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Amelioration of alkaline soil using amendments in tail end reach of VC canal in Cauvery command area of Karnataka

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Abstract
Areas of tail end of Visveswaraya Canal area indicated that soils are sandy clay in nature, alkaline in reaction (pH 7.61-8.20) with EC in the range between 0.43 and 1.1 dS/m. Soils were low organic carbon, medium nitrogen, high phosphorus, low potassium, high calcium, magnesium, sulphur and micronutrients. Sodium ion ranged between 0.85-0.98 and exchangeable sodium percentage (ESP) 4.40-6.10.
Field experiment were conducted during *kharif* season 2017 at farmers field in Hemmnahalli village, Maddur taluk, Mandya district to assess the growth and yield response to organic and inorganic amendments to alkaline soil. The experiment were laid out in a randomized complete block design with nine treatment combinations and replicated thrice. The results revealed that the application of 100% NPK+ Green manure+ $ZnSO_4$+ Gypsum+ FYM recorded significantly higher grain (6266 kg/ha) and straw (6892 kg/ha) yield of rice, nutrient content and uptake as compared to other treatment. Further higher primary, secondary and micronutrient status in soil and decreased pH, EC, Na and ESP were recorded in the same treatment.
The study clearly showed that in alkaline soils, application of 100% NPK+ Green manure+ $ZnSO_4$+ Gypsum+ FYM is more beneficial in enhancing the crop yield, crop productivity as well as fertility of the soil.

Keywords: Alkaline soil, gypsum, green manure, paddy, FYM

Introduction
The world's population is continuously rising and the current projections indicate that the population is likely to increase from 6.9 billion people to 9.1 billion by 2050. As a result world food demand will surge and it is projected that food production will increase by 70 per cent in the world and 100 per cent in the developing countries. But intensive cultivation and irrigations are posing a threat to land and water resources, causing soil degradation. Soil alkalinity is a condition that results from the accumulation of soluble salts in the soil. The chief minerals in irrigation water are chloride, sulfate, bicarbonate, sodium, calcium, and magnesium. These minerals, present in the irrigation water, accumulates in the soil and cause problems. Sodium, bicarbonates, and chlorides are the three minerals that contribute most to soil salinity and alkalinity.
About 831 m ha of land in the world is under soil salinity and alkalinity, of which 397 m ha is under salinity and 434 m ha under alkalinity (Martinez-Beltran and Manzur, 2005). In India, the salt affected area in the country as reported by Sharma (1998) was 7.42 m ha (soil salinity plus alkalinity) of which 0.179 m ha area is in Karnataka. Gypsum applied to the soil surface increases the electrolyte concentration of the infiltrating water and compresses the electric double layer and providing Ca to the exchange complex, where it has selectivity over Mg and Na in most soils (Dontsova and Norton, 2002) [4].

Material and Methods
The study was conducted during *kharif* season 2017 at farmer's field in Hemmanahalli village, Maddur taluk, Mandya district, and situated at 12° 36' North latitude 77° 4' East longitude and at an altitude of 662 meters above mean sea level, located in Southern Dry Zone of Karnataka. The test crop was paddy with variety GNV-1089, the experiment were laid out in a randomized complete block design (RCBD) with nine treatment combination replicated thrice. The treatments were T_1= 100% NPK +FYM (POP), T_2= 100% NPK+ Green Manure,

T_3 =50% NPK + Green Manure, T_4= 100% NPK + Green Manure+ZnSO4, T_5= 50% NPK + Green Manure +$ZnSO_4$, T_6= 100%NPK + Green Manure+$ZnSO_4$+Gypsum, T_7= 50%NPK + Green Manure+$ZnSO_4$+Gypsum, T_8= 100%NPK + Green Manure+$ZnSO_4$+Gypsum+FYM, T_9= 50%NPK + Green Manure+$ZnSO_4$+Gypsum+FYM.

