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Effect of crop residues and green manuring on soil properties and yield of cotton in salt affected soils of purna vally

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Abstract
The present investigation was carried out to study the effect of various crop residues and green manuring on soil properties and yield of cotton in salt affected soils of purna valley. The experiment was conducted on farmers field at kutasa during 2015-16 comprising cotton-green gram-cotton-green gram-cotton rotation in RBD with nine treatments and three replications. The experiment comprises various green manuring, crop residues and biomulch treatments. The results of the present experiment indicate that various green manuring treatment significantly decreased the pH value over initial status, whereas electrical conductivity was increased under almost all the treatments over initial status. The status of organic carbon (6.32 & 5.44 g kg^{-1}) was improved with the green manuring of sunhemp in surface and subsurface of soils, respectively. The bulk density and mean weight diameter was slightly improved with dhaincha in situ green manuring as compared with control. The application of in situ dhaincha green manuring significantly increased available N (249.90 kg ha^{-1}), P_2O_5 (30.46 kg ha^{-1}) and K_2O (459.20 kg ha^{-1}).
The in situ green manuring and gypsum @ 2.5 t ha^{-1} helps in reducing detrimental effect of soluble Na^{++} cations and some anions (HCO_3^- and Cl^-) whereas concentration of Ca^{2+}, Mg^{2+} and K^+ was increased. The CEC increased significantly with the sunhemp in situ green manuring over control, however, the difference among various green manuring, crop residues and gypsum treatment were non-significant. The exchangeable sodium percentage (ESP) was decreased significantly with the application of gypsum @ 2.5 t ha^{-1} (7.32%). The application of gypsum @ 2.5 t ha^{-1} registered highest seed cotton yield (12.29 q ha^{-1}), cotton stalk (29.68 q ha^{-1}), root (2.98 q ha^{-1}) and leaf biomass (11.02 q ha^{-1}). The same has not been observed in SOC stock, where cowpea in situ green manuring registered highest SOC stock (41.60 Mg ha^{-1}). The pH and EC of saturate paste extract influenced significantly among various green manuring and crop residues treatments. In general pH was decreased and EC was significantly increased over initial and control treatment. The lowest pH value, however was *viz.* 8.19 registered in gypsum @ 2.5 t ha^{-1} treated plot followed by in situ sunhemp green manuring (8.21). The electrical conductivity was increased with the application of gypsum @ 2.5 t ha^{-1}, followed by green manuring and crop residues treatments.

Keywords: Cations, anions, CEC, ESP, carbon sequestration, SOC

Introduction

Soil is the most basic natural resource and the primary substrate for growing crops. It is also non-renewable over the human timescale. Salt affected soils in Vidarbha occurs mainly in Purna valley which covers part of Amravati, Akola and Buldhana district on both sides of the river Purna affecting about 892 villages and covering an area about 4692 sq. km.

Soil carbon (C) sequestration has been proposed as a major agriculturally based strategy for mitigating rising atmospheric concentrations of greenhouse gases (Smith, 2004) [12]. The process of photosynthesis by which growing plants fix carbon dioxide in to biomass is mainly responsible for its removal from the atmosphere. As photosynthesis is a primary source of carbon dioxide, 100 billion metric tons of carbon is estimated to be sequestered in coming 50 years by plant at global scale (Third IPCC Assessment Report). The amount of worldwide carbon dioxide emission due to agricultural and deforestation activities is calculated approximately 1.6 billion tons of carbon per year (Lal, 2001) [5]. An increasing awareness about environmental pollution by carbon dioxide emissions has led to recognition of the need to enhance soil C sequestration for minimizing greenhouse effects (Lal *et al.* 2003) [6].

Soil represents a main sink of carbon cycle, and estimates are about 1100 to 1600 billion tons of carbon is sequestered in world soils annually which is almost than double the amount of carbon in living vegetation and in the troposphere together (Izaurraldeet *et al.* 2000).The potential to sequester carbon in agricultural soils is promising. By sequestering carbon through sustainable agricultural management practices, carbon sequestration may become one of the important factors reducing greenhouse effects and improving soil quality in degraded lands too (Lal 2001; Lal *et al.* 2003) [5, 6].

Application of green manure enhances the reclamation action of organic manures by improving physical and chemical properties of soil and by markedly decreasing soil pH. Plant litter incorporation improves aggregation and leads to better aeration and water relationship. Application of straw mulch had been found to curtail the evaporation from soil surface resulting in reduced salt concentration in the root zone profile that may help in arresting sub soil sodicity (Kaur, 1994) [4].

