www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(2): 745-750

www.thepharmajournal.com
Received: 16-12-2021
Accepted: 23-01-2022

Suraj Mali
Ph.D., Scholar, Department of Soil Science, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Sanjay Tiwari
Associate Professor, Department of Soil Science, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Corresponding Author:
Suraj Mali
Ph.D., Scholar, Department of Soil Science, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, India

Impact of nitrogen availability and uptake in rice genotypes after gypsum and bio-compost application in *sodic* soils

Suraj Mali and Sanjay Tiwari

Abstract

Sodic soils have immense productivity potential, if managed through proper technology interventions. Bio-compost is prepared by composting pressmud (a sugar industry byproduct) received from cane juice filtration and spent wash received from distilleries through microbial aerobic decomposition and gypsum received from waste material of mining can be used to reclaim sodic soils and increase nitrogen availability in soils. A field experiments were carried out during *Kharif* seasons 2018 & 2019 at ICAR - Indian Agricultural Research Institute, Sub Regional Station, Pusa (Samastipur), Bihar. Our objective was to study the increase availability of nitrogen & uptake by genotypes under sodic soils. The results obtained from the present investigation revealed that the mean of soil reaction (pH) of all genotypes ranged from 9.10 to 9.23 during 2018 and 9.01 to 9.11 during 2019. Available nitrogen of all the genotypes ranged between 161.62 to 172.67 kg ha^{-1} in the first year while in the second year it ranged between 163.89 to 174.16 kg ha^{-1}. The mean nitrogen uptake in grain of the genotypes varied between 28.69 kg ha^{-1} to 44.09 kg ha^{-1} during 2018 and 30.85 kg ha^{-1} to 44.43 kg ha^{-1} during 2019. The nitrogen uptake in straw of the genotypes varied between 11.49 kg ha^{-1} to 18.07 kg ha^{-1} in the first year while in the second year it varied between 11.76 kg ha^{-1} to 17.99 kg ha^{-1}.

Keywords: Gypsum requirement (GR), gypsum, bio-compost and rice genotypes

Introduction

Worldwide, approximately 1.2 billion hectare of area is estimated to be salt affected with different levels of salinity and sodicity of soils (Massoud 1974; Ponnamperuma 1984; Tanji 1990 and FAO 2007) [15, 18, 23, 5]. However, India has the largest area under salt affected soils i.e. 6.74 million hectare. In India alone, 1.25 million hectare areas are characterized by coastal salinity, 3.79 million hectare as sodic and 1.71 million hectare area under saline soils. However, in Bihar, the total salt affected soils are spread over 0.15 million hectare area among which 0.11 million hectare area is under alkaline (sodic) soils and 0.047 million hectare area is under saline soils (NRSA and Associates 1996) [17]. Over 6.74 million hectare of the area is estimated to be lost each year to salinity, sodicity and drainage problems (Gupta and Abrol 1990) [7].

In world, 769.9 million tonnes rice have been produced in the year 2018-19 from the total harvested area of 165.93 million hectare with 4.64 t ha^{-1} productivity. As we know that Asia is the biggest rice producer as well as consumer of the world and majority of all rice produce comes from India, China, Japan, Indonesia, Thailand, Burma and Bangladesh while Asian farmers account for 92% of the world's rice production. In the year 2018-19, 169.5 million tonnes rice was produced from 44.49 million hectare in India with 3.81 t ha^{-1} productivity however, 8.3 million tonnes of rice was produced from 3.24 million hectare in Bihar with 2.56 t ha^{-1} productivity (FAO 2018) [4]. Soil salinity is a major abiotic stress limiting plant growth and development. In crops known as glycophyte or salt susceptible [Hasegawa *et al.* 2000; Qadir *et al.* 2007] [9, 19]. It causes yield losses by depressing the uptake of water, and disturbing mineral and normal metabolism. Salt-affected soils are identified by excessive levels of water-soluble salts, especially sodium chloride (NaCl) [Tanji 2002] [24]. NaCl is a small molecule which when ionized by water, produces sodium (Na$^+$) and chloride (Cl$^-$) ions. Excess Na$^+$ in plant cells directly damages membrane systems and organelles, resulting in growth reduction and abnormal development prior to plant death. The toxic ions cause ionic and osmotic stress at the cellular level in higher plants, especially in susceptible germplasm [Mansour and Salama 2000; Chinnusamy *et al.* 2005] [14, 2]. Salinity reduces plant growth through osmotic effects and reduces the water uptake, thereby causing a reduction in growth.