The effect of application of FYM, $ZnSO_4$ and Gypsum on physical and chemical properties of soil was determined for the samples collected after the harvest of the crop. Soil samples collected from each plot were air dried, passed through 2 mm sized sieve and analyzed for physical and chemical properties by adopting standard chemical analytical methods.

Yield parameters like grain and straw yield were recorded. Grains were separated by threshing the produce obtained from each plot and sun dried, winnowed and weighed. Grain yield per hectare was worked out from the grain yield per plot and expressed in quintal per hectare and Straw obtained from each plot was dried under the sun for ten days, weighed and expressed in quintal per hectare at harvest of the crop.

Statistical analysis: The analyses and interpretation of the data was done using the Fisher's method of analysis and variance technique as given by Panse and Sukhatme (1967) [6]. The level of significance used in 'F' and 't' test was 5 per cent probability and wherever 'F' test was found significant, the 't' test was performed to estimate critical differences among various treatment.

Results and Discussion

The soil of the experimental site was alkaline in soil reaction (pH of 8.2), non-saline (EC 1.1 dS m^{-1}) with organic carbon content of 3.0 g $kg^{-1}$and CEC 14.3 cmol (p^+) kg^{-1} with respect to available nutrient status soil were low in available N (313.6 kg ha^{-1}), high in available P (211.42 kg ha^{-1}) and medium in available K (123.78 kg ha^{-1}) status. Exchangeable Ca [12.82 cmol (p^+) kg^{-1}], Exchangeable Mg [3.89 cmol (p^+) kg^{-1}], Exchangeable Na (0.98 cmol (p^+) kg^{-1}), Available S (10.76 mg kg^{-1}). Available Fe, Mn, Cu, Zn and B contents were present in an appreciable amounts of 0.51, 9.99, 3.17, 1.04 and 0.51 mg kg^{-1}, respectively. The HCO_3^{-2} (531.7ppm), Cl^- (810.1 ppm), ESP (6.10) and CO_3 (ppm) in the soil sample was not detected (Table 1).

Effect of organic and inorganic amendments on nutrient status of the soil.

The application of 100% NPK+ Green manure+ $ZnSO_4$+ Gypsum+ FYM decreased the soil pH (7.61) reduction in pH from the initial value of 10.2 due to application of gypsum along with farm yard manure and green manure was observed by Anand Swarup (1991) [1] in sodic soils of Karnal., EC (0.43 dS m^{-1}) Prapagar *et al.*, (2012) [8] suggested that the decrease in EC of soil was resulted from the addition of organic matter and leaching of excessive ions by improving soil physical properties. and increase in the organic carbon and cation exchange capacity (CEC) (Table 2) Bellakki *et al*. (1997) [3] concluded that continuous application of organic manure increase the organic carbon content, CEC as well as exchangeable calcium in sodic soil.

Decrease in the salt content like Na, ESP. Anand Swarup (1991) [1] studied the effects of gypsum with green manure and farmyard manure on nutrition of rice in a sodic soil and found that the combination of gypsum with GM and FYM reduced the Na and ESP (Table 3). Cl^-, HCO_3^{-2} (Table 3) Patagundi *et al*. (1996) [7] who opinioned that calcite, and carbonate minerals from rocks and soils was dissolved in percolating water due to the presence of CO_2 in solution, thus adding to the total HCO_3^- in solution. Dissolved CO_2 becomes hydrated to form carbonic acid (H_2CO_3), which undergoes two stages of dissociation, producing HCO_3^- and then CO_3^{2-}.

Increase in the major and secondary nutrient status of the soil (Table 4). The addition of gypsum brought about remarkable improvement in physico-chemical properties of soil which increased the mineralization of native as well as applied nitrogen which brought about a considerable increased in nitrogen content in soil Maurya *et al*. (2009) [5]. The higher phosphorus at surface of the soil was mainly due to higher organic matter content of soil which helps in solubility of fixed phosphorus and acidulation in salt affected soils (Basavaraja, 2006 and Sunitha, 2008) [2, 12]. Surendra Singh *et al*. (2002) [13] also reported that favorable effect of incorporating FYM and green manuring in sodic soil in increasing the available potassium.

