The Effect of Crop Residues, Green Manuring and Gypsum on Sequestration of Carbon in Soils of Purna Valley

Pawar S. K.[1], G. A. Kumbhar[2], S. B. Dahiphale[3]

Department of SSAC, P.D.K.V. Akola, Maharashtra

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 improves mean weight diameter of soil, 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 improves the physical properties bulk density and mean weight diameter of soil, decreased soil salinity, soil sodicity, free calcium carbonate of soil and increase the SMBC, SMBN, DHA, CO_2 evolution, organic carbon, available nutrients and CEC of soil. Therefore from the It is concluded that the yield of cotton under gypsum was higher in comparison to organic amendments. 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: SMBC, SMBN, DHA, CO_2 Evolution, CEC, and Carbon sequestration

1. 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 atmo-spheric concentrations of greenhouse gases (Smith, 2004). 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). 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).

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).

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).

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).

2. 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 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 density, mean weight diameter, pH, EC, organic carbon and free calcium carbonate at 0-15 and 15-30 cm depth, SMBC, SMBN, DHA, CO_2 evolution, available nutrients, yield of seed cotton, stalk, root and organic carbon stalk in soil 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 SMBC, SMBN, DHA and CO_2 evolution were analyzed by the standard methods. The analysis of data was done by the using standard statistical methods of analysis.

3. Results and Discussion

Seed cotton and straw yield

The seed cotton and straw yield of cotton in different treatments (table 3) varied from 9.86 to 12.29 q ha^{-1} and 18.85 to 29.68 q ha^{-1} respectively. 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} (12.29 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 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 (T_1).

Soil properties

The bulk density of soils varied from 1.58 to1.65 Mg m^{-3} under various treatments which was influenced slightly with the use of organics (Table 2). The lowest bulk density has been recorded under dhiancha *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 bulk density was least influenced in control (T_1). 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} (T_9) which was superior to all the remaining treatments and at par with sunhemp *in situ* green manuring (T_2) 0.63 mm, dhaincha *in situ* green manuring (T_3) 0.63 mm and cow pea green manuring (T_5) 0.62 mm (Table 2). The lowest mean weight diameter (0.53 mm) was observed under control (T_1).

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.

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 (6.26g kg^{-1}) and dhaincha (6.25 g kg^{-1}) in situ green manuring in 0-15 cm soil layer, while in 15-30 cm layer of soil, sunhemp (5.44 g kg^{-1}) was most superior in increasing organic carbon followed by Leucaena lopping (5.39 g kg^{-1}) and dhaincha (5.38 g kg^{-1}). Similar results has also been reported previously by Yaduvanshi, 2003 ; Vipin Kumar and A.P. Singh 2010.

Table 2: Effect of different treatment on physico-chemical properties of soil after harvesting 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})		$CaCO_3$ (g kg^{-1})		Available nutrients (kg ha^{-1})		
	Cotton						(0-15)	(15-30)	(0-15)	(15-30)	N	P	K
T_1	Control (No residue No green manure)	Residual effect	1.65	0.53	8.32	0.26	5.45	4.97	11.30	12.46	210.30	20.90	391.10
T_2	Sunhemp in situ green manuring	Residual effect	1.60	0.63	8.21	0.25	6.32	5.44	9.31	9.71	243.30	28.97	451.73
T_3	Dhaincha in situ	Residual	1.58	0.63	8.22	0.26	6.25	5.38	9.50	10.02	249.90	30.46	459.20