There are many effective ways for improving salt-affected land, such as leaching, chemical remediation and phytoremediation [Qadir *et al*. 2007; Sharma and Minhas 2005] [19, 21]. The remediation of salt-affected soils using chemical agents, including gypsum ($CaSO_4{\cdot}2H_2O$), pyrite (FeS_2), calcite ($CaCO_3$), calcium chloride ($CaCl_2.2H_2O$), and organic matter (farmyard manure, green manure, organic amendment and municipal solid waste), was successful in many cases and has been implemented worldwide, being effective and simple [Sharma and Minhas 2005; Mitchell *et al.* 2000; Hanay *et al.* 2004; Tejada *et al.* 2006] [21, 16, 8, 25]. Gypsum and pyrite are the most effective reclamation agents for sodic soils, but they are expensive and beyond the reach of poor farmers in rainfed lowland areas. But the physical, chemical and biological properties of soils in salt-affected areas can also be improved by the application of organic matter, leading to enhanced plant growth and development [Choudhary *et al.* 2004; Wong *et al.* 2009] [14, 28]. Pressmud, a sugar industry by-product, is readily available in eastern Uttar Pradesh (U.P.) and less expensive compared to gypsum. Biocompost is prepared by composting pressmud received from cane juice filtration and spent wash received from distilleries through microbial aerobic decomposition. It contains nutrients like N, P, K, Zn and big amounts of organic carbon. Calcium replaces Na^+ from the cation exchange complex, and about 2% - 3% sulphur converts into sulphuric acid and lowers soil pH.

Materials and Methods

A field experiments were carried out during 23th June 2018 to 28th November 2018 and 23th June 2019 to 28th November 2019 (two *kharif* seasons). The experiment was conducted at ICAR - Indian Agricultural Research Institute, Sub Regional Station, Pusa (Samastipur), Bihar which lies at 85^0 40' 19.7" E latitude 25^0 59' 06.2" N longitudes with an elevation of 55.00 meter above mean sea level. The experimental site is having hot and humid climate summers and too cold winters with average rainfall of 1344 mm of which 70% received during the monsoon period (mid June - mid September, 2018 and 2019).

Experimental details

A field experiment laid out in split plot design with four treatment T_1- Control, T_2- Gypsum @ 100% G.R., T_3- Gypsum @ 50% G.R. + Biocompost @ 2.5 t ha^{-1}, T_4- Biocompost @ 5.0 t ha^{-1} in main plots and ten genotypes G_1 - Suwasini, G_2 - Rajendra Bhagwati, G_3 - Boro-3, G_4 - Rajendra Neelam, G_5 - CSR-30, G_6 - CSR-36, G_7 - CR-3884-244-8-5-6-1-1, G_8 - CR-2851-SB-1-2-B-1, G_9 - CSR-27, G_{10} - Pusa-44 in sub plots and replicated in thrice. The main plots and sub plots are permanent plots for both the years (2018 and 2019). During experimentation (2018 and 2019), the plots were kept same for a particular treatment. the experiment site in each plots size was 4.2 m × 2.7 m and spacing in each plot 20 cm × 15 cm. Transplanted rice genotypes were taken with the recommended dose of N: P_2O_5: K_2O @ 120: 60: 40 in the form of urea, diammonium phosphate (DAP) and muriate of potash (MOP).

Fifty per cent of N, and full doses of P_2O_5 and K_2O were applied as basal and the rest fifty per cent of N was applied in two splits at 30 days interval. The study aimed to evaluate the effect of amendments on macronutrient uptake in grain and straw of various rice genotypes.

Collection and preparation of soil samples

Representative soil samples from 0-15 cm depth were collected before rice sowing and after rice harvesting stage *Kharif* (2018 and 2019), respectively. Collected soil samples were air dried in shade and grinded with wooden hammer. These grinded samples were then passed through a 2 mm sieve and stored in polyethylene bags with proper labels for further analysis of soil to determine various soil parameters. The pH of soil was measured with the help of a pH meter, maintaining the soil, water ratio of 1:2 as described by Jackson (1967) [12]. Available N of soil was measured by alkaline permanganate methods as described by Subbiah and Asija (1956) [22].

