Indian Journal of Agronomy **64** (3): 406–409 (September 2019)

Research Communication

Yield enhancement of rice (*Oryza sativa*) by remediation of sodic soil

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Received : October 2018; Revised accepted : August 2019

ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2016–17 at Navalur Kuttapattu, Tamil Nadu to study the effect of sodic soil reclamation with the application of organic amendments on yield enhancement of rice (*Oryza sativa* L.). Application of gypsum @ 50% gypsum requirement (GR) + *dhaincha* [*Sesbania bispinosa* (Jacq.) W. Wight] incorporation along with poultry manure @ 5 t/ha recorded higher grain yield (5.68 t/ha) and registered yield increase ranging from 13.0 to 38.9% compared to other amendments. Application of gypsum @ 50% GR + *dhaincha* incorporation + poultry manure @ 5 t/ha lowered *p*H (8.37), electrical conductivity (EC 0.58 dS/m) and exchangeable sodium percentage (ESP 14.6) compared with the control (*p*H 9.08, EC 0.52dS/m and ESP 25.6). Post-harvest soil-available N, P and K were higher with the application of gypsum @ 50% GR + *dhaincha* + poultry manure @ 5 t/ha (N 271 kg/ha; P, 26.6 kg/ha; and K, 189 kg/ha).The higher net returns of ₹56,349/ha with benefit: cost (B: C) ratio of 2.41 was realized with gypsum @ 50% GR + *dhaincha* incorporation + poultry manure @ 5 t/ha. The combined application of gypsum @ 50% GR + *dhaincha* + poultry manure @ 5 t/ha was more effective in realizing higher yield, availability of nutrients and monetary benefits.

Key words: *Dhaincha*, Distillery yeast sludge, Gypsum, Poultry manure, Pressmud

Food security concerns coupled with the scarcity of new productive land have put productivity enhancement of degraded lands back on the agenda of research and development. Salt-affected land is a valuable resource that cannot be neglected nor easily abandoned even with their limitations to crop yields. This is especially true in areas where significant investments have already been made in irrigation and drainage infrastructure. Sodic soil is characterized by the excess of sodium ions leading to the dispersion of soil aggregates and inhibition of soil microbial activity. The crops grown in such soils suffering from unavailability of plant essential nutrients especially N, P and K (Lakdhar *et al.,* 2009). Chemical amendment gypsum is mainly used for reclamation of sodic soil, which replaces the excessive sodium ions from soils. However, the application of chemical amendments and subsequent leaching may also bring about loss of soil nutrients (Qadir *et al.,* 2006). Alternatively, use of different organic amendments in such soils improves soil properties and promotes greater levels of plant-useful nutrients (Gill *et al.,* 2009). The use of gypsum with the organic amendments significantly improves the soil physico-chemical properties of sodic soils as compared to their individual application (Ullah and Bhatti, 2007). Keeping all the above information in view, a field experiment was carried out to enhance rice yield by reclamating sodic soil through combined application of gypsum and organic amendments in transplanted rice.

The field experiment was conducted during the winter (*rabi*) season of 2016–17 at the Anbil Dharmalingam Agricultural College and Research Institute, Navalur Kullapattu, Tiruchirapalli, Tamil Nadu. The farm is situated at Cauvery Delta Agro-climatic Zone of Tamil Nadu, (10°45'N, and 78°36'E, 85 m above mean sea-level). During the experimental period, a total rainfall of 131 mm was received in 15 rainy days. The mean maximum and minimum temperatures were 32.7°C and 22.3°C, respectively. The mean relative humidity was 85% in the forenoon and 58.2% in the afternoon and the mean sunshine hours were 5.8. Soil of the experimental field was sandy clay loam and taxonomically the soil belongs to the family *Vertic Ustropept,* having *p*H 8.80, EC 0.40 dS/m, available N, P

Based on a part of M.Sc. thesis of the first author submitted to Tamil Nadu Agricultural University, Tiruchirapalli, Tamil Nadu (Unpublished)

