <8.7 and ESP <20) growing alkali tolerant rice cultivars like TRY-1 or BPT 5204 recorded average rice yield of 5.8 Mg /ha. Though both gypsum @50% GR or DSW @ 5 lakh litres /ha are effective in reclamation of alkali soils, DSW recorded significantly higher yield due to the addition of organic matter and potassium. Reclamation of alkali soils either with DSW or gypsum @50%GR increased the total factor productivity and partial factor productivity of N, P and K in both years. The agronomic efficiency (AE) for N and P are lower under DSW application than gypsum or no amendment while the trend of AE for potassium is variable over the years. In moderately alkali soils, gypsum reclamation improved the recovery efficiency of N and P and decreased the recovery efficiency of K. In the first year, DSW reclamation recorded significantly higher N and Na uptake while the P and K uptake in both years and N and Na uptake during second year were not significant.

In moderately alkali soils, 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 / tonne of grain respectively which is higher than nutrient requirement under normal soils. Similarly reclamation of alkali soils with DSW recorded higher indigenous supply of N, P and K than gypsum reclamation @ 50%GR. Hence based upon the sodicity levels, tolerant cultivars or amendments like gypsum or DSW can be used to increase rice yields in alkali soils.

Acknowledgement

The financial support given by Indian Council of Agricultural Research, New Delhi for this project under ICAR-adhoc scheme is gratefully acknowledged.

References

1. Cassman KG, Peng S, Olk DC, Ladha JK, Reichardt W, Dobermann A, Singh U. Opportunities for increased nitrogen use efficiency from improved resource management in irrigated rice systems. Field Crops Res. 1998; 56:7-38
2. Dobermann A, Smbahan GC, Moya PF, Adviento MAA, Tiongco M, Witt C *et al*. Methodology for socioeconomic and agronomic on farm research in the RTDP project. In A. Dobermann *et al*. (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, 2004, 11-27.
3. Dobermann A, Cassman KG. Plant nutrient management for enhanced productivity in intensive grain production systems of the United States and Asia. Plant Soil. 2002; 247:153-175.
4. Dobermann A, Cassman KG, Mamaril CP, Sheehy JE. Management of phosphorus, potassium and sulfur in intensive, irrigated lowland rice. Field Crops Res. 1998; 56:113-138
5. Dobermann A, Cassman KG, Sta PC, Cruz MAA, Adviento, Pampolino MF. Fertilizer inputs, nutrient balance, and soil nutrient-supplying power in intensive, irrigated rice systems: III. Phosphorus. Nutr. Cycling Agroecosyst. 1996; 46:111-125.
6. Dobermann A, Witt C, Dawe D, Gines GC, Nagarajan R, Satawathananont S *et al*. Site-specific nutrient management for intensive rice cropping systems in Asia. Field Crops Res. 2002; 74:37-66.
7. Janssen BH, Guiking FCT. Modelling the response of crops to fertilizers. *In* M.L. van Beusichem (ed.) Plant nutrition-physiology and applications. Kluwer Academic Press, Dordrecht, the Netherlands, 1990, 699-703.
8. Wang GH, Dobermann A, Witt C, Sun QZ, Fu RX. Performance of site-specific nutrient management for irrigated rice in southeast China. Agron. J. 2001; 93:869-878.
9. Witt C, Dobermann A, Abdulrachman S, Gines HC, Wang GH, Nagarajan R *et al*. Internal nutrient efficiencies of irrigated lowland rice in tropical and subtropical Asia. Field Crops Res. 1999; 63:113-138.