EFFECT OF DIFFERENT AMENDMENTS AND INORGANIC NUTRIENT MANAGEMENT APPROACHES IN CORRECTING SODICITY UNDER PADDY ECO SYSTEM

ABSTARCT

Agricultural production in sodic soil may be hindered by its unfavorable physicochemical properties. In order to find effective measure to improve the health of sodic soil and make it to favourable for crop production, a field experiment was conducted at ZARS VC Farm Mandya to study the effect of different amendments on properties of sodic soil. The experiment was laid under split plot design with inorganic nutrient management viz., RDF, SSNM and STCR as main treatments and amendments such as press mud, gypsum and Mangala setright, (a commercial soil conditioner containing 15% calcium and 3% magnesium and 5% sulphur) as sub treatments. Results of experiment revealed that application of gypsum significantly reduced pH to 8.5 from 8.96 of initial soil which was on par with application of setright at 600kg/ha (8.68) and press mud (8.69). Whereas exchangeable sodium and ESP was reduced significantly due to application of setright at 400 kg/ha (1.78 cmol/kg and 6.52 respectively) and pressmud at 100% GR (1.85 cmol/kg and 7.03) compared to control (3.69 cmol/kg and 13.72 respectively) and initial soil. Thus application of Mangala Setright at 400kg/ha or pressmud at 100% GR are more beneficial in rectifying sodicity of soil.

Key words: Sodic soil, Preemud, Gypsum, Mangala Setright, Recommended dose of fertilizer (RDF) Soil test crop response (STCR) Sit specific Nutrient Management (SSNM)

INTRODUCTION

Land is most vital resource of any country which is fixed asset and cannot be expanded to meet the needs of increasing population both in case of space and agricultural production. Degradation of these lands due to various factors leads to significant challenges in their effective utilization. Out of many factor of soil degradation, excess salt is prominent one which led to evolution of salt affected. The saline–alkali situation has been perceived as one of the most significant factors causing soil degradation throughout the world (Zhang et al., 2021) salinity and sodicity development in soil are of universally notable, can cause more negative impact on crop production. Increasing the soil salinity and sodicity are serious worldwide issue and may be even increase rapidly in the future (Wong et al., 2009). In India large area for about 9.38 million hectare is occupied by salt affcetd soil out of which 3.88 million hectare are alkaline soil and 5.50 million hectare are saline soils (Gopikannan and Ganesh 2013, Sandeep and vinay, 2022). The elevated soil pH due to soluble carbonates is main problem associated with sodicity. Under these conditions the availability of certain plant nutrients is reduced resulting in to severe loss in crop production (Sharma, 2006). Even if nutrients are available, imbalanced nutrition prevent or limit the growth of most crops (Qadir et al., 2007; Garg and Malhotra, 2008). Apart from this, sodicity is result of elevated concentration of sodium ion which is highly toxic to the many agricultural crops even though some species have meger level of tolerance. High concentration of sodium in soil complex impart the dispersion of soil particles (David *et al.*, 2001), impacting adversely on physic-chemical properties of soil leading to poor Air-water- plant relationship (Acharya and Abrol, 1975, Prapagar *et al.*, 2012). These soils have, therefore, extremely low permeability, are puddle easily and upon drying form compact blocks that may present a physical barrier to seed germination, root penetration ultimately poor stand of crop. Due to these problems whole process of agricultural production in sodic environment will get upset and productivity of these soil drastically go down. Thus it is necessarily to bring such soils under healthy and productive soil group with proper management practices. Maintaining and restoring the quality soil of is the greatest challenge fall in front of us because quality and fertility is the one of the vital feature controlling yields of agricultural crops. Soil fertility changes and the nutrient balance are taken as key indicator of soil quality (Jansen et al., 1995). To meet the healthy nutrient status, management of these soils is essential with effective amendments. Successful amelioration of these soil involves, addition of calcium externally through soil amendments or mobilized from native $CaCO_3$ (Pagaria and Totawat 2007) to replace the excess concentration of sodium on clay complex which further act as flocculent (Wuddivira and Camps, 2007) and improve the both physical and chemical properties of soil favoring the growth of any plant. The management of these sodic soils will not only increase soil fertility but also helps to add the security to food production of country in a way, bringing unfertile sodic soil to cultivated land. Thus in present study, an attempt was made to find out comparative effect of different amendments obtained from various source in reclaiming sodic soil.