Application of gypsum might also have resulted in higher dissolution of free $CaCO_3$, thus increasing the calcium on exchange sites (due to its divalent nature, preferentially adsorption on clay surface). The acidic nature of gypsum might have solubilized the native free lime which released Ca+Mg in free ionic forms which in turn contributed for increased Ca+Mg on exchange sites with the replacement of exchangeable sodium. Similar observations were made by Sunitha (2008) [12] and Srinivasa (1999) [11]. The application of gypsum added sulphate to the soil, in addition to improving the soil condition, which resulted in mineralization of the native as well as applied nutrients (Sunitha, 2008) [12].

Increase in the micronutrient status of the soil after the harvest of the crop (Table 5). Increase in the micronutrient availability was also due to microbial decomposition of organic manures with simultaneous release of organic acid which might have favored the availability of micronutrients in soil and their uptake by soybean. This may be due to faster decomposition of organic manures as results of narrowing of C:N ratio with the combined application of both organic and inorganic sources of nutrients. These results are in support with the findings of Sakal *et al.* (1993) [9].

Effect of organic and inorganic amendments on yield parameters

The increased grain and straw yield attributes in paddy might be due to the combined application of gypsum and FYM along with RDF which might have enhanced the soil physical properties and better dissolution of nutrient element which favoured increasing in the yield attributes. In addition, a better supplementation of nutrient from organic and inorganic amendments might have increases the cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency and increased nutrient absorption by increased root activity leading to better growth and development of the crop, increased fertile panicles, number of grains per panicle and test weight and all this led to increased grain and straw yield of the crop Sharma and Yadav (1986) [10] (Table 6).

Table 1: Initial physico-chemical properties of the experimental site

Physical parameters	
Sand sized particles (%)	47.18
Silt sized particles (%)	15.33
Clay sized particles (%)	36.49
Texture	Sandy Clay
Bulk density (Mg m^{-3})	1.45
MWHC (%)	32.67
Chemical parameters	
pH (1:2.5 Soil water suspension)	8.2
Electrical conductivity (dS m^{-1})	1.1
Organic carbon (g kg^{-1})	3.0
Available Nitrogen (kg ha^{-1})	313.6
Available Phosphorus (kg ha^{-1})	211.42
Available Potassium (kg ha^{-1})	123.78
Exchangeable Calcium [cmol (p^+) kg^{-1}]	12.82
Exchangeable Magnesium [cmol (p^+) kg^{-1}]	3.89
Exchangeable Sodium (ppm)	0.98
CEC (cmol (p+) kg^{-1})	14.3
Available Sulphur (mg kg^{-1})	10.76
DTPA-Iron (mg kg^{-1})	0.51
DTPA- Manganese (mg kg^{-1})	9.99
DTPA- Copper (mg kg^{-1})	3.17
DTPA-Zinc (mg kg^{-1})	1.04
Boron (mg kg^{-1})	0.51
CO_3 (ppm)	ND
HCO_3^{-2}(ppm)	531.7
Cl^-(ppm)	810.1
ESP	6.10

Table 2: Effect of organic and inorganic amendments on chemical properties of soil after harvest of paddy

Treatments	**pH**	**EC (dS m^{-1})**	**OC (g kg^{-1})**	**CEC (cmol (p^+) kg^{-1})**
T_1	7.85	0.66	5.9	17.07
T_2	7.80	0.67	5.7	18.50
T_3	7.89	0.66	6.6	18.87
T_4	7.83	0.62	5.1	18.97
T_5	7.88	0.64	5.9	20.00
T_6	7.76	0.44	6.5	19.60
T_7	7.76	0.43	5.6	21.27
T_8	7.61	0.44	7.5	23.87
T_9	7.74	0.46	6.6	21.33
S. Em±	0.04	0.01	0.26	0.84
C. D. at 5%	0.14	0.05	0.90	2.55