	green manuring	effect											
T_4	Leucaena loppings green leaf manuring	Residual effect	1.61	0.60	8.30	0.26	6.26	5.39	9.42	9.86	226.50	28.38	434.10
T_5	Cow pea in situ green manuring	Residual effect	1.62	0.62	8.24	0.26	6.22	5.35	9.40	9.82	230.10	28.17	423.20
T_6	Green gram in situ green manuring	Residual effect	1.60	0.58	8.25	0.27	5.95	5.34	9.80	10.02	236.60	27.47	418.13
T_7	Composted cotton stalk residue	Residual effect	1.59	0.56	8.28	0.28	5.91	5.32	9.86	10.12	222.90	28.97	432.10
T_8	Biomulch (Mulching with farm waste)	Residual effect	1.60	0.56	8.27	0.26	5.67	5.15	9.88	10.22	241.60	26.67	401.60
T_9	Gypsum @ 2.5 t ha^{-1}	Residual effect	1.62	0.64	8.19	0.32	5.81	5.29	9.96	11.80	221.30	25.98	429.33
SE (m) ±			0.010	0.012	0.031	0.008	0.03	0.05	0.07	0.04	4.18	0.77	11.11
CD at 5 %			0.030	0.036	0.093	0.026	0.09	0.15	0.21	0.12	12.61	2.34	33.44
Initial soil test value (2011-12)			--	--	8.32	0.24	5.45	3.89	10.18	--	200.0	20.98	380.8

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). The highest decrease was observed under Sunhemp in-situ green manuring to 9.31(T_2) 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, also found same sequence of free $CaCO_3$ content in soil among all treatments. The highest decrease was observed under sunhemp *in-situ* green manuring to 9.71 (T_2) followed by cow pea *in situ* green manuring 9.82 (T_5) and Leucaena loppings green leaf manuring 9.86 (T_4) under 15 -30 cm layer of soil.

Available nutrient status

The fertility status of soil also studied during the experimentation. The data generated is placed in table .The available nitrogen as influenced by various treatments was found to be significant (Table 2). The highest available soil Nitrogen status was recorded under dhiancha *in situ* green manuring 249.90 kg ha^{-1} (T_3) followed by sunhemp *in situ* green manuring 243.30 kg ha^{-1} (T_2) and Biomulch (Mulching with farm waste) 241.60 kg ha^{-1} (T_8). (Anand Swarup, 1987 and Prasad *et al.* 2004).

The available Phosphorous of soil increased with incorporation with green manuring as compare to its initial status of 20.98 kg ha^{-1}. The available Phosphorous status of soil was highest under dhiancha *in situ* green manuring 30.46 kg ha^{-1} (T_3) followed by sunhemp *in situ* green manuring 28.97 kg ha^{-1} (T_2). The lowest availability of Phosphorous was observed with application of gypsum and control (Singh et al. 2011). The availability of potassium was observed during the experimentation. The data generated is presented in table 2. The effect of various treatments on available potassium was found to be significant (Table 2). The highest 459.20 kg ha^{-1} available potassium was observed with green manuring of dhaincha (T_3) followed by sunhemp 451.73 kg ha^{-1} in situ green manuring (T_2) which were found at par with each other. The green manuring and crop residue application recorded significant available potassium over control. The lowest available potassium (391.10 kg ha^{-1}) was recorded in control where no residues were incorporated (Yadav and Chhipa 2007).

Biological properties of soil

The data pertaining to soil microbial biomass carbon is presented in table 3. Soil microbial biomass carbon (SMBC) was observed to be significantly increased under various treatments of organic amendments. It was comparatively lower with gypsum (T_9) and control (T_1). While it was highest 168.72 µg g^{-1} soil in dhaincha in situ green manuring (T_3) Among all treatments dhaincha in situ green manuring (T_3) followed by sunhemp 145.15 µg g^{-1} soil *in situ* green manuring (T_2) and Cow pea 141.82 µg g^{-1} soil in situ green manuring (T_5). The lowest value of SMBC was recorded under the control 90.86 µg g^{-1} soil (T_1) due to less microbial activity in soil, high pH and low organic carbon content(Choudhary *et al.* 2013). Similarly SMBN was recorded significantly highest increased with 36.33 µg g^{-1} soil in dhaincha *in situ* green manuring(T_3) followed by sunhemp 32.34 µg g^{-1} soil *in situ* green manuring (T_2) and lower with gypsum (T_9) and control (T_1). The lowest value of SMBN was recorded under the control 12.76 µg g^{-1} soil (T_1) due to less microbial activity in soil, high pH.