MATERIAL AND METHODS

Field experiment was carried at the experiment was conducted at ZARS, V.C. Farm, Mandya that comes under Agro Climatic Zone-6, Southern Dry Zone, Karnataka. It lies between 76°82'05" E longitude and 12°58'06" N latitude with 705 meters above mean sea level.

The study was arranged in split plot design with 3 main treatment and 7 sub treatment where each treatment replicated thrice. The following treatments were imposed in field experiment. Nutrient management practices: M_1: Recommended Dose of Fertilizer M_2: Soil Test Crop Response M_3: Site Specific Nutrient Management Amendment Application: Amendments: T_1: No amendment control T_2: Gypsum @ 100% GR T_3: Pressmud @ 100% GR T_4: Setright @ 200 kg ha^{-1} T_5: Setright @ 400 kg ha^{-1} T_6: Setright @ 600 kg ha^{-1} T_7: Setright @ 800 kg ha^{-1}. Pertaining to nutrient management practices treatment, the recommended dose of 125-62.5-50 was applied as per the Standard Package of practice for paddy by UAS, Bengaluru. Where in STCR approach, under mentioned fertilizer adjustment equation developed by AICRP on STCR, UAS, Bengaluru centre for southern dry zone (zone 6) was used.

$$FN = 4.703T-274.805\ SN\ (OC\ \%)-0.00141\ OM$$

$$FP_2O_5 = 1.636-0.256\ P_2O_5\ (\text{Olsen's } P_2O_5)\ -0.00077\ OM$$

$$FK_2O = 2.306T-0.494SK_2O\ (NH_4OAC\text{-}K_2O)-0.0014\ OM$$

Using the above fertilizer adjustment equation, the quantity of fertilizer nutrient required for achieving 50q ha^{-1} grain yield of paddy was worked out. The nutrient supplied by 10 t FYM was deducted from total quantity of fertilizer require for targeted yield. Fertilizer N, P_2O_5, K_2O applied for STCR treatment was 15.25:68:5.57 kg ha^{-1}. Required quantity of K fertilizer was very low hence 50 per cent of recommended dose was applied as per the AICRP on STCR rules.

With respect to nutrient management in SSNM, crop nutrient removal (N = 20.1 kg ton^{-1}, P_2O_5 = 11.2 kg ton^{-1}, K_2O = 30 kg ton^{-1}) for producing one ton of rice grain has taken as bench mark to fix the nutrient recommendation. The quantity of fertilizer nutrient required for achieving 50q ha^{-1} grain yield of paddy was worked out using mathematical formula (Nutrient requirement = targeted yield X crop nutrient removal per ton of production) for SSNM calculation. These procedures of fertilizer quantity were computed by keeping methodology given by Witt and Dobermann, 2002 as base reference. Fertilizer quantity calculated for SSNM treatment was 100.5:56:150 kg ha^{-1} of N, P_2O_5, and K_2O. Recommended dose of potassium as per SSNM approach was high so that 30 per cent less than the actual dose were applied. The amendments are applied 15 days advance in order to get good incubation.

Semi dwarf saline tolerant Paddy variety IR 30864 was transplanted after 32 days of sowing in nursery as test crop. All cultivation practices were carried as per the standard package of practice given by University of Agricultural Sciences Bangalore and representative soil samples from each treatment plot have taken after harvest of crop for chemical analysis. The soil samples were air dried ground to pass through 2mm sieve and stored for analysis. Chemical property of all plot samples were measured by standard methods. The pH of soil is estimated by potentiometric method in 1:2.5 Ratios as described by Jackson (1973). The same suspension was kept overnight, electrical conductivity of soil was measured in clear supernatant solution using conductivity bridge and results were expressed in terms of dS m^{-1} at 25 ^{0}C (Jackson, 1973). The Exchangeable sodium and cation exchange capacity of soils was determined by the procedure of Jackson (1973) and Richard (1954) respectively. Whereas exchangeable sodium percentage was computed by under mentioned formula,

$$ESP = \frac{\text{Exchangeable sodium}}{\text{Cation Exchange Capacity}} \times 100$$

The data collected from the experiment on different soil are subjected to statistical analysis as described by Gomez and Gomez (1984) and interpreted accordingly at 5% significance level.

