Madras Agric. J., 102 (4-6): 193-195, June 2015
https://doi.org/10.29321/MAJ.10.001098

Study on Effect of Incorporation of Shredded Cotton Stalks by Cotton Stalk Shredder on Soil Properties

T. Senthilkumar* and V. Kasthuri Thilagam
CIAE- Regional Centre , Coimbatore
ICAR-IISWC, Research Centre, Ooty

Incorporation of cotton stalks into the soil ensures rapid decomposition. The most rapid decomposition occurs when residue is placed 10 cm deep and shredding stalks as finely as possible. A tractor operated cotton stalk shredder was used for shredding cotton stalks in the field. The commercially available rotavator is used as *insitu* applicator for incorporation of shredded materials. The shredding was accomplished by ashredder fitted in the front portion of the tractor and incorporation of the shredded material was done by rotary tiller in the rear portion of the tractor. Experiments were conducted with 4 treatments *viz.* disc ploughing with the standing cotton stalks, operation with cotton stalk shredder cum *insitu* applicator with 2.0, 2.5 and 3.0 km h^{-1}to find out the efficient method. The influence of the selected treatments on soil physical and chemical properties was investigated. Operation with prototype shredder cum *insitu* application at 2 km h^{-1} forward speed was judged as the best among all the treatments which recorded favorable increase in hydraulic conductivity (1.38 to 2.30 cm hr^{-1}), decrease in bulk density (1.33 to 1.25 Mg m^{-3}), increased available N (199.0 to 252.0 kg ha^{-1}), P (12.6 to 20.1 kg ha^{-1}), K (541.0 to 640.0 kg ha^{-1}) and organic carbon (0.36 to 0.54 kg ha^{-1}) in soil.

Key words: Cotton stalk shredding, Incorporation, Soil properties

Cotton has been one of the main sources of India's economic growth and a foreign exchange earner. It is grown commercially over 111 countries through out the world. In India, the major area of cotton is under rainfed condition occupying 12.2 million ha with a production potential of 26.0 million bales (Pavithra and Kunnal, 2013). Cotton stalk is treated as an agricultural waste which is available in large quantities. In India about 46 million tonnes of surplus residue of cotton is generated every year (Hiloidhari *et al.,* 2014). Most of the stalk produced is treated as waste though a part of it is used as fuel by rural masses. The bulk of the stalk is burnt off in the field after the harvest of the cotton crop.

One of the difficulties in cotton production is the need to clear crop residues after harvesting. Normally, the plants are removed either by manual pulling or by cutting with sickle up to a height of 50 to 75 mm above ground and burnt later. The above facts necessitate an urgent study to find the effect of incorporation of shredded cotton stalk on soil properties.

Materials and Methods

Shredding of cotton stalks

A tractor operated prototype cotton stalk shredder was developed and used for shredding cotton stalks in the field.The prototype was mounted on a 59 HP tractor.

*Corresponding author email : thasekumar@gmail.com

Insitu applicator

The tractor operated commercially available chain drive, 42 blade, GES make rotavator is