Collection and preparation of grain and straw samples

Grain and straw samples of rice were collected from each plot at the time of harvesting. Samples were washed with an acidified detergent solution after that rinsed in distilled water and subsequent cleaning was done according to the method suggested by Chapman (1964) [1]. The samples were spread on a filter paper for air drying and afterwards put in paper bags, which were kept in hot air oven at 65°C for 48 hrs for drying. The dried samples were crushed, grinded with the help of Willey heavy duty grinding mill having a stainless steel blade and, then stored in polyethylene bags for the estimation of macro-nutrient contents.

Well grinded samples of known weight were digested in concentrated H_2SO_4 and digestion mixture (Potassium sulphate 400 parts, copper sulphate 20 parts, mercuric oxide 3 parts, selenium powder 1 part) as suggested by Jackson (1973) [12]. Nitrogen in the processed sample was determined by Kjeldahal digestion method.

Statistical analysis

The data recorded for different parameters were analyzed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) [6] for split plot design. ANOVA was found significant and accordingly results are presented at 5% level of significance (P=0.05).

Empirical formulae

$$\text{Macro-nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{dry matter (q ha}^{-1})}{100}$$

Results and Discussion

Physico-chemical properties of experimental soil

The soil of the experimental site belongs to order *Entisol*, silt loam in texture at surface containing 10.45% sand, 72.06% silt and 17.49% clay the physico-chemical properties of soil was alkaline pH 9.69 in reaction, electrical conductivity 2.12 dS m^{-1} and organic carbon 2.6 g kg^{-1}. The soil had the available N, P, K and S was recorded 136.8 kg ha^{-1}, 7.83 kg ha^{-1}, 93.2 kg ha^{-1} and 3.53 kg ha^{-1} (Table 1). High pH and low EC of the experimental site might be from excessive accumulation of exchangeable Na^+ in the soil particles. This indicates that the soil of the experimental site was sodic (USDA 1954) [26]. The soil had very low organic carbon content indicating moderate potential of the soil to supply nitrogen to plants through mineralization of organic carbon. Soils in salt-affected landscapes produce less biomass than non-saline soils resulting less in soil organic carbon (Wong *et al.* 2010) [27].

Table 1: Physico-chemical properties of experimental soil (0-15 cm depth before start of the experiment)

Properties	Value
Physical properties	
Sand (%)	10.45
Silt (%)	72.06
Clay (%)	17.49
Textural Class	Silt loam
Bulk density(g cm^{-3})	1.63
Water Holding Capacity (%)	38.62
Wet Aggregate Stability (%)	8.45
Chemical properties	
pH (1:2 Soil: Water) (0 -15 cm depth)	9.69
EC (dS m^{-1})	2.12
Organic Carbon (g kg^{-1} soil)	2.6
Available Nitrogen (kg ha^{-1})	136.8
Available Phosphorous (P_2O_5) (kg ha^{-1})	7.83
Available Potassium (K_2O) (kg ha^{-1})	93.2
Available Sulphur (kg ha^{-1})	3.53

Soil reaction (pH)

Soil reaction (pH) in all the genotypes had non-significant in the first year while in the second year genotypes Boro-3, Rajendra Neelam and Pusa-44 were significantly higher than the all genotypes (Figure 1). The mean of soil reaction (pH) of all genotypes ranged from 9.10 to 9.23 during 2018 and 9.01 to 9.11 during 2019. All the soil amendments had significantly higher Soil reaction (pH) as compared to the gypsum @ 100% GR treated plot in both the years. Without treated in any amendments had higher value than the combination of gypsum @ 50% GR and biocompost @ 2.5 t ha^{-1} treated plot and biocompost @ 5.0 t ha^{-1} treated plot. However, biocompost @ 5.0 t ha^{-1} treated plot had higher soil reaction (pH) than the combination of gypsum @ 50% GR and biocompost @ 2.5 t ha^{-1} treated plot in both the years.

The interaction between genotype and soil amendment was non-significant in both the years. Soil reaction (pH) ranged from 8.86 to 9.48 in the first year while in the second year it was ranged from 8.79 to 9.35.

