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# Comparative study of crop residue, green manuring and gypsum on chemical properties and yield of cotton in salt affected soils of purna valley

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**Abstract**

The present investigation was carried out to study the Effect of crop residues, green manuring and gypsum on carbon sequestration in soils of purna valley. The study revealed that the treatment gypsum application 2.5 t $ha^{-1}$ is significantly increase the production of cotton and decreased soil salinity, soil sodicity of soil. The treatment of dhaincha and sunhemp *in situ* green manuring is significantly increase the productivity of cotton in salt affected soil and besides decreased soil salinity, soil sodicity, free calcium carbonate of soil, available nutrients, CEC and ESP of soil. The application of gypsum found most beneficial in increasing soluble cations $Ca^{++}$, $Mg^{+}$ and $K^{+}$ and reducing $Na^{++}$ concentration in soil as comparison with the application of green manures dhaincha, sunhemp and crop residues. However, the yield of cotton under dhaincha and green gram in situ green manuring was at par with gypsum indicating green manures have equal potential to improve yield of crops in sodic soils besides improving soil properties, helping soil reclamation.

**Keywords:** CEC, ESP, soil reclamation, soil salinity, sodicity, cations & anions

## Introduction

Soil is the most basic natural resource and the primary substrate for growing crops. It is also non-renewable over the human timescale. 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 area 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)

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. The pH is in the range of 8.1 to 9.4, exchangeable sodium ranges from 4 to 21 per cent and electrical conductivity from 0.3 to 5.2 dS $m^{-1}$. The well water in Purna valley is also alkaline. The farmers of the valley face problems like water stagnation in rainy season, poor drainage, deterioration of soil structure, moisture stress and soil erosion. For management of problematic soils in this valley several integrated reclamation technologies have been recommended but all are beyond the economic limits of the farmers and not affordable by the farmers at all.

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 Calcilsterts (Padole *et al*., 1998).

Increasing salinity and sodicity affects soil carbon dynamics with soil carbon level, dependent on a balance between inputs and losses. Since inputs are largely related to biomass production with soil conditions affecting microbial activity. Increasing salinity and sodicity levels can potentially alter carbon stocks and fluxes in the landscape. These process can lead to decline in vegetation, plant biomass production and decrease in a soil productive capacity.

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 favorable environment for microbial activity which reflects in improvement of microbial activity (Rao and Pathak, 1996) [10]. In view of the above, the amendments which are available on farm could probably be the most effective option for improving soil health, maintaining soil productivity and sustaining crop yields in salt-affected areas. A holistic approach should be to considered for the cost and availability of the inputs. Considering potential of crop residues and green manuring in soil reclamation the present study was carried out.

## Materials and Methods

The field experiments on cotton-greengram-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 three 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:

**Table 1:** Different treatments of organic and inorganic amendment

| Treat. No. | Cotton | Greengram-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 |

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.

The physico-chemical properties like bulk pH, EC, organic carbon, $Caco_3$, cation and anion concentration of saturate paste extract, CEC, ESP, and available nutrients in soil after harvesting of cotton.

pH, EC, organic carbon, free calcium carbonate, available N,P and K was analyzed by the method of 1:2 soil water suspension (Jackson, 1973), EC measurement using conductivity bridge (Jackson, 1973), Walkley and Black method (1934), Subbiah and Asija (1956), Watanabe and Olsen (1965), Hanway and Heidel (1952), respectively. Similarly ESP, CEC, concentration of cations and anions were analyzed by the standard methods. The saturation extracts of the soil samples were analysed for pHs, electrical conductivity (ECe), cations and anions as per the methods outlined by Richards (1954). The analysis of data was done by the using standard statistical methods of analysis.

## Results and Discussion

### Seed cotton yield

The seed cotton yield of cotton in different treatments (table 2) varied from 9.86 to 12.26 q $ha^{-1}$. 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 in response of cotton noted in treatment receiving cotton + gypsum application @ 2.5 t $ha^{-1}$ (12.26 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.

### Soil properties

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 acidifying effect of organic amendments. Similarly Electrical conductivity of soil was found to be low in almost all the treatments similarly it was well below the critical limit of soil electrical conductivity to cause salinity.

