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Impact of crop residues, green manuring and gypsum on nutrient status in salt affected purna valley soils

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Abstract
The field experiments on cotton were conducted on selected farmers' fields in Purna valley during 2013-14.The treatments comprised of five different green manures, two crop residues, gypsum and control. There were nine treatments replicated on three farmers' fields. The design of experiment was randomized block design, replicated three times, where one farmer was treated as one replication. Salt affected soils limit crop yields around the world. Knowledge of how nutrient availability is affected in plants growing on salt affected soils is important in adopting appropriate management practices to satisfy plants' nutritional requirements and improve yields to meet food demands of increasing world populations. In the salt affected environment plants required to absorb essential nutrients from a dilute source in the presence of highly concentrated nonessential nutrients. Nutrient uptake and use efficiency in salt affected soils is low due to salt stress and negative interactions with cations and anions present in high concentrations. Hence, a higher amount of nutrients is necessary in salt affected soils compared to normal soils. So in these view our treatments were found beneficial as that of gypsum in physical properties of the soils in addition to gradual chemical amelioration. Although considerable improvement in chemical properties has been observed under gypsum indicating reduction in pH from the average initial of 8.31 to 8.19 and ESP from average initial of 11.15 to 7.12, but simultaneously the significant reduction has also been observed under organic amendments like dhaincha and sunhemp. Similarly significantly highest available soil N status was recorded in dhaincha *in situ* green manuring. However, the use of crop residues and green manures have shown relatively more available N status, which was superior over gypsum. In same manner of crop resiues and green manuring increased the available P and under organic amendments average available K status of 439.9 kg ha^{-1} over average initial value of 393.2 kg ha^{-}. The organic amendments showed their potential not only for slow reclamation but also for improvement in characteristics of sodic soils. The organic amendments like dhaincha and sunhemp were found equally beneficial for obtaining crop yields as that of gypsum besides gradual soil reclamation.

Keywords: Gypsum, dhaincha, sunhemp, Reclamation

Introduction
Salt affected soils can be defined as those soils that have been adversely modified for the growth of most crop plants by the presence of soluble salts. Common ions contributing to this problem are Ca2+, Mg^{2+}, Cl^{-}, Na^{+}, sulfate ($SO^{2-}{}_4$), bicarbonate (HCO^{-3}) and in somecases K^{+} and nitrate (NO^{3}) (Bernstein, 1975). Salt affected soils limit crop production around the world. Civilizations have been destroyed by the encroachment of salinity on the soils, and a result is vast areas of the land being rendered unfit for agriculture. Salt affected soils are found in many regions of the world. Salt affected soils normally occur in arid and semiarid regions where rainfall is insufficient to leach salts from the root zone. Salt problems, however, are not restricted to arid or semiarid regions. They can develop even in sub humid and humid regions under appropriate conditions (Bohn *et al.*, 1979) [2]. In addition, these soils may also occur in coastal areas subject to tides. Salts generally originate from native soil and irrigation water. Roughly 263 million hectares are irrigated area worldwide and in most of that area salinity is a growing threat (Epstein and Bloom, 2005) [4]. This are represents about 19% of the total area of the world under crop production. Use of inappropriate levels of fertilizers with inadequate management practices can create saline conditions even in humid conditions. In the salt affected environment there is a preponderance of nonessential elements over essential elements. In the salt affected soils, plants must absorb the essential nutrients from a diluted source in the presence of highly.

Out of 329 million hectares of total geographical area in our country, the arid and semi-arid zones occupy more than one-third of the area (127.4 m ha). The salt affected soils occurring in these zones occupy 12 m ha spread over in 15 states of the country. These salt affected soils comprise of 4.12 m ha of alkali soil, 3.26 m ha of saline soil and 4.62 m ha of saline alkali soils. Among these salt affected soils, alkali soils are found to be highly problematic for crop production because of very poor physical and chemical environment particularly in irrigated areas. Sodicity problem in irrigated agriculture is becoming more and more serious because of faulty methods of irrigation, intensive cultivation of high water requirement crops, use of poor quality water, lack of adequate knowledge about soils and poor management practices. The amelioration of these alkali soils is not only expensive but also time consuming and laborious. (Gupta *et al*., 1995) [6].