Dehydrogenase activity of soil significant improvement with dhaincha *in-situ* green manuring 79.39 µg TPF g^{-1} 24 h^{-1} (T_3) followed by Sunhemp *in situ* green manuring 68.66 µg TPF g^{-1} 24 h^{-1} (T_2) and lowest in control 30.45 µg TPF g^{-1} 24 h^{-1} (T_1), and slightly more with application of gypsum 36.43 µg TPF g^{-1} 24 h^{-1} (T_9) (Rao and Pathak 1996 and Kharche *et al*. 2010).

The significant increase in CO_2 evolution recorded with application of organic amendments. Among all treatments dhaincha *in situ* green manuring 53.10 mg 100 g^{-1} soil (T_3) was significantly at par with sunhemp *in situ* green manuring 51.99 mg 100 g^{-1} soil (T_2) and Leucaena loppings green leaf manuring 47.39 mg 100 g^{-1} soil (T_4). The lowest CO_2 evolution was recorded in gypsum 36.60 mg 100 g^{-1} soil (T_9) and control (T_1) (27.89 mg 100 g^{-1} soil)(Rao and Pathak,1996).

Table 3: Effect of different treatment on biological properties, yield of cotton and Soil Organic Carbon stock

Tr. No.	Treatment	Green gram-Chickpea	SMBC	SMBN	DHA	CO_2 evolution	Seed cotton	Cotton stalk	Root	Leaf biomass	Soil Organic Carbon stock
	Cotton		(μg g^{-1} soil)		(μg TPF g^{-1} 24 h^{-1})	(mg 100 g^{-1} soil)	Cotton Yield (q ha^{-1})		(q ha^{-1})		(Mg ha^{-1})
T_1	Control (No residue No green manure)	Residual effect	90.86	12.76	30.45	27.89	9.86	18.85	1.90	9.89	38.54
T_2	Sunhemp in situ green manuring	Residual effect	145.15	32.34	68.66	51.99	11.12	24.84	2.51	10.41	41.77
T_3	Dhaincha in situ green manuring	Residual effect	168.72	36.33	79.39	53.10	11.70	27.58	2.80	10.60	40.64
T_4	Leucaena loppings green leaf manuring	Residual effect	140.09	30.53	61.93	47.39	10.95	23.95	2.40	10.18	41.31
T_5	Cow pea in situ green manuring	Residual effect	141.82	30.99	52.60	42.30	11.01	24.65	2.47	10.33	41.60
T_6	Green gram in situ green manuring	Residual effect	119.62	28.16	50.09	40.10	11.24	25.25	2.52	10.54	40.55
T_7	Composted cotton stalk residue	Residual effect	110.30	26.76	46.31	38.90	10.49	23.11	2.31	9.98	40.11
T_8	Biomulch (Mulching with farm waste)	Residual effect	113.45	28.10	44.16	42.75	10.56	23.55	2.36	10.11	38.64
T_9	Gypsum @ 2.5 t ha^{-1}	Residual effect	98.60	20.10	36.43	36.60	12.29	29.68	2.98	11.02	40.30
SE (m) ±			3.21	0.76	1.22	1.18	0.22	0.77	0.12	0.04	0.20
CD at 5 %			9.66	2.30	3.67	3.54	0.66	2.32	0.36	0.12	0.61

Root and Leaf Biomass

The application of gypsum (T_9) shows higher cotton root stalk 2.98 q ha^{-1} followed by dhaincha *in situ* green manuring 2.80 q ha^{-1} (T_3) and sunhemp *in situ* green manuring 2.51 q ha^{-1} (T_2) were found superior in improving yield of cotton root stalk respectively. The highest cotton root stalk was obtained with the application of gypsum @ 2.5 t ha^{-1} and he lowest cotton root stalk was observed in control where no green manuring and crop residues were applied. in similar way leaf biomass is also seen highest Sunhemp *in situ* green manuring (T_2) followed that Leucaena loppings green leaf manuring(T_4) and Dhaincha *in situ* green manuring(T_3).

Organic carbon stock of the soil

The total soil organic carbon stock was found highest in Sunhemp *in situ* green manuring (T_2), Cow pea *in situ* green manuring (T_5), Leucaena loppings green leaf manuring (T_4), Dhaincha *in situ* green manuring (T_3), and lowest in control (T_1) followed by and slightly more with Biomulch (Mulching with farm waste) (T_8). (Benbi *et al*. 2012 and Srinivasarao *et al.* 2012).