RESULTS AND DISCUSSION

Initial properties of soil and characteristics of amendments

The soil of experimental site was purely alkaline in reaction with high pH of 8.96. The electrical conductivity, exchangeable sodium, CEC and exchangeable sodium percentage was 1.22 dS m^{-1}, 5.53 cmol/kg, 25 cmol (p+) kg^{-1} and 22.59% respectively. By this parameter, soil is classified as sodic soil. Amelioration process of sodic soil involves replacement of sodium ion with calcium ion. Total Calcium required to bring the sodic soil to normal soil was computed in term of gypsum requirement which was about 1.13 t/acre. There are three amendments were used viz., press mud having 5.60 cmol/kg of calcium, gypsum with 20.72 % of calcium and Mangala setright, a commercial product of 15.0% Calcium. (Table.1)

Table 1. Initial physico-chemical properties of soil and different amendments at experimental site

SN	Properties	Soil	Pressmud	Gypsum	Setright
1	Soil pH (1:2.5)	08.96	6.75	4.22	4.56
2	EC (1:2.5) (dS m^{-1})	01.22	4.20	2.62	1.65
3	Organic carbon (g kg^{-1})	08.00	2.73	ND	ND

4	CEC (cmol (p+) kg^{-1})	25.00	-	-	-
5	Exchangeable calcium (cmol kg^{-1})	12.62	5.60	20.70%	15.0%
6	Exchangeable magnesium (cmol kg^{-1})	02.50	-	-	-
7	Exchangeable sodium (cmol kg^{-1})	05.53	-	-	-
8	Exchangeable sodium percentage	22.59	-	-	-
9	Gypsum requirement (t $acre^{-1}$)	01.13	-	-	-

pH and EC

The soil pH was analyzed after harvest of paddy crop. There was ample change was observed due to application of various amendments (Table 2). The drastic reduction in pH was observed from 8.96 to 8.6 ranges due to different amendments. pH in no amendment control was 8.81 which decreased significantly to 8.68 due to application of setright @ 600 kg ha^{-1} but it was on par with treatment receiving pressmud @ 100 % GR and setright @ 400 Kg ha^{-1}(8.69 and 8.69 respectively). Further it reduced significantly to 8.50 on application of gypsum @ 100 % GR compared to all other treatments (Fig.1).

Table:2 Soil pH and electrical conductivity of soil as influenced by application of different amendments and nutrient management practices

Treatments	**pH**				**Electrical conductivity (dS m^{-1})**			
	M_1	**M_2**	**M_3**	**MEAN**	**M_1**	**M_2**	**M_3**	**MEAN**
T_1	8.71	8.91	8.80	8.81	0.99	0.87	0.80	0.89
T_2	8.40	8.55	8.56	8.50	0.91	1.12	1.12	1.05
T_3	8.68	8.76	8.64	8.69	0.73	0.77	0.86	0.79
T_4	8.78	8.90	8.84	8.84	0.85	0.92	0.86	0.88
T_5	8.69	8.77	8.60	8.69	0.91	0.75	0.75	0.81
T_6	8.61	8.56	8.85	8.68	0.61	0.79	0.82	0.74
T_7	8.72	8.85	8.65	8.74	0.82	0.89	0.79	0.83
MEAN	8.66	8.76	8.70		0.83	0.87	0.86	
	M	**T**	**M x T**		**M**	**T**	**M x T**	
S.Em±	0.06	0.04	0.07		0.05	0.04	0.07	
CD (p=0.05)	**NS**	**0.12**	**NS**		**NS**	**0.11**	**NS**	