The Purna valley is the unique tract of Vertisols in Vidarbha region (M.S.) of India having combination of three fold problems, the native salinity, poor drainability and poor quality of ground water. The unique features of the salt affected soils of Purna valley is that though the salinity and sodicity is widely reported in this tract the presence of salt on surface is hardly seen. These soils are mainly derived from the basaltic alluvium and have clay texture with smectitic clay mineralogy. They have high swell-shrink potential, slow permeability with very low hydraulic conductivity and poor drainage conditions. Taxonomically these salt affected soils are classified as Sodic Haplusterts and Sodic Calciusterts (Padole *et al*., 1998) [11]

Material and Methods

The experiment was carried out to study the effect of crop residues, green manuring and gypsum on soil properties and yield of cotton in salt affected soils of Purna valley in Vidarbha on farmers' fields in Kutasa village during 2013 - 14. Which is 32km from Akola, 19 km from Akot and 20 km from Daryapur. The Kutasa village lies about 10 km away from the Purna river. The materials used and methods adopted are discussed in this chapter under the following heads. The exploratory borehole data indicated the basement (Deccan basalt) to be an uneven platform sloping northerly or west northwesterly towards depressed region of Akot and Bawanbir. The upper cover of the alluvial deposit comprises three lithostratigraphic formations (Tiwari and Mukhopadhyay, 1989), which is decreasing in order of the antiquity are the virual formation, the kural formation and the Purna formation. The virual formation forms morphostratigraphic units referable to the older and the younger (present) alluvium deposits, while the Purna formation is observed only in the bank formation observed only in the bank sections. The virual formation is overlain by either the kural formation or the Purna formation with an erosional unconformity. Cotton was grown in kharif and green manuring crops were sown in between two rows of cotton which are buried subsequently in soil. The cotton stalk residues were decomposed using decomposing culture and applied to the soil before sowing. The crop residues available on farm viz., pigeon pea, soybean, sorghum stubbles and chickpea residues were utilized as biomulch. Gypsum application was made to the respective treatment plots uniformly by mixing in the top ten centimeter layer. The crop residues from the crops were incorporated into soil of respective treatments after harvest of the crops so as to ascertain their residual effect. The soil of the experimental field comprised of clayey montmorillonitic, deep with soil order Vertisols.

Table 1: Treatment details.

Treatment No.	Cotton	Greengram-Chickpea
T1	No residue No green manure (Control)	Residual effect
T2	Sunhemp in situ green manuring	Residual effect
T3	Dhaincha in situ green manuring	Residual effect
T4	Leucaenaloppings green leaf manuring	Residual effect
T5	Cow pea in situ green manuring	Residual effect
T6	Green gram in situ green manuring	Residual effect
T7	Cotton stalk residue composted with PDKV decomposer	Residual effect
T8	Mulching with farm waste with PDKV decomposer	Residual effect
T9	Gypsum @ 2.5 t/ha	Residual effect

Table 2: Classification of Salt Affected Soils:

Class	ECe	ESP	PH	Local Names
Saline soil	>4	<15	<8.5	Thur, Vippu, Lona, Soula, Khama and Kari
Saline Alkali Soil	>4	15	Variable	Usar, Kallar, Kari, Chopan, Bari, Reh, Choudv, Kshar and Fougu.
Alkali Soils	<4	>15	> 8.5	Usar, Rakkar

Methods Adopted

Collection of plot wise soil samples of the experimental sites before sowing in kharif and Collection of plot wise soil samples (0 - 20 cm depth) after harvest of cotton was carried out. Analysis of soil for physical and chemical properties has been carried out. Soil bulk density was determined by clod coating technique as described by Blake and Hartge (1986) [3]. Hydraulic conductivity was determined by constant head method as described by Klute and Dirksen (1986) [9]. Hydrogen ion activity expressed as pH is determined by potentiometry using 1:2 soil water suspension (Jackson, 1973) [8]. The clear water supernatant obtained from the suspension used for pH was utilized for the EC measurement using conductivity bridge (Jackson, 1973) [8]. Available N, P, K alkaline permanganate method as described by Subbiah and Asija (1956) [14]. Olsen's method as described by Watanabe and Olsen using 0.5 M sodium bicarbonate pH (8.5) as an extractant. Darco-G-60 soluble phosphorus was used to absorb the dispersed organic matter and make the filtrate colourless for further colorimetric analysis. (Watanabe and Olsen, 1965) [16]. Flamephotometer using neutral N ammonium acetate (pH 7.0) as an extractants described by Hanway and Heidel (1952) [7], respectively.