Considering the magnitude of crop residues and green leaf manuring in addition of potential biomass, similarly the quantum of biomass added by cotton and soil conditioning activity of gypsum, the sequestration potential of soil need to be assessed. Application of organic amendments in the form of green manures and crop residues reduces pH and ESP of the alkali soils due to production of organic acids and increase in availability of Ca^{2+} that exchange with Na^{+} of clay complex leading to creation of favourable environment for microbial activity which reflects in improvement of microbial activity (Rao and Pathak, 1996) [10]. In view of the above the present experiment was proposed to study the effect of crop residues and green manuring on soil properties and yield of cotton in salt affected soils of purna valley.

Materials and Methods

The field experiments on cotton-green gram-chickpea rotation had been initiated on the farmers field in Kutasa village of Purna valley during 2011-12. Cotton was grown during 2011-12, green gram and chickpea during 2012-13, Cotton during 2013-14 and green gram and chickpea during 2014-15. The present study was carried out to study 5th cycle of the experiment with cotton (2015-16). The experiment was carried out on three farmers fields in Kutasa village on the same site. The effect of green manuring, crop residues and gypsum were studied on soil properties and yield of cotton. The treatments were imposed on three farmers fields serving as one farmer as one replications in randomized block design. The plot size was 7.0×7.2 m with 90×45 cm. The different treatments were consisted as below:

Cotton was grown in *kharif* and green manuring crops were sown in between two rows of cotton which were 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.

Table 1: Different treatments of organic and inorganic amendment

Treat. No.	Cotton	Green gram-Chickpea
T_1	No residue No green manure (Control)	Residual effect
T_2	Sunhemp in situ green manuring	Residual effect
T_3	Dhaincha in situ green manuring	Residual effect
T_4	Leucaena loppings green leaf manuring	Residual effect
T_5	Cow pea in situ green manuring	Residual effect
T_6	Green gram in situ green manuring	Residual effect
T_7	Cotton stalk residue composted with PDKV decomposer	Residual effect
T_8	Mulching with farm waste with PDKV decomposer	Residual effect
T_9	Gypsum @ 2.5 t ha^{-1}	Residual effect

The soil sample were collected from surface layer after harvest of cotton and analysed for physico-chemical properties like bulk density, mean weight diameter, pH, EC, organic carbon, cation and anion concentration of saturate paste extract, CEC, ESP, and available nutrients.

pH was analyzed by the method of 1:2 soil water suspension (Jackson, 1973), EC by EC measurement using conductivity bridge (Jackson, 1973), Organic carbon by Walkley and Black method (1934), Available N by Subbiah and Asija (1956), Available P Watanabe and Olsen (1965), Available K by Hanway and Heidel (1952), respectively. Similarly ESP, CEC, concentration of cations and anions were analyzed by the standard methods. The analysis of data was done by using standard statistical methods of analysis.

Results and Discussion

Seed cotton and straw yield-

The seed cotton and straw yield of cotton in different treatments (table 2) varied from 9.86 to 12.29 q ha^{-1} and 18.85 to 29.68 q ha^{-1} respectively. The seed cotton yield response varied from 0.63 to 2.43 q ha^{-1} depending upon treatments. The effect of treatment cotton + gypsum application @ 2.5 t ha^{-1} was significant over the control followed by cotton + dhaincha *in situ* green manuring, cotton + green gram *in situ* green manuring and cotton + sunhemp *in situ* green manuring. The highest seed cotton yield was noted in treatment receiving gypsum @ 2.5 t ha^{-1} (12.29 q ha^{-1}) was significant over the control (9.86 q ha^{-1}). Among the green manuring effect of dhaincha *in situ* green manuring was superior over sunhemp and green gram in cotton based cropping system. Similarly (29.68 q ha^{-1}) straw yield also highest in treatment cotton + gypsum application @ 2.5 t ha^{-1} followed by cotton + dhaincha *in situ* green manuring and lowest in control (18.85 q ha^{-1}). The results are in close agreement with earlier findings of.