Nutrient management practices: M_1: Recommended Dose of Fertilizer **M_2:** Soil Test Crop Response **M_3:** Site Specific Nutrient Management **Amendment Application: T_1:** No amendment control **T_2:** Gypsum @ 100% GR **T_3:** Pressmud @ 100% GR **T_4:** Setright @ 200 kg ha^{-1} **T_5:** Setright @ 400 kg ha^{-1} **T_6:** Setright @ 600 kg ha^{-1} **T_7:** Setright @ 800 kg ha^{-1}

The reduction in soil pH was attributed to displacement of exchangeable sodium by calcium ion (Mamoun *et.al.,* 2009, Dodd *et.al.,* 2013) which is present in amendments and subsequent formation of sodium sulphate which gets leached out of soil through drainage process. Similar decrease in soil pH from initial value of 9.38 to 7.80 by application of gypsum @ 100 % GR was observed by Santhosh and thiyageshwari (2018). Further Hoda, 2019 reported that application of gypsum at 10.2 ton.fed^{-1} decreased the pH of sodic soil to 7.2. Where in Archana and Jithendra (2014) observed that decrease in soil pH (8.8 to 7.6) due to application of pressmud applied at the rate of 200 t ha^{-1}. Beneficial effect of pressmud application in reduction of soil pH might be due to acidifying effect of organic and inorganic acids produced during the process of decomposition of organic amendments (Prapagar *et al.*, 2012) and also by supply of calcium on decomposition of organic matter which displaces the sodium as reported by Patel and Bhajan sing (1991). The higher reduction in soil pH with pressmud treatment may be also due to the presence of acidic compounds as the product is the outcome of sulphitation process from the sugar mill (Singh *et al.*, 2015). Liberation of CO_2 and organic acid during decomposition of pressmud which solubilized the native $CaCO_3$ and neutralized the sodicity as reported by Trilok *et al*. (2010) also caused the reduction of soil pH. Decrease in pH due to different nutrient management practices and interaction was not significant. Although considerable decrease in pH was found compared to pH of initial soil due to fertilizer application methods. Shreyasi et al., 2018 reported that considerable decrease in pH Due to balanced application of nutrient to 8.40 compared to control (8.44). These findings are evident that meager decrease in pH due to different Nutrient management treatment practices.