4. Summary 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.

References

[1] Anand Swarup. 1991[b]. Long term effect of green manuring (sesbania aculeate) on soil properties and sustainability of rice and wheat on a sodic soil. *J. Indian Soc. Soil Sci*. 39 : 777-780.

[2] Benbi. D.K., A.S.Toor., S. Kumar 2012. Management of organic amendments in rice- wheat cropping system determines the pool where carbon is sequestered.*Plant & Soil*.360:145-162.

[3] Choudhary, O. P., J. K. Gill and Bijay Singh. 2013. Water extractable carbon pools and microbial biomass carbon in sodic water irrigated soil amended with gypsum and organic manures. *Pedosphere* 23(1) : 88-97..

[4] Izaurraldeet, R. C., W. B. McGill and N. J. Rosenberg, 2000. Carbon cost of applying nitrogen fertilizer. *Science* 288, 811.

[5] Kharche, V. K., S. R. Patil, S. V. Belur and N. S. Ghogare. 2010. Integrated use of gypsum, spent-wash press-mud compost and bio-inoculants for reclamation of sodic swell shrink soils of Maharashtra. *J. of Soil Salinity and Water Quality* 2(2) :110-115.

[6] Kaur, R. 1994. Physics of salt-affected soils. In salinity management for sustainable Agriculture (D. L. N. Rao, N. T. Singh, R. K. Gupta and N. K. Tyagi, Eds.) :1-17. CSSRI, Karnal, India.

[7] Lal, R., 2001. Myths and sequestration and the greenhouse effects. SSSA, Madison, WI. P 9-26.

[8] Lal, R., R. F. Follett, and J. M. Kimble. 2003. Achieving soil carbon sequestration in the U.S: A challenge to the policy makers. *Soil Science*, 168: 827–845.

[9] Panse, V.G. and P.V. Sukhatme. 1971. Statistical Methods for Agricultural Workers. ICAR, New Delhi, pp- 110-113.

[10] Prasad, B.R., M. Shanti, P. R. K. Prasad, S. P. Moula and P. S. Minhas. 2004. Minimisation of adverse effect of residual sodium carbonate waters with use of amendments on rice yields. Extended summeries, International conference on sustainable management of sodic lands, Laknow, India. Feb 9-14, 2004 :429-431.

[11] Rao, D. L. N. and H. Pathak. 1996. Ameliorative influence of organic matter on biological activity of salt affected soils. *Arid Soil Research and Rehabilitation*, 10 : 311-319.

[12] Srinivasarao Ch., B. Venkateswarlu, Rattan Lal, Anil Kumar Singh, Sumanta Kundu, K. P. R. Vittal, S. K. Sharma, R. A. Sharma, M. P. Jain, and G. Ravindra Chary (2012) Sustaining agronomic productivity and quality of Vertisolic soil (Vertisol) under soybean safflower cropping system in semi-arid central India. *Can. J. Soil Sci*. 92: 771-785.

[13] Singh, Y. P., S. V. S. Chauhan, H. C. Singh and Sudhir Singh.2011. Impact of sodic soils reclamation technology :An assessment of on farm trials. Indian Res. J. Ext. Edu.11(1).

[14] Vipin Kumar and A. P. Singh. 2010. Long term effect of green manuring and farm yard manure on yield and soil fertility status in rice-wheat cropping system. *J. Indian Soc. Soil Sci*. 58 (4):409-412.

[15] Yadav, K. K. and B. R. Chhipa. 2007. Effect of FYM, gypsum and iron pyrites on fertility of soil and yield of wheat irrigated with high RSC water. *J. of Indian Soc. of Soil Sci*. 55(3):324-329.

[16] Yaduvanshi, N. P. S. 2003. Substitution of inorganic fertilizers by organic manures and effect on soil fertility in a rice-wheat rotation on reclaimed sodic soil in India. *Journal of Agricultural Sciences*, 140 : 161-168.