Table 3: Effect of organic and inorganic amendments on Sodium, Exchangeable Sodium Percentage, Chlorides and Bicabronates of soil after harvest of paddy

Treatments	**Exch. Na (cmol (p^+) kg^{-1})**	**ESP**	**Cl^-**	**HCO_3^{-2}**
			(ppm)	
T_1	0.89	4.50	725.94	464.33
T_2	0.91	4.56	769.07	476.00
T_3	0.89	4.82	731.24	484.00
T_4	0.91	4.58	750.44	470.67
T_5	0.97	4.69	759.44	488.67
T_6	0.87	4.44	722.67	451.00
T_7	0.88	4.37	723.74	462.00
T_8	0.85	4.34	706.55	450.00
T_9	0.86	4.30	716.01	450.67
S. Em±	0.01	0.068	10.551	10.866
C. D. at 5%	0.04	0.203	31.632	32.577

Table 4: Effect of organic and inorganic amendments on available nutrient status of soil after harvest of paddy

Treatments	**Available N**	**Available P_2O_5**	**Available- K_2O**	**Exch. Ca**	**Exch. Mg**	**Available-S (mg kg^{-1})**
	(kg ha^{-1})			**(cmol (p^+) kg^{-1})**		
T_1	234.50	144.37	207.67	16.10	5.47	15.19
T_2	353.44	165.04	224.62	16.47	4.43	14.33
T_3	318.13	175.39	216.91	16.33	4.23	14.61
T_4	334.50	153.53	227.04	16.30	4.33	15.26

T_5	253.44	226.46	217.22	16.57	4.50	15.24
T_6	338.47	240.11	236.05	16.77	5.30	15.66
T_7	334.36	161.97	229.71	16.70	5.43	15.52
T_8	432.55	276.41	276.84	17.53	5.63	15.82
T_9	355.43	273.86	269.40	17.43	5.57	15.70
S. Em±	25.70	16.836	6.23	0.12	0.12	0.08
C. D. at 5%	78.13	50.474	18.69	0.38	0.37	0.26

Table 5: Effect of organic and inorganic amendments on available micronutrient content of soil after harvest of paddy

Treatments	DTPA-Fe	DTPA-Cu	DTPA-Zn	DTPA-Mn	Hot water –B
	(mg kg^{-1})				
T_1	1.16	2.42	1.31	26.77	0.43
T_2	1.24	2.94	1.44	30.94	0.48
T_3	1.26	3.29	1.50	33.07	0.46
T_4	1.20	3.02	1.71	30.05	0.47
T_5	1.17	2.96	1.65	28.13	0.45
T_6	1.20	3.28	1.95	35.65	0.43
T_7	1.17	3.00	1.62	27.19	0.43
T_8	1.42	3.57	2.58	43.64	0.42
T_9	1.26	3.48	2.52	36.78	0.42
S. Em±	0.04	0.16	0.33	2.71	0.009
C. D. at 5%	NS	0.48	0.98	8.12	0.028

Table 6: Effect of organic and inorganic amendments on grain yield, straw yield and harvest index of paddy

Treatments	Grain yield	Straw yield	Harvest Index
	(kg ha^{-1})		
T_1	3953	4348	0.46
T_2	4949	5444	0.47
T_3	4550	5005	0.46
T_4	5206	5727	0.47
T_5	5084	5592	0.47
T_6	5014	5516	0.47
T_7	5023	5525	0.47
T_8	6266	6892	0.47
T_9	6238	6862	0.47
S. Em±	322.1	354.3	0.003
C. D. at 5%	965.7	1062.3	0.01

Conclusion

The treatment imposed of 100% NPK + Green manure + $ZnSO_4$ + Gypsum + FYM significantly improved and yield of rice and significant improvement of N, P, K, Ca, Mg, S and Fe, Zn, Cu, Mn and B status in the soil and also improved OC, pH, EC, ESP, Cl^{l-1}, HCO_3^{-2}Na as compared to 100% NPK + FYM (POP).

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