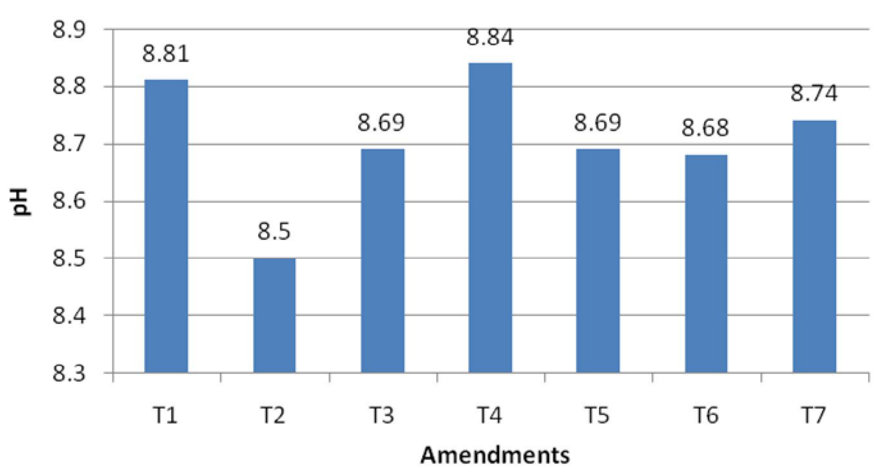

Fig 1: Soil pH as influenced by application of different amendments

Use of different amendments significantly decreased the EC of soil after harvest of the crop. Significant reduction in EC was maximum with application of setright @ 600 kg ha^{-1} (0.74 dS m^{-1}) followed by 0.79 dS m^{-1} in pressmud applied @ 100 % GR (Table2). Leaching of excess salt which are replaced by the calcium through drainage might be the reason for reduced EC in treated plots. Similar results were also observed by Veerendra and Mishra (2001); Negim, 2015 who reported that application of sulphitation pressmud decreased the EC of alkali soil and this finding will be evident for decrease in the EC in pressmud treated plot. While Patel and Bhajan Singh (1991) revealed that application of pressmud @ 25 % GR reduced the EC to 1.1 from 1.5 dS m^{-1}. He also suggested that application of gypsum @ 25 % GR reduced the EC to 1.00 dS m^{-1} this holds good for reduction of EC in setright as it considered as calcium source like gypsum. The effect of nutrient management alone and their interaction effect with amendments were not-significant. However lowest EC of 0.69 dS m^{-1} was recorded in RDF+Setright @600 kg /ha followed by pressmud @100% GR and SSNM+Mangala Setright @400 Kg/ha (0.73 dS m^{-1} and 0.75 dS m^{-1} Respectively).

Exchangeable Sodium, Cation Exchange Capacity (CEC) and Exchangeable Sodium Percentage

Exchangeable sodium in sodic soil, is such element which has disruptive action of clay particles in sodic soil (Wang *et al.,* 2014). The data on effect of amendments on exchangeable sodium after harvest of crop is presented in Table.3. Initial sodium content was 5.53 cmol kg^{-1} which reduced drastically due to application of amendments. The exchangeable sodium content in no amendment control was 3.69 cmol kg^{-1} which decreased significantly to 1.78 cmol kg^{-1} due to application of setright @ 400 kg ha^{-1} but it was on par with pressmud @ 100 % GR (1.85 cmol kg^{-1}). Mean while superior Decrease in sodium content was also recorded due to application gypsum @ 100 % GR (1.91 cmol kg^{-1}) which was on par to pressmud applied @ 100 % GR treatment and is significant compared to no amendment control. Whereas chemical nutrient application approaches alone did not produced significant effect on Exchangeable sodium content. But the interaction effect of both amendments and nutrient management was found significant. The significant reduction in sodium content (1.37 cmol kg^{-1}) was recorded due to SSNM + setright @ 400 kg ha^{-1} but found on par with treatment received RDF+ setright @ 400 kg ha^{-1} (1.58 cmol kg^{-1}) and RDF+ gypsum @100 % GR (1.69 cmol kg^{-1}) treatments. The reduction in sodium content due to leaching process of free sodium ion which comes into soil solution after displacement by calcium sourced by amendments or acids which produced during the process of decomposition of amendments mobilized the solubility of native calcium carbonate (Puttaswamygowda *et. al.*, 1973). This result is in accordance with that reported by Tejada *et al*., 2006; Mamoun *et al.*, 2009; Udayasoorian *et al*. 2009.

CEC of soil after harvest of crop (Table 3) did not show significant variation due to incorporation of different amendments. In spite very slight increase in CEC was found from 25 cmol (p+) kg^{-1} to approximate range of 26.00 to 27.50 cmol (p+) kg^{-1} in amended soil which is insignificant (Table.3). CEC values will vary according to soil particle, grain size, distribution, type and amount of different clay minerals present in soil (Matha and Prasad 2017) thus Change in CEC of soil occurs only when change in the quantity of clay separates. This may be the reason behind the non significant change CEC of soil, as used amendments are capable of change chemical property of soil.

Table 3. Exchangeable sodium, CEC and ESP of soil after harvest of crop as influenced by application of different amendments and nutrient management practices