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**Table 2:** Effect of different treatment on chemical properties of soil after harvesting of cotton

| Tr. No. | Treatment | Green gram-Chickpea | Cotton Yield (q ha$^{-1}$) | pH | EC (dS m$^{-1}$) | Organic carbon (g kg$^{-1}$) | $CaCO_3$ (g kg$^{-1}$) | Available nutrients ( kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cotton | | Seed cotton | | | | | N | P | K |
| $T_1$ | Control (No residue No green manure) | Residual effect | 9.86 | 8.32 | 0.26 | 5.45 | 11.30 | 210.30 | 20.90 | 339.73 |
| $T_2$ | Sunhemp in situ green manuring | Residual effect | 11.12 | 8.21 | 0.25 | 6.32 | 9.31 | 243.30 | 28.97 | 451.73 |
| $T_3$ | Dhaincha in situ green manuring | Residual effect | 11.70 | 8.22 | 0.26 | 6.25 | 9.50 | 249.90 | 30.46 | 459.20 |
| $T_4$ | Leucaena loppings green leaf manuring | Residual effect | 10.95 | 8.30 | 0.26 | 6.26 | 9.42 | 226.50 | 28.38 | 434.10 |
| $T_5$ | Cow pea in situ green manuring | Residual effect | 11.01 | 8.24 | 0.26 | 6.22 | 9.40 | 230.10 | 28.17 | 423.20 |
| $T_6$ | Green gram in situ green manuring | Residual effect | 11.24 | 8.25 | 0.27 | 5.95 | 9.80 | 236.60 | 27.47 | 418.13 |
| $T_7$ | Composted cotton stalk residue | Residual effect | 10.49 | 8.28 | 0.28 | 5.91 | 9.86 | 222.90 | 28.97 | 432.10 |
| $T_8$ | Biomulch (Mulching with farm waste) | Residual effect | 10.56 | 8.27 | 0.26 | 5.67 | 9.88 | 241.60 | 26.67 | 401.60 |
| $T_9$ | Gypsum @ 2.5 t ha$^{-1}$ | Residual effect | 12.29 | 8.19 | 0.32 | 5.81 | 9.96 | 221.30 | 25.98 | 429.33 |
| SE (m) ± | | | 0.22 | 0.031 | 0.22 | 0.03 | 0.07 | 4.18 | 0.77 | 11.11 |
| CD at 5 % | | | 0.66 | 0.093 | 0.66 | 0.09 | 0.21 | 12.61 | 2.34 | 33.44 |
| Initial soil test value (2011-12) | | | | 8.32 | 0.24 | 5.45 | 10.18 | 200.0 | 20.98 | 380.8 |

After harvest of cotton crop, highest organic carbon content was recorded among the crop residue and green manures, the sunhemp (6.32 g kg$^{-1}$) was most superior in increasing organic carbon followed by Leucaena loppings green leaf manuring (6.26 g kg$^{-1}$) and dhaincha (6.25 g kg$^{-1}$) in situ green manuring in 0-15 cm soil layer, and lowest availability organic carbon status was observed with application of gypsum (5.81 g kg$^{-1}$) ($T_9$) compare with organic ammendments. Similar results has also been reported previously by Yaduvanshi, 2003 [15]; Vipin Kumar and A.P. Singh 2010 [13].

The free $CaCO_3$ content of the experimental sites was influenced significantly due to application of green manuring and crop residues (Table 2). However, the $CaCO_3$ content after harvest of cotton decreased slightly under green manuring and crop residues ($T_2$-$T_8$). (6.25 g kg$^{-1}$) from initial value of 10.18 followed by Cow pea *in situ* green manuring 9.40 ($T_5$) and Leucaena loppings green leaf manuring 9.42($T_4$) under 0-15 cm layer of soil and lowest reduction of $CaCO_3$ was observed with application of gypsum (9.96 g kg$^{-1}$) ($T_9$) compare with organic ammendments.

## Available nutrient status

The fertility status of soil also studied during the experimentation. The data generated is placed in (Table 2). The available nitrogen, phosphorous and potassium as influenced by various treatments was found to be significant (Table 2). The highest available soil Nitrogen, phosphorous and potassium status was recorded under dhiancha *in situ* green manuring 249.90 kg ha$^{-1}$, 30.46 kg ha$^{-1}$ & 459.20 kg ha$^{-1}$ respectively ($T_3$) followed by sunhemp *in situ* green manuring 243.30 kg ha$^{-1}$, 28.97 kg ha$^{-1}$, & 451.73 kg ha$^{-1}$ ($T_2$) and lowest availability of Nitrogen, phosphorous and potassium status was observed with application of gypsum ($T_9$) and control ($T_1$) (Singh *et al*. 2011, Anand Swarup, 1987 and Prasad *et al*. 2004, Yadav and Chhipa 2007) [11, 9, 14].