Table 2: Effect of different treatment on yield of cotton and Soil properties

Tr. No.	Treatment	Green gram-Chickpea	Seed cotton	Cotton stalk	Available nutrients (kg ha^{-1})		
	Cotton		Cotton Yield (q ha^{-1})		N	P	K
T_1	Control (No residue No green manure)	Residual effect	9.86	18.85	210.30	20.90	339.73
T_2	Sunhemp in situ green manuring	Residual effect	11.12	24.84	243.30	28.97	451.73
T_3	Dhaincha in situ green manuring	Residual effect	11.70	27.58	249.90	30.46	459.20
T_4	Leucaena loppings green leaf manuring	Residual effect	10.95	23.95	226.50	28.38	434.10
T_5	Cow pea in situ green manuring	Residual effect	11.01	24.65	230.10	28.17	423.20
T_6	Green gram in situ green manuring	Residual effect	11.24	25.25	236.60	27.47	418.13
T_7	Composted cotton stalk residue	Residual effect	10.49	23.11	222.90	28.97	432.10
T_8	Biomulch (Mulching with farm waste)	Residual effect	10.56	23.55	241.60	26.67	401.60
T_9	Gypsum @ 2.5 t ha^{-1}	Residual effect	12.29	29.68	221.30	25.98	429.33
SE (m) ±			0.22	0.77	4.18	0.77	11.11
CD at 5%			0.66	2.32	12.61	2.34	33.44

The bulk density of soils varied from 1.58 to 1.65 Mg m^{-3} under various treatments which was influenced slightly with the use of organics (Table 3). The lowest bulk density was recorded under dhaincha *in situ* green manuring (1.58 Mg m^{-3}) and highest in control (1.65 Mg m^{-3}) where no residue, no green manure was given, similarly the slight reduction in bulk density was also identified under all the treatments. However, the difference were non-significant among the treatments. The mean weight diameter of soil also showed significant variation from 0.53 mm to 0.64 mm under various treatments. The mean weight diameter was significantly highest (0.64) mm under use of gypsum @ 2.5 t ha^{-1} which was superior to all the remaining treatments and at par with sunhemp *in situ* green manuring (0.63 mm), dhaincha *in situ* green manuring (0.63 mm)and cow pea green manuring (0.62 mm). The lowest mean weight diameter (0.53 mm) was observed under control. The slight improvement in mean weight diameter might be due to overall improvement in soil physical condition which was reflected in bulk density also.

The significant reduction was observed in soil pH from 8.32 (initial) 8.19 (gypsum) followed by 8.21 (sunhemp) and dhaincha (8.22) *in situ* green manuring. The reduction in pH due to application of organic amendments could be attributed to release of organic acids from organic amendments in the course of time. Similarly electrical conductivity of soil was found to be low in almost all the treatments in comparison with gypsum.

After harvest of cotton crop, highest organic carbon content was recorded among the crop residue and green manures, the sunhemp *in situ* green manuring (6.32 g kg^{-1}) was most superior in increasing organic carbon followed by Leucaena loppings *in situ* green leaf manuring (6.26g kg^{-1}) and dhaincha (6.25 g kg^{-1}) *in situ* green manuring. Similar results has also been reported previously by Yaduvanshi, 2003 [16]; Vipin Kumar and A.P. Singh 2010 [14].

Available nutrient status-

Table 3: Effect of different treatment on physico-chemical properties and SOC stock after harvest of cotton

Tr. No.	Treatment	Green gram-Chickpea	Bulk density (Mg m^3)	Mean weight diameter (mm)	pH	EC (dS m^{-1})	Organic carbon (g kg^{-1})	Biomass (q ha^{-1})		Soil Organic Carbon stock (Mg ha^{-1})
	Cotton						(0-15)	root	leaf	
T_1	Control (No residue No green manure)	Residual effect	1.65	0.53	8.32	0.26	5.45	1.90	9.89	38.54
T_2	Sunhemp in situ green manuring	Residual effect	1.60	0.63	8.21	0.25	6.32	2.51	10.41	41.77
T_3	Dhaincha in situ green manuring	Residual effect	1.58	0.63	8.22	0.26	6.25	2.80	10.60	40.64
T_4	Leucaena loppings green leaf manuring	Residual effect	1.61	0.60	8.30	0.26	6.26	2.40	10.18	41.31
T_5	Cow pea in situ green manuring	Residual effect	1.62	0.62	8.24	0.26	6.22	2.47	10.33	41.60
T_6	Green gram in situ green manuring	Residual effect	1.60	0.58	8.25	0.27	5.95	2.52	10.54	40.55
T_7	Composted cotton stalk residue	Residual effect	1.59	0.56	8.28	0.28	5.91	2.31	9.98	40.11
T_8	Biomulch (Mulching with farm waste)	Residual effect	1.60	0.56	8.27	0.26	5.67	2.36	10.11	38.64
T_9	Gypsum @ 2.5 t ha^{-1}	Residual effect	1.62	0.64	8.19	0.32	5.81	2.98	11.02	40.30
SE (m) ±			0.010	0.012	0.031	0.008	0.03	0.12	0.04	0.20
CD at 5%			0.030	0.036	0.093	0.026	0.09	0.36	0.12	0.60
Initial soil test value (2011-12)			--	--	8.32	0.24	5.45	--	--	--