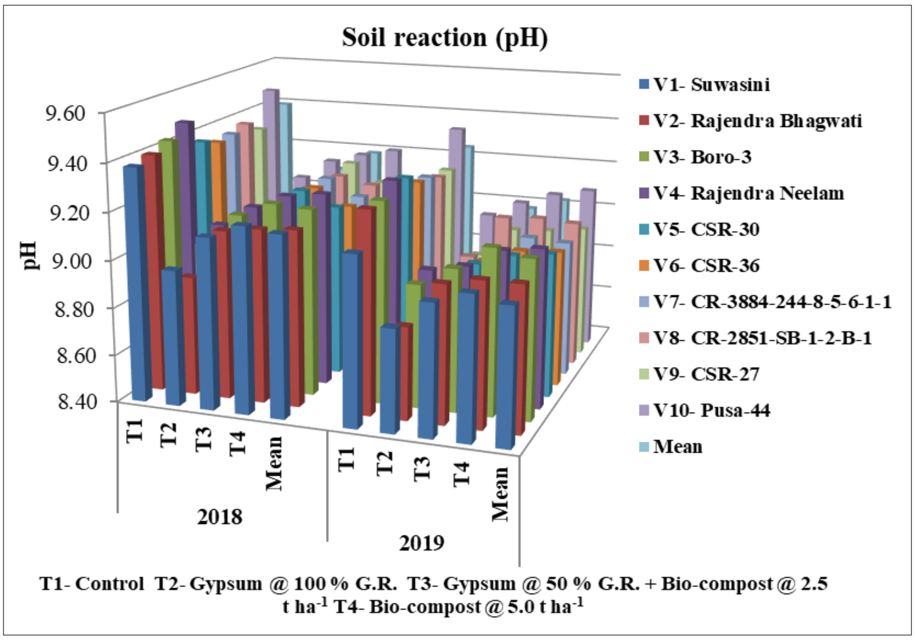

Fig 1: The influence of organic and inorganic amendments and their combination on soil reaction (pH - 1:2 Soil: Water) after harvest of rice crop

Available Nitrogen in soil

Available nitrogen in all the salt tolerant genotypes were significantly higher than the check Pusa-44, Rajendra Bhagwati, Boro-3 and Rajendra Neelam in the first year while in the second year it was higher in salt tolerant genotypes: CSR-30 (Salt tolerant Basmati), CSR-36, CR-3884-244-8-5-6-1-1 and CSR-27. During both the years the minimum and maximum values were obtained in check Pusa-44 and CSR-30, respectively (Figure 2). Available nitrogen of all the genotypes ranged between 161.62 to 172.67 kg ha^{-1} in the first year while in the second year it ranged between 163.89 to 174.16 kg ha^{-1}. All the soil amendments had significantly higher available nitrogen than the control plot. Biocompost @ 5.0 t ha^{-1} applications had higher value than the other two amendments application. However, the combination of gypsum @ 50% GR and biocompost @ 2.5 t ha^{-1} applications had higher available nitrogen than the gypsum @ 100% GR applications in both the years.

Amendments and genotypes interaction was non-significant in both the years. Available nitrogen varied from 138.73 to 199.73 kg ha^{-1} in the first year while in the second year it varied from 141.47 to 191.37 kg ha^{-1}.

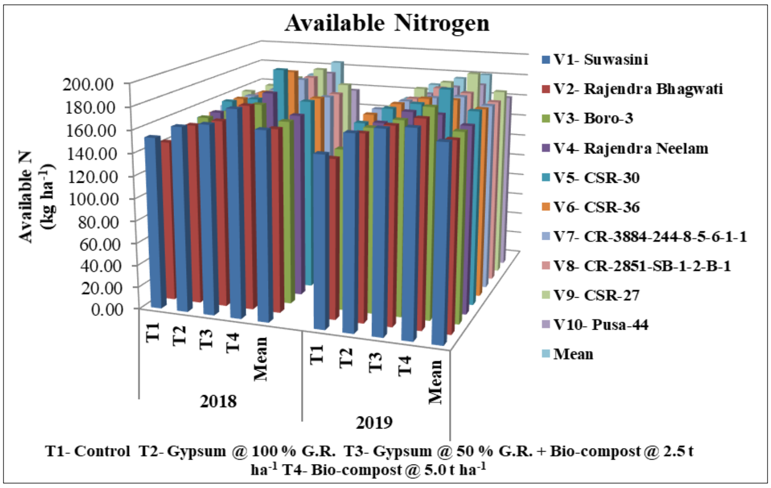

Fig 2: The influence of organic and inorganic amendments and their combination on Available Nitrogen (kg ha^{-1}) after harvest of rice crop