Treatments	Sodium (cmol kg^{-1})				CEC (cmol (p+) kg^{-1})				ESP			
	M_1	M_2	M_3	MEAN	M_1	M_2	M_3	MEAN	M_1	M_2	M_3	MEAN
T_1	3.66	3.76	3.65	3.69	25.37	28.24	27.95	27.19	14.09	13.86	13.22	13.72
T_2	1.69	2.21	1.85	1.91	25.19	25.91	27.09	26.06	6.45	8.27	6.90	7.20
T_3	1.69	1.93	1.93	1.85	27.95	26.62	26.23	26.93	6.18	7.51	7.41	7.03
T_4	2.19	2.27	1.80	2.09	26.60	27.25	25.37	26.41	8.22	8.11	6.97	7.77
T_5	2.11	1.85	1.37	1.78	26.60	27.19	27.09	26.96	7.92	6.59	5.05	6.52
T_6	1.58	2.25	2.12	1.99	26.60	29.67	27.09	27.79	5.92	7.74	7.77	7.14
T_7	1.94	2.56	1.85	2.12	27.00	27.95	27.95	27.63	7.24	9.14	6.63	7.67
MEAN	2.12	2.40	2.08		26.47	27.55	26.97		8.00	8.75	7.71	
	M	**T**	**M x T**		**M**	**T**	**M x T**		**M**	**T**	**M x T**	

S.Em±	0.11	0.09	0.16		0.28	0.42	0.73		0.30	0.34	0.59	
CD (p=0.05)	**NS**	**0.26**	**0.45**		**NS**	**NS**	**NS**		**NS**	**0.98**	**1.69**	

Nutrient management practices: M_1: Recommended Dose of Fertilizer **M_2:** Soil Test Crop Response **M_3:** Site Specific Nutrient Management **Amendment Application: T_1:** No amendment control **T_2:** Gypsum @ 100% GR **T_3:** Pressmud @ 100% GR **T_4:** Setright @ 200 kg ha^{-1} **T_5:** Setright @ 400 kg ha^{-1} **T_6:** Setright @ 600 kg ha^{-1}

Exchangeable sodium percentage is prominent parameter to categories the sodic soil. In perusal of data from Table.3, Decrease in the ESP of soil was registered by application of different amendments and fertilization approaches. Application various amendments to sodic soil found significant over control (13.72). Gypsum applied at rate of 100 % GR reduced the ESP to 7.20 followed by 7.03 due to pressmud @ 100% GR incorporation. Further Application of setright @ 400 kg ha^{-1} found most favorable reduction in ESP of 6.52 compared to all other treatment. Among various level, setright @ 400 kg/ha was superior. Similarly the interaction between SSNM and setright 400 kg ha^{-1} recorded significant reduction in ESP (5.05) compared to most of other combinations followed by RDF+ setright 600 kg ha^{-1} (5.92). Whereas application of RDF+Gypsum @ 100% GR and RDF+ Press mud @ 100% GR (6.18 & 6.45 Respectively) found significant over control + nutrient management approaches but are on par to each other. The reduction in ESP due to different nutrient management practice found non significant however lowest value was in SSNM (7.71) treatment. Similar results were also observed by The reduction in ESP due to application of amendments followed by natural leaching may be attributed to replacement of Na from exchange site and its removal for the soil through leaching (Mamoun *et al.*, 2009). Gyspum and setright contains calcium as major chemical constituent and remarkable reduction in ESP in Gypsum and setright treatment may be due to in providing Ca^{2+} cation to replace the exchangeable Na^+ on the exchange sites as observed by Sharma and Minhas (2005) and Saied *et al*, (2017) with consequent leaching of sodium salt. In contrast to this the findings of Choudhary *et al.*, 2004, evident that, addition of pressmud with gypsum decreased the ESP of the sodic and sodic saline soil. Thrilok *et al*. (2010). By their investigation reported that, application of gypsum and pressmud reduced the ESP of soil to 14 and 28 respectively from 55 in control. Similarly, Shaimaa *et al*, (2012) observed that reduction in ESP of soil due to application of gypsum along with Zinc from 16.53 to 12.53. These results are also in conformity with findings of Archana singh and Jithendra Kuma, (2014).