Fertilizer Application

The nitrogen, phosphorus and potassium nutrients were applied through fertilizers viz. urea, single super phosphate (SSP) and Muriate of potash. The recommended dose of NPK for cotton was 60:30:30 NPK kg ha^{-1}.The half of the dose of N and full dose of P and K was applied at the time of sowing and remaining half dose of N was applied at flowering to cotton.

Statistical analysis

The data on different parameters were tabulated and analyzed statistically by the methods described by Panse and Sukhatme (1971) [12].

Table 3: Initial physical and chemical properties of soil (2011-12).

Sr. No.	Particulars	Site-I	Site-II	Site-III
A	Physical properties			
1	Hydraulic conductivity (cm h-1)	0.58	0.53	0.49
2	BD (Mg m-3)	1.63	1.62	1.63
B	Chemical properties			
1	pH (1:2)	8.27	8.32	8.34
2	EC (1:2 dS m-1)	0.20	0.22	0.25
3	Organic carbon (g kg-1)	5.43	5.71	5.23
4	CaCO3 (%)	10.29	10.60	9.67
5	Exchangeable cations (cmol(p+)kg-1)			
	Ca	27.60	28.0	27.40
	Mg	16.0	16.0	16.4
	Na	6.0	5.91	5.82
	K	0.95	0.92	0.98
6	CEC (cmol(p+)kg-1)	53.47	53.04	52.17
7	ESP	11.22	11.14	10.39
8	Base saturation (%)	94.53	95.83	96.99
C	Saturation paste extract analysis			
9	pHs	8.24	8.26	8.29
10	ECe (dS m-1)	1.05	1.12	1.01
11	Soluble cations			
	Ca2+ (me L-1)	2.8	3.0	2.6
	Mg2+ (me L-1)	3.8	4.0	4.8
	Na+ (me L-1)	4.5	4.7	5.1
	K+ (me L-1)	0.58	0.53	0.56
12	Soluble anions			
	$CO3^{-2}$ (me L-1	----	-----	-----
	HCO3-(me L-1)	7.5	5.0	8.0
	SO4 2-(me L-1)	4.98	4.51	4.36
	Cl-(me L-1)	2.0	1.2	0.8

Resultsand Discussions

Available nitrogen

The available *nitrogen* as influenced by various treatments was found to be significant. The significantly highest available N (274.8kg ha^{-1}) was observed under the treatment receiving dhaincha green manuring followed by green manuring with sunhemp (262.8 kg ha^{-1}) which were found on par with each other. The application of various green manuring and crop residues recorded significantly higher available nitrogen over control. The lowest available N was recorded in control application.

Table 4: Available nitrogen as influenced by various treatments

Tr. No.	Treatment		Available N (kg ha^{-1})
	Cotton	**Green gram-Chickpea**	
T1	Control (No residue No green manure)	Residual effect	215.0
T2	Sunhemp *in situ* green manuring	Residual effect	262.8
T3	Dhaincha *in situ* green manuring	Residual effect	274.8
T4	Leucaena loppings green leaf manuring	Residual effect	247.9
T5	Cow pea *in situ* green manuring	Residual effect	248.3
T6	Green gram *in situ* green manuring	Residual effect	255.4
T7	Composted cotton stalk residue	Residual effect	246.4
T8	Biomulch (Mulching with farm waste)	Residual effect	258.3
T9	Gypsum @ 2.5 t ha^{-1}	Residual effect	240.4
	SE (m) ±		3.7
	CD at 5 %		11.1
	Initial (2011-12)		200.0

The increase in the treatment of green manure and crop residue is also recorded over the use of gypsum (T9) indicating that although gypsum is useful for soil reclamation green manure and crop residues in spite of their slow reclamation they have potential for improving soil fertility simultaneously. The results thus revealed that the organics with low C: N ratio reported to accumulate more N in soil. Application of green manure and FYM along with 100% NPK significantly enhanced available N content of soil over 100% NPK alone (Vipin Kumar and Singh, 2010) [15]. The favourable soil condition under green manuring might have helped mineralization of soil N leading to buildup of available nitrogen. It is seen that the efficient use of crop residues and green manuring in sodic soils is essential for augmenting N status in Sodic Vertisols besides their ameliorative effect.