The available nitrogen as influenced by various treatments was found to be significant (Table 2). The highest available Nitrogen status was recorded under dhiancha *in situ* green manuring (249.90 kg ha^{-1}) followed by sunhemp *in situ* green manuring (243.30 kg ha^{-1}) and Biomulch (241.60 kg ha^{-1}). The results are in accordance with earlier finding reported by Anand Swarup, 1987 and Prasad *et al*. 2004 [9].

The available phosphorous of soil increased with incorporation with green manuring as compared to its initial status of 20.90 kg ha^{-1}. The available phosphorous status of soil was highest under dhiancha *in situ* green manuring (30.46 kg ha^{-1}) followed by sunhemp *in situ* green manuring (28.97 kg ha^{-1}). The lowest availability of phosphorous was observed with application of gypsum and control. The increased availability of P due to green manuring were also reported by Singh *et al*. 2011 [11]. The effect of various treatments on available potassium was found to be significant (Table 2). The highest available K (459.20 kg ha^{-1}) was observed with green manuring of dhaincha followed by sunhemp in situ green manuring 451.73 kg ha^{-1} which was found at par with each other. The green manuring and crop residue application significantly the available potassium over control. The lowest available potassium (339.73 kg ha^{-1}) was recorded in control where no residues were incorporated. Yadav and Chhipa 2007 [15] reported similar findings.

Concentration of soluble Cations

The data pertaining to concentration of soluble cation of saturation extract is presented in Table 4. It was observed that the significant increase was noticed in all treatment except control.

Table 4: Effect of different treatment on soluable cation and anion concentration of saturate paste extract, CEC and ESP

Tr. No.	Treatment	Green gram-	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{-}	CECC mol	ESP
	Cotton	Chickpea	(meq L^{-1})							$(p^+)kg^{-1}$	
T_1	Control (No residue No green manure)	Residual effect	2.75	4.08	4.80	0.49	8.23	1.80	4.91	50.43	11.00
T_2	Sunhemp in situ green manuring	Residual effect	3.65	4.51	3.81	0.82	5.07	0.95	3.82	57.67	8.77
T_3	Dhaincha in situ green manuring	Residual effect	3.91	4.44	3.72	0.83	5.03	0.81	3.56	56.61	8.70
T_4	Leucaena loppings green leaf manuring	Residual effect	3.18	4.31	4.12	0.80	6.17	1.10	3.85	56.47	9.18
T_5	Cow pea in situ green manuring	Residual effect	3.07	4.14	3.85	0.81	5.67	1.08	4.19	56.23	9.10
T_6	Green gram in situ green manuring	Residual effect	3.10	4.24	4.10	0.78	5.70	1.06	3.88	56.44	9.28
T_7	Composted cotton stalk residue	Residual effect	3.12	4.20	4.07	0.80	6.20	1.27	3.92	56.20	9.39
T_8	Biomulch (Mulching with farm waste)	Residual effect	3.03	4.10	4.15	0.77	5.90	1.15	4.11	54.60	9.66
T_9	Gypsum @ 2.5 t ha^{-1}	Residual effect	3.20	4.72	3.10	0.90	2.83	0.74	3.27	53.90	7.32
SE (m) ±			0.13	0.06	0.11	0.018	0.12	0.18	0.13	1.38	0.23
CD at 5%			0.39	0.18	0.33	0.057	0.36	0.55	0.39	4.15	0.71

The Ca^{++}, Mg^{+} and K^{+} concentration in soil was increased significantly with the application of inorganic and organic amendments over control. However, Ca^{++} content in saturation paste extract was observed highest under dhaincha *in situ* green manuring (3.91 meq L^{-1}). Mg^{+} content in saturation paste extract was significantly highest (4.72 meq L^{-1}) under gypsum followed by sunhemp in-situ green manuring (4.51 meq L^{-1}) and dhaincha in-situ green manuring (4.44 meq L^{-1}). The soluble K^{+} was observed highest 0.90 meq L^{-1} value under gypsum (T_9) and among the organic treatments the higher (0.83 meq L^{-1}) value of soluble K was observed under dhaincha *in situ* green manuring and lowest (0.49 meq L^{-1}) in control.