## Concentration of soluble Cations

The data pertaining to Concentration of soluble cation of saturation extract is presented in (Table 3). It was observed that the significant increase was noticed in all treatment except control.

The cations $Ca^{++}$, $Mg^{+}$ and $K^{+}$ concentration in soil is increase 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$^{-1}$ ($T_3$). $Mg^{+}$ content in saturation paste extract was significantly highest 4.72 meq L$^{-1}$ under gypsum ($T_9$) followed by sunhemp in-situ green manuring ($T_2$) (4.51 meq L$^{-1}$) and dhaincha in-situ green manuring ($T_3$) (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 (T3) and lowest 0.49 meq L$^{-1}$ in control ($T_1$).

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$^{-1}$ ($T_9$) recorded significantly lower value (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.

**Table 3:** Effect of different treatment on soluable cation and anion concentration of saturate paste extract, CEC and ESP

| Tr. No. | Treatment | Green gram-Chickpea | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $HCO_3^-$ | $Cl^-$ | $SO_4^-$ | CEC (cmol ($p^+$)kg$^{-1}$) | ESP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cotton | | (meq L$^{-1}$) | | | | (meq L$^{-1}$) | | | | |
| $T_1$ | 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 |

**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 3. The application of organic sources and gypsum was found effective in removing soluble anions in soluble phase.

As regard to bicarbonates the highest 2.83 meq $L^{-1}$ significant 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. (Patel and Singh, 1991) [8]. Chlorides and sulphates they were also reduced significantly due to gypsum ($T_9$) and organics ($T_2$-$T_8$) application. The Chlorides of saturation paste extract were significantly reduced under dhaincha *in situ* green manuring 0.81 meq $L^{-1}$ ($T_3$) followed by sunhemp *in situ* green manuring 0.95 meq $L^{-1}$ ($T_2$) over control 1.80 meq $L^{-1}$ ($T_1$).

The Sulphates reduction was significantly highest under gypsum 3.27 meq $L^{-1}$ ($T_9$) followed by dhaincha *in situ* green manuring 3.56 meq $L^{-1}$ ($T_3$) over control 4.91 meq $L^{-1}$ ($T_1$). The highest reduction in Sulphates in gypsum amended plot might be due to fast reclamation of gypsum as against organic amendments. Similar findings were also reported by Kharche *et al*. (2010) [3].

**CEC and ESP**

Application of crop residues and green manuring was not effective in significant improvement in CEC. The CEC after harvest of cotton varied from 50.43 cmol ($p^+$) $kg^{-1}$ ($T_1$) to 57.67 cmol ($p^+$) $kg^{-1}$ ($T_2$). The slight improvement in CEC was also noticed in control ($T_1$) 50.43 cmol ($p^+$) $kg^{-1}$, 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 57.67 cmol ($p^+$) $kg^{-1}$ value and lowest in gypsum @ 2.5 t $ha^{-1}$ ($T_9$) Application as compare with applications of different organic amendment.

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 significant reduction (7.32) in ESP was observed with the use of gypsum @ 2.5 t $ha^{-1}$ ($T_9$) Application followed by dhiancha in-situ green manuring ($T_3$) (8.70) over control ($T_1$).

**Summery & Conclusion**

- The application of gypsum recorded significant improvement in chemical properties of soil resulting into momentous improvement in crop yield.
- The crop residues and green manuring crops found improvement in organic carbon, $CaCO_3$ and available nutrients of soil as compared to gypsum.
- The application of gypsum found most beneficial in increasing soluble cations $Ca^{++}$, $Mg^+$ and $K^+$ and reducing $Na^{++}$ concentration in soil as comparison with the application of green manures dhaincha, sunhemp and crop residues.
- The CEC of salt affected soil is comparatively improved in addition of green manures and gypsum application @ 2.5 t $ha^{-1}$. and highest reduction of ESP is found most in gypsum application with comparison of green manure application.

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