Available phosphorus
The initial available soil phosphorus was 20.98 kg ha^{-1} which was improved due to use of crop residues, green manuring and gypsum

Table 5: Available phosphorus as influenced by various treatments

Tr. No.	Treatment		Available P (kg ha^{-1})
	Cotton	Green gram-Chickpea	
T1	Control (No residue No green manure)	Residual effect	23.56
T2	Sunhemp *in situ* green manuring	Residual effect	30.36
T3	Dhaincha *in situ* green manuring	Residual effect	31.04
T4	Leucaena loppings green leaf manuring	Residual effect	29.32
T5	Cow pea *in situ* green manuring	Residual effect	29.22
T6	Green gram *in situ* green manuring	Residual effect	29.22
T7	Composted cotton stalk residue	Residual effect	29.52
T8	Biomulch (Mulching with farm waste)	Residual effect	28.91
T9	Gypsum @ 2.5 t ha^{-1}	Residual effect	28.01
	SE (m) ±		0.49
	CD at 5 %		1.48
	Initial (2011-12)		20.98

The available P after harvest of cotton was significantly influenced by various treatments, The highest available P (31.04 kg ha^{-1}) was observed with the application of dhaincha in situ green manuring followed by sunhemp in situ green manuring (30.63 kg ha^{-1}) which were found at par with each other. The lowest availability of P was observed under control treatment. Availability of phosphorous was significantly increased due to application of gypsum @ 50% GR with green manuing (dhaincha) from 12.7 kg ha^{-1} to 14.5 kg ha^{-1} (Singh *et al*. 2011) [13].

Available Potassium
The effect of various treatments on available K was found to be significant. The highest available K (475.8 kg ha^{-1}) was observed with green manuring of dhaincha followed by sunhemp in situ green manuring **(**471.3 kg ha^{-1}) which were found at par with each other. The green manuring and crop residue application recorded significant available Kover control. The lowest available K **(**393.2 kg ha^{-1}) was recorded in control treatment.

Potassium availability in alkali soils generally has been reported as adequate (Chhabra, 2002). The application of gypsum @ 2.5 t ha^{-1} significantly enhanced the available K (440.8kg ha^{-1}) status of soil after harvest of cotton (2013-14). The significant increase in available K status due to application of gypsum may be attributed to the fact that addition of gypsum brought about remarkable improvement in the physical and chemical properties of soil. These findings were in conformity with Yaduvanshi and Sharma (2007) [18].

Table 6: Available potassium as influenced by various treatments

Tr. No.	Treatment		Available K (kg ha^{-1})
	Cotton	Green gram-Chickpea	
T1	Control (No residue No green manure)	Residual effect	393.2
T2	Sunhemp *in situ* green manuring	Residual effect	471.3
T3	Dhaincha *in situ* green manuring	Residual effect	475.8
T4	Leucaena loppings green leaf manuring	Residual effect	452.9
T5	Cow pea *in situ* green manuring	Residual effect	438.0
T6	Green gram *in situ* green manuring	Residual effect	432.8
T7	Composted cotton stalk residue	Residual effect	451.3
T8	Biomulch (Mulching with farm waste)	Residual effect	414.4
T9	Gypsum @ 2.5 t ha^{-1}	Residual effect	440.8
	SE (m) ±		1.6
	CD at 5 %		4.7
	Initial (2011-12)		380.8

The application of organic and chemical amendments in conjunction increased the K content of the soil. Similar results were recorded by Yadav and Chhipa (2007) [17].

Conclusion
Management practices which can be adopted to reduce negative effects of salts on plant growth includes leaching salts from soil profile, use of amendments such as gypsum, use of crop residues, green manuring were shown beneficial effect In terms of nutrient status of the salt affected soils of purna valley in vidarbha region of Maharashtra state.

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