The application of gypsum and organic amendments were effective in reducing soluble Na^{++} concentration in saturation paste extract. Among the various treatments application of gypsum @ 2.5 t ha^{-1} recorded significantly lower value Na^{++} concentration (3.10 meq L^{-1}). Among the organic treatments dhaincha *in situ* green manuring (T_3) recorded lowest value of Na^{++} (3.72 meq L^{-1}) over control.

Concentration soluble anions

The data pertaining to effect of crop residues and green manuring on soluble anion content in saturation paste extract is presented in Table 4. The application of organic sources and gypsum was found effective in removing soluble anions in soluble phase.

As regard to bicarbonate anion the highest (2.83 meq L^{-1}) reduction was observed under gypsum @ 2.5 t ha^{-1} followed by dhaincha in-situ green manuring (5.03 meq L^{-1}). Among the organic amendments dhaincha in-situ green manuring and sunhemp in-situ green manuring was found most effective in reducing bicarbonate concentration. Reported similar findings Patel and Singh, 1991. Chlorides and sulphates they were also reduced significantly due to various organics and gypsum alone treatment. The Chlorides of saturation paste extract were significantly reduced under dhaincha *in situ* green manuring (0.81 meq L^{-1}) followed by sunhemp *in situ* green manuring (0.95 meq L^{-1}) over control (1.80 meq L^{-1}).

The Sulphates reduction was significantly highest under gypsum alone @ 2.5 t ha^{-1} (3.27 meq L^{-1}) followed by dhaincha *in situ* green manuring (3.56 meq L^{-1}) over control (4.91 meq L^{-1}). The highest reduction in Sulphates in gypsum amended plot might be due to higher rate of reclamation of salt affected soil by gypsum as against organic amendments. Similar findings were also reported by Kharche *et al*. (2010).

CEC and ESP

The CEC after harvest of cotton varied from 50.43 to 57.67 c mol (p^+) kg^{-1} (T_2). The slight improvement in CEC was noticed under almost all the treatments except that control, which might be due to influence of cropping under RDF which can be ascribed to enhanced root growth which becomes part of soil organic matter after harvest of economical part of crops. Among the treatments of organic amendments application of sunhemp *in situ* green manuring recorded the highest CEC (57.67 c mol (p^+) kg^{-1}) value.

Similarly the ESP of soils under investigation varied from 7.32 to 11.00. The use of organic and chemical amendments was found useful practice for reclamation of soils of Purna valley. The ESP of soil was significantly influenced after harvest of cotton. The highest reduction (7.32) in ESP was observed with the use of gypsum @ 2.5 t ha^{-1} application followed by dhiancha *in situ* green manuring (8.70) over control.

Root and Leaf Biomass

The root and leaf biomass was increased significantly with various organic amendments and gypsum application (table 3). However, the application of gypsum @ 2.5 t ha^{-1} significantly increased the root (2.98 q ha^{-1}) and leaf biomass (11.02 q ha^{-1}). The least contribution of root and leaf biomass was noted under control treatment *viz*. 1.90 and 9.89 q ha^{-1}, respectively.

Soil Organic Carbon Stock

As a result, the SOC stock increased significantly irrespective of root and leaf biomass indicating substantial contribution of these two parts in buildup and net carbon regime of the soil (table 3).

The total soil organic carbon stock was found highest in Sunhemp *in situ* green manuring (41.77 Mg ha^{-1}), Cow pea *in situ* green manuring (41.60 Mg ha^{-1}), Leucaena loppings green leaf manuring (41.31 Mg ha^{-1}). The SOC is a cumulative mineralized carbon indicative of accumulated effect of green manuring and crop residues. As a result the effect was more pronounced under *in situ* green manuring crop residues and biomulch treatment compared to gypsum. Similar findings were also reported by Benbi *et al*. (2012) [1] and Shrinivasrao *et al*. (2012).

Summery and conclusion-

- Among all the green manures, the use of sunhemp supported significantly in enhancing carbon stock in soil. Similarly, cowpea, leucaena and dhaincha have also greater potential of sequestration of carbon in soil.
- The different green manuring crops followed the sequence as dhaincha > sunhemp > cowpea > leucaena > green gram in improving soil physical and biological

properties besides improving chemical properties of sodic soil.

- The application of gypsum recorded significant improvement in physical and chemical properties of soils resulting into momentous improvement in crop yield.
- The crop residues and green manuring were found useful for improvement in organic carbon, available nutrients and biological properties as compared to gypsum.
- The application of gypsum, green manures dhiancha and sunhemp were found most beneficial in increasing soluble Ca^{++}, Mg^{++}, and K^{+} and reducing Na^{+}.

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