Nitrogen uptake in grain and straw

Grain

All the genotypes had significantly higher nitrogen uptake in grain as compared to the check, Pusa-44 in both the years (Figure 3). The mean nitrogen uptake in grain of the genotypes varied between 28.69 kg ha^{-1} to 44.09 kg ha^{-1} during 2018 and 30.85 kg ha^{-1} to 44.43 kg ha^{-1} during 2019. All the soil amendments had significantly higher nitrogen uptake in grain as compared to the control plot. The combination of gypsum and bio-compost had higher value than the other two amendments in both the years. However, bio-compost application had higher nitrogen uptake in grain than the gypsum application during 2018 and gypsum application had higher nitrogen uptake in grain than the bio-compost application during 2019. The interaction between genotypes and soil amendments was non-significant in both the years. Nitrogen uptake in grain varied between 22.73 kg ha^{-1} to 50.69 kg ha^{-1} during 2018 and 26.29 kg ha^{-1} to 49.45 kg ha^{-1} during 2019.

Straw

It was observed that the nitrogen uptake in straw of all the salt tolerant genotypes were significantly higher than Pusa-44, Suwasini, Rajendra Bhagwati, Boro-3, Rajendra Neelam and CR-2851-SB-1-2-B-1 in the first year while in the second year it was significantly higher in all genotypes than the Pusa-44, Rajendra Bhagwati, CR-2851-SB-1-2-B-1 and Rajendra Neelam. The nitrogen uptake in straw of the genotypes varied between 11.49 kg ha^{-1} to 18.07 kg ha^{-1} in the first year while in the second year it varied between 11.76 kg ha^{-1} to 17.99 kg ha^{-1} (Figure 4). During both the years the maximum value was obtained in CSR-36. All the soil amendments had significantly higher nitrogen uptake in straw as compared to the without application in any amendments. The combination of gypsum and bio-compost had higher value than the other two amendments. However, bio-compost application had higher nitrogen uptake in straw than the gypsum application during 2018 and gypsum application had higher nitrogen uptake in straw than the bio-compost application during 2019. Nitrogen uptake in straw varied between 8.86 kg ha^{-1} to 21.70 kg ha^{-1} in the first year while in the second year it varied between 8.97 kg ha^{-1} to 22.07 kg ha^{-1}. Amendment and genotype interaction was non-significant in both the years.

It might be due to organic amendment improved soil physical conditions which helped to reduce leaching losses, prolong nutrient availability, and synchronize nutrient release with crop demand. The results are in agreement with those of Hossain and Sarker (2015) [10]; Lakshmi *et al.* (2016) [13] and Ram *et al.* (2017) [20].

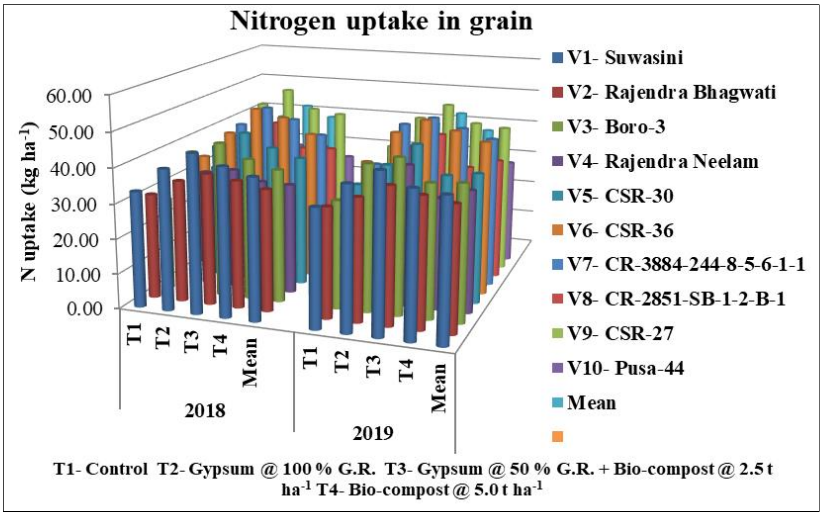

Fig 3: The influence of organic and inorganic amendments and their combination on Nitrogen uptake (kg ha^{-1}) in grain of different rice genotypes