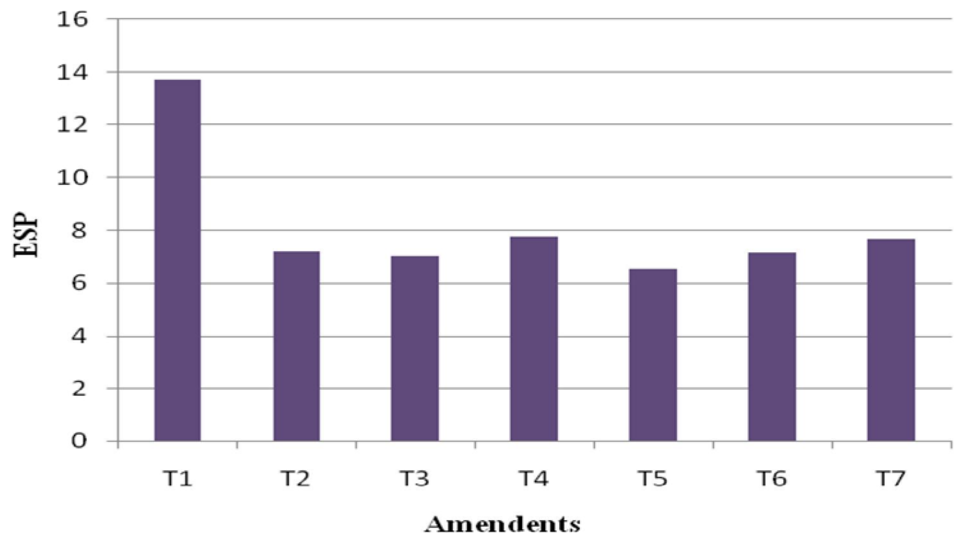

Fig 2. Effcet of different amendments on ESP of soil

Grain and Straw Yield

Perusal of data presented in Table 4 revealed that application of RDF (125:62.5:50 kg $N:P_2O_5:K_2O$ ha^{-1}) recorded significantly higher grain yield of 2.27 t ha^{-1} compared to application of fertilizers on STCR basis (2.14 t ha^{-1}) and SSNM (2.11 t ha^{-1}). However, the significantly higher straw yield of paddy (5.78 t ha^{-1}) was recorded in the treatment receiving nutrients on SSNM approach followed by RDF and STCR treatments. Among these treatment RDF treatment got high Nitrogen application compared to other two. It is well known fact that N is required for growth of plants, tillering and chlorophyll synthesis, which in turn resulted in higher grain yield. It was also observed by many workers that higher N level is required for better growth and yield of rice grown in salt affected soil than the rice grown under normal soils (125 kg v/s 100 kg N ha^{-1}). Similar results are obtained by Yaduvanshi and Chhipa (2007) who reported that application of nitrogen @ 120 kg ha^{-1} increased the yield than applied @ 90 kg ha^{-1} and Pandey *et al*., 2013 reported that application of RDF produced significant superior grain and straw yield of paddy (29.52 and 41.77 q/ha respectively) over control in sodic soil. Similarly significant rice yield of 5.52 t/ha in paddy with treatment of RDF (120:26:42) was also reported by Choudhary and Yaduvanshi 2016. The difference in yield between three nutrient management practices are not far, thus STCR and SSNM can be also employed to get economical yield in paddy.

Table 4. Grain Straw yield of paddy crop as influenced by application of different amendments and nutrient management practices

Treatments	Grain yield (t ha^{-1})				Straw yield (t ha^{-1})			
	M_1	M_2	M_3	MEAN	M_1	M_2	M_3	MEAN
T_1	1.18	1.15	1.36	1.23	2.90	3.60	4.63	3.71
T_2	2.15	2.22	2.28	2.21	6.13	4.73	5.83	5.57
T_3	2.93	2.45	2.40	2.59	6.23	5.57	6.33	6.04
T_4	2.35	2.08	1.85	2.10	4.83	5.43	5.57	5.28

T_5	2.14	2.76	2.47	2.46	5.60	6.20	5.93	5.91
T_6	2.90	2.21	2.17	2.43	5.40	5.53	6.23	5.72
T_7	2.27	2.17	2.27	2.23	5.47	5.50	5.95	5.64
MEAN	2.27	2.15	2.11		5.22	5.22	5.78	
	M	**T**	**M x T**		**M**	**T**	**M x T**	
S.Em±	0.03	0.06	0.11		0.09	0.18	0.32	
CD (p=0.05)	**0.13**	**0.18**	**0.30**		**0.35**	**0.52**	**0.91**	