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and K were 190, 13.2 and 147 kg/ha, respectively. Treatments were: T_1, control; T_2, gypsum @ 50% gypsum requirement (GR) + *dhaincha*; T_3, gypsum @ 25% GR + *dhaincha* + distillery yeast sludge (5 t/ha); T_4, gypsum @ 50% GR + *dhaincha* + distillery yeast sludge (5 t/ha); T_5, gypsum @ 25% GR + *dhaincha* + sugarcane trash compost (10 t/ha); T_6, gypsum @ 50% GR + *dhaincha* + sugarcane trash compost (10 t/ha); T_7, gypsum @ 25% GR + *dhaincha* + decomposed poultry manure (5 t/ha); T_8, gypsum @ 50% GR + *dhaincha* + decomposed poultry manure (5 t/ha); T_9, gypsum @ 25% GR + *dhaincha* + pressmud (10 t/ha); T_{10}, gypsum @ 50% GR + *dhaincha* + pressmud (10 t/ha). Gypsum was applied to the field as per the treatment schedule based on the GR, i.e. 50% GR @ 6.8 t/ha and 25% GR @ 3.4 t/ha. *Dhaincha* @ 25 kg/ha was sown in the main field and total biomass of 1,294 kg/ha (dry-weight basis) was incorporated as *in-situ* and left for 15 days to decompose. Organic amendments, viz. well-decomposed poultry manure, distillery yeast sludge, sugarcane trash compost and pressmud were applied 10 days before transplanting as per the treatment combinations. For yield attributes, number of productive tillers were counted from 10 plants and expressed as total productive tillers/hill. Number of filled grains/panicle was counted from 10 tagged panicles and the fertility percentage was worked out by dividing number of filled grains/panicle with total number of grains/panicle. Grain yield was computed at 14% moisture content and expressed in t/ha. Post-harvest soil samples were collected and analyzed. Exchangeable sodium percentage of the field under different treatments were calculated by dividing exchangeable Na with total CEC. Economic analysis was done by computing the cost of cultivation, gross return and net returns for each treatment considering the prevailing market rate of inputs, produce and the wages paid to the labourers at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirapalli. The data from the experiments were analysed statistically, wherever treatment differences were found significant, the critical differences were worked out at 5% probability level (P=0.05).

The highest grain yield of rice was obtained with the application of gypsum @ 50% GR + *dhaincha* incorporation + poultry manure @ 5 t/ha (5.68 t/ha) which was 39, 17, 14, 17, 14, 13, 19, and 13% higher respectively, over application of other treatment combinations, i.e. T_2, T_3, T_4, T_5, T_6, T_7, T_9, T_{10} (Table 1). Enhanced growth characters with improved yield components, led to higher grain yield. Moreover, higher concentration of macro- and micronutrients in the poultry manure and higher and steady nutrient release compared to the other organic amendments such as distillery yeast sludge, sugarcane trash compost and pressmud could make it to perform well (Ananda *et al.,* 2006). The supply of the required nutrients through organic and inorganic sources facilitated balanced nutrition of the crop, which might have resulted in enhanced grain yield. The lower grain yield might be due to less availability of nutrients at initial stages of crop-growth period and unavailability of nutrients at later stages of crop growth. These findings are in agreement with those of Pandey *et al.* (2009) and Kumar *et al.* (2012).

In the present investigation, an application of gypsum @ 25% GR + *dhaincha* along with poultry manure @ 5 t/ha resulted in the highest B : C ratio (2.46) because of lesser cost of cultivation (₹34,125/ha) compared to higher expenditure (₹40,061/ha) involved for rice production in the treatment application of gypsum @ 50% GR + *dhaincha* along with poultry manure @ 5 t/ha (B : C ratio of 2.41).

In general due to the inclusion of amendments, non-significant reduction in *p*H was noticed at post-harvest stage compared to the initial *p*H (8.80). The lowest *p*H of 8.37 was noticed with the application of gypsum @ 50% GR + *dhaincha* + poultry manure @ 5 t/ha. Similarly, there was no significant difference in the electrical conductivity (EC) due to various organic amendments with gypsum application. Application of gypsum @ 50% GR + *dhaincha* + poultry manure @ 5 t/ha resulted in the exchangeable sodium percentage (ESP 14.6) which was significantly superior to the other treatment combination (Table 2).

In present investigation, the soil-available N, P and K 271, 26.6 and 189 kg/ha) were higher under application of gypsum @ 50% GR + *dhaincha* incorporation + poultry manure @ 5 t/ha (Table 2). Owing to increase in microbial activity in the presence of organic matter, soil released the available form of native and unavailable form of nutrients. Consequently, available nutrients status was improved and when organic manure was added to the soil complex, nitrogenous compounds brokedown slowly and made steady N supply throughout the growth period of the crop. The organic matter may also reduce the fixation of phosphate by providing protective cover on sesqueoxides and chelating cations like Ca^{2+} and Mg^{2+} (when applied along with inorganic fertilizer) which in turn enhanced the availability of P (Singh *et al.,* 2010) and build up of available phosphorus in soil was released from organic acids during the microbial decomposition of organic manures which improved native phosphorous content of soil.