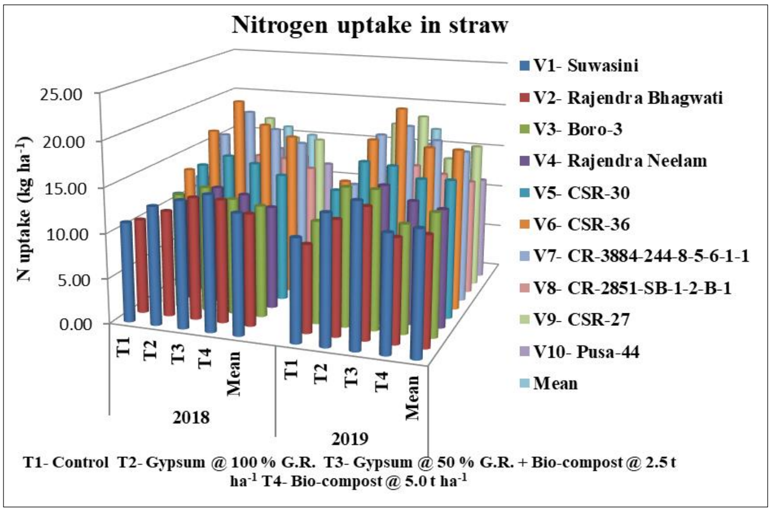

Fig 4: The influence of organic and inorganic amendments and their combination on Nitrogen uptake (kg ha^{-1}) in straw of different rice genotypes

Conclusion

Soil reaction (pH) in all the genotypes had non-significant in the first year while in the second year genotypes Boro-3, Rajendra Neelam and Pusa-44 were significantly higher than the all genotypes. Available nitrogen in all the salt tolerant genotypes were significantly higher than the check Pusa-44, Rajendra Bhagwati, Boro-3 and Rajendra Neelam in the first year while in the second year it was higher in salt tolerant genotypes: CSR-30 (Salt tolerant Basmati), CSR-36, CR-3884-244-8-5-6-1-1 and CSR-27. Nitrogen uptake in grain had significantly higher in the genotypes CSR-27 followed by CSR-36 and CR-3884-244-8-5-6-1-1 and combination of gypsum @ 50% G.R. and bio-compost @ 2.5 t ha^{-1} application had significantly higher followed by gypsum @ 100% G.R. application and Nitrogen uptake in straw had significantly higher in the genotypes CSR-36 followed by CSR-27 and CR-3884-244-8-5-6-1-1 and combination of gypsum @ 50% G.R. and bio-compost @ 2.5 t ha^{-1} application had significantly higher than the control treatment.

Acknowledgement

The authors are thankful to the support of the Professor Dr. Ranjan Laik in Department of Soil Science, Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar, to conduct the field experiment in the ICAR - Indian Agricultural Research Institute, Sub Regional Station, Pusa (Samastipur), Bihar of the Department and providing the necessary facilities and financial support to carry out the work smoothly.

References

1. Chapman HD. Suggested foliar sampling and handling techniques for determining the nutrient status of some field, horticultural and plantation crops. Indian Journal of Horticulture. 1964;21:97-119.
2. Chinnusamy V, Jagendorf A, Zhu JK. Understanding and Improving Salt Tolerance in Plants. Crop Science. 2005;45:437-448. http://dx.doi.org/10.2135/cropsci2005.0437
3. Choudhary OP, Josan AS, Bajwa MS, Kapur L. Effect of Sustained Sodic and Saline-Sodic Irrigation and Application of Gypsum and Farmyard Manure on Yield and Quality of Sugarcane Under Semi-Arid Conditions. Field Crops Research. 2004;87:103-116. http://dx.doi.org/10.1016/j.fcr.2003.10.001
4. FAO (Food and Agriculture Organization of the United Nations). 2018 April, XXI(I). www.fao.org/economics/RMM.
5. FAO (Food and Agriculture Organization) database. 2007.
6. Gomez KA, Gomez AA. Statistical Procedure for Agricultural Research, 2nd Edition. An International Rice Research Institute Book. A Wiley-Inter-science. Publication, John Wiley and Sons, New York. 1984.
7. Gupta RK, Abrol IP. Salt-affected soils: their reclamation and management for crop production. In Advances in soil science, pp. 223-288. Springer, New York, NY. 1990.
8. Hanay A, Buyuksonmez F, Kiziloglu FM, Canbolart MY. Reclamation of Saline-Sodic with Gypsum and MSW Compost. Compost Science and Utilization. 2004;12:175-179. http://dx.doi.org/10.1080/1065657X.2004.10702177
9. Hasegawa PM, Bressan RA, Zhu JK, Bohnert HJ. Plant Cellular and Molecular Responses to High Salinity. Annual Review of Plant Physiology and Molecular Biology. 2000;51:463-499. http://dx.doi.org/10.1146/annurev.arplant. 51.1.463
10. Hossain MB, Sarker RR. Organic and inorganic amendments on rice (*Oryza Sativa* L.) and soil in salt affected areas of Bangladesh. Journal of Environmental Science and Natural Resources. 2015;8(2):109-113.
11. Jackson ML. Soil chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi. 1967.
12. Jackson ML. Soil Chemical Analysis. Printice Hall, India Pvt. Ltd., New Delhi. 1973.
13. Lakshmi TB, Srinivasamurthy CA, Bhaskar S. Increasing rice production in sodic soil through ferti-irrigation with distillery spentwash. Asian Journal of Soil Science. 2016;11(1):1-8.
14. Mansour MMF, Salama KHA. Cellular Basis of Salinity Tolerance in Plants. Environmental and Experimental of Botany. 2000;52:113-122. http://dx.doi.org/10.1016/j.envexpbot.2004.01.009
15. Massoud FI. Salinity and alkalinity a degradation hazards. FAOUNESCO Publication, Rome. 1974;74:10.
16. Mitchell JP, Shennan C, Singer MJ, Peters DW, Miller KO, Prichars T, *et al*. Impacts of Gypsum and Winter

Cover Crops on Soil Physical Properties and Crop Productivity When Irrigated with Saline Water. Agriculture Water Management. 2000;45:55-71. http://dx.doi.org/10.1016/S0378-3774(99)00070-0

17. NRSA and Associates. Mapping salt affected soils of India, 1:250,000 mapsheets, Legend. NRSA, Hyderabad. 1996.
18. Ponnamperuma FN. Role of cultivar tolerance in increasing rice production on saline lands. In: Salinity Tolerance in Plants: *Strategies for* Crop Improvement (R C Staples and G H Toenniessen, Eds). Wiley, New York. 1984, 255-271.
19. Qadir M, Oster JD, Schubert S, Noble AD, Sahrawat KL. Phytoremediation of Sodic and Saline-Sodic Soils. Advances in Agronomy. 2007;96:197-247. http://dx.doi.org/10.1016/S0065-2113(07)96006-X
20. Ram S, Singh RP, Santosh K, Yadav PK, Singh DK, Chandel SK, *et al*. Residual effect of gypsum on growth, yield and nutrient uptake by onion (*Allium cepa* L.) under groundnut-onion cropping sequence. Environment and Ecology. 2017;35(1B):423-426.
21. Sharma BR, Minhas PS. Strategies for Managing Saline/Alkali Waters for Sustainable Agricultural Production in South Asia. Agricultural Water Management. 2005;78:136-151. http://dx.doi.org/10.1016/j.agwat. 2005.04.019
22. Subbiah BV, Asija GL. A rapid procedure for the determination of available nitrogen in soils. Current Science. 1956;25:259-260.
23. Tanji KK. In: Agricultural Salinity Assessment and Management. Ed.: K.K. Tanji, American Society of Civil Engineers N.Y. 1990, 620.
24. Tanji KK. Salinity in the Soil Environment. In: A. Lauchli, Luttge U, Eds., Salinity Environment-Plant-Molecules, Kluwer Academic, Dordrecht. 2002, 21-51.
25. Tejada M, Garcia C, Gonzalez JL, Hernandez MT. Use of Organic Amendment as a Strategy for Saline Soil Remediation: Influence on the Physical, Chemical and Biological Properties of Soil. Soil Biology and Biochemistry. 2005;38:1413-1421. http://dx.doi.org/10.1016/j.soilbio.2005.10.017
26. USDA. Diagnosis and Improvement of Saline and Alkali soils. United States Salinity Laboratory staff. Agriculture Handbook No. 60, United States Department of Agriculture. 1954, 160.
27. Wong VN, Greene RSB, Dalal RC, Murphy BW. Soil carbon dynamics in saline and sodic soils: a review. Soil use and management. 2010;26(1):2-11.
28. Wong VNL, Dalal RC, Greene RSB. Carbon Dynamics of Sodic and Saline Soil Following Gypsum and Organic Material Additions: A Laboratory Incubation. Applied Soil Ecology. 2009;41:29-40. http://dx.doi.org/10.1016/j.apsoil.2008.08.006