Nutrient management practices: M_1: Recommended Dose of Fertilizer **M_2:** Soil Test Crop Response **M_3:** Site Specific Nutrient Management **Amendment Application: T_1:** No amendment control **T_2:** Gypsum @ 100% GR **T_3:** Pressmud @ 100% GR **T_4:** Setright @ 200 kg ha^{-1} **T_5:** Setright @ 400 kg ha^{-1} **T_6:** Setright @ 600 kg ha^{-1}

The grain yield of paddy in control was 1.23 t ha^{-1} which increased significantly to 2.59 t ha^{-1} due to application of pressmud @ 100 % GR but it was statistically at par with those recorded in T_5 and T_6 (2.46 and 2.43 t ha^{-1}, respectively). However grain yield recorded in T_2, T_4 and T_7 (2.21, 2.09 and 2.23 t ha^{-1}, respectively) was significantly lower than that recorded with application of pressmud @ 100 % GR. Significantly higher grain and straw yield in this treatment is probably due to addition of more plant nutrients as compared to gypsum and setright (Patel and Bajan singh, 1991). Lower grain yield in gypsum amended treatment might be attributed to increase in EC as indicated by Table.2 due to addition of calcium sulphate. Apart from this, The low grain yield obtained in control plot clearly demonstrates the effect of excess sodium on exchange complex on yield, while significantly higher grain yield was obtained with amendments (2.09 to 2.59 t ha^{-1}) might be attributed to decrease in pH and ESP of sodic soil upon incorporation of amendments, which might have helped in better nutrient utilization by crop. The low yield of paddy crop in control might be attributed to poor growth and yield parameters suggests that although the available nutrients status of soil is medium to high (medium in N and P and high in K), plants are not able to utilize the nutrients efficiently because poor root environment due to higher ESP (Garg and Malhotra, 2008). Similar low yield of paddy grown in unamended sodic soils have been documented by Suwiphaporn *et al*. (2014) However, Lal Bahadur *et al*, 2013, Kumar and Sharma (2009) Reina *et al*., 2022, Pavani et al., 2019 recorded higher yield due to application of amendments in sodic soils.

The interaction of amendments application and nutrient management practices had significant effect on grain and straw yield of paddy. The highest grain yield of 2.92 t ha^{-1} was registered due to RDF + pressmud @ 100 % GR but it was on par with RDF + setright @ 600 kg ha^{-1} (2.89 t ha^{-1}). Similarly, significantly higher straw yield of 6.33 t ha^{-1} was recorded due to application of nutrients on SSNM approach + pressmud @ 100 % GR. The higher yield may be attributed to improvement in soil properties due to addition of pressmud followed by application of nutrients. The improved availability of nutrients and improvement in sodicity enhanced the growth and yield parameters of paddy (Parvender *et al*., 2021), as result of improvement in these parameters higher grain and straw yield was recorded due to application of pressmud @ 100 % GR or setright @ 600 kg ha^{-1} along with RDF.

CONCLUSION

Investigation revealed that application of different amendments considerably decreased the pH Exchangeable sodium and ESP of soil compared to control. Application of pressmud and Mangala setright showed superior in reclamation process with successful reduction of sodicity of soil. As application of pressmud require in bulk and large quantity, mangala setright will be a good alternate option to bring the sodic soil to normal condition. In concern to different levels of managla setright 400 kg per hectare sufficient to bring down the soil sodicity and to support the good growth of the crop. If cultivation is organic in sodic soil, pressmud can be used effectively as it is prominent in reclamation of sodic soil as well as provide some amount of nutrients for growth and development of crop upon decomposition. Among interaction of nutrient with amendments RDF+Setright and SSNM+ Setright application had remarkable effect on reduction in sodicity. The different Fertilizer recommendation system such as SSNM and STCR are also works well under sodic environment in uplifting the paddy yield. Thus STCR and SSNM approaches can be used effectively in nutrient management system under sodic soil as these approaches precisely use the specific recommendations per growing site which intern reduce the cost of cultivation.

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