Application of gypsum @ 50% + *dhaincha* + poultry manure @ 5 t/ha recorded higher Cu (2.0 mg/kg soil), Zn (4.6 mg/kg soil), Fe (14.4 mg/kg soil), Mn (5.3 mg/kg soil), being superior to the other treatment combinations (Table 2). The decrease in soil ESP with addition of amendments (organic/ inorganic) either alone or in combination may be attributed to increase Ca in soil solution as

Table 1. Yield and yield attributes of rice under sodic soil with organic amendments

Treatment	Productive tillers/hill (Nos.)	Panicle length (cm)	Filled grains/ panicle	Fertility percentage (%)	Grain yield (t/ha)	Benefit: cost ratio
T_1, Control	6.1	25.2	79.00	79	2.68	1.74
T_2, 50% GR + *dhaincha*	10.0	25.8	89.03	87	4.09	2.21
T_3, 25% GR + *dhaincha* + distillery yeast sludge @ 5 t/ha	12.2	24.8	87.87	87	4.69	2.34
T_4, 50% GR + *dhaincha* + distillery yeast sludge @ 5 t/ha	11.0	24.8	87.77	82	4.88	2.06
T_5, 25% GR + *dhaincha* + Sugarcane trash compost @ 10 t/ha	12.8	26.9	91.00	84	4.67	2.33
T_6, 50% GR + *dhaincha* + sugarcane trash compost @ 10 t/ha	11.3	25.5	99.33	87	4.88	2.07
T_7, 25% GR + *dhaincha* + poultry manure @ 5 t/ha	16.0	26.9	112.33	92	4.94	2.46
T_8, 50% GR + *dhaincha* + poultry manure @ 5 t/ha	20.1	27.8	120.40	94	5.68	2.41
T_9, 25% GR + *dhaincha* + pressmud @ 10 t/ha	13.2	25.9	90.67	92	4.60	2.30
T_{10}, 50% GR + *dhaincha* + pressmud @ 10 t/ha	14.1	26.4	108.00	94	4.92	2.09
SEm±	0.65	0.4	4.0	–	0.21	–
CD (P=0.05)	1.4	1.0	8.5	–	0.44	–

GR, Gypsum requirement

Table 2. Post-harvest analysis of chemical properties in sodic soil

Treatment	*p*H	EC (dS/m)	ESP	N	P	K	Micronutrients (mg/kg)			
				(kg/ha)			Cu	Zn	Fe	Mn
T_1, Control	9.08	0.52	25.6	173	9.9	127	1.6	2.8	6.1	4.0
T_2, 50% GR + *dhaincha*	8.58	0.58	16.2	203	13.7	146	1.7	4.3	11.6	4.1
T_3, 25% GR + *dhaincha* + distillery yeast sludge @ 5 t/ha	8.55	0.67	15.8	227	12.8	159	1.7	3.3	10.9	4.4
T_4, 50% GR + *dhaincha* + distillery yeast sludge @ 5 t/ha	8.43	0.51	15.1	220	15.2	173	1.8	4.3	10.4	4.4
T_5, 25% GR + *dhaincha* + Sugarcane trash compost @ 10 t/ha	8.54	0.59	16.0	230	19.6	170	1.7	2.8	10.8	4.6
T_6, 50% GR + *dhaincha* + sugarcane trash compost @ 10 t/ha	8.50	0.66	16.2	237	22.9	174	1.8	3.3	12.2	4.9
T_7, 25% GR + *dhaincha* + poultry manure @ 5 t/ha	8.51	0.55	15.8	263	21.8	180	1.6	3.5	10.3	4.2
T_8, 50% GR + *dhaincha* + poultry manure @ 5 t/ha	8.37	0.58	14.6	271	26.6	189	2.0	4.6	14.4	5.3
T_9, 25% GR + *dhaincha* + pressmud @ 10 t/ha	8.55	0.60	15.7	235	19.2	146	1.8	4.5	12.4	4.1
T_{10}, 50% GR + *dhaincha* + pressmud @ 10 t/ha	8.46	0.51	14.9	247	22.8	154	1.7	3.8	14.2	4.1
SEm±	0.09	0.07	0.3	11	1.2	14	0.1	0.5	1.8	0.8
CD (P=0.05)	NS	NS	0.6	24	3.2	30	NS	1.0	3.8	NS

GR, Gypsum requirement

a result of addition of gypsum and organic sources which promoted Na displacement and its subsequent removal during irrigation to lower soil layers (Gharaibeh *et al.,* 2009, 2011).

The combined application of gypsum with organic amendments + *dhaincha* incorporation varied widely among themselves for various parameters recorded in rice under sodic soil condition. Higher yield in rice and better post-harvest soil quality was achieved with the application of gypsum @ 50% GR + *dhaincha* incorporation + poultry manure @ 5 t/ha followed by 25% GR + *dhaincha* incorporation + poultry manure @ 5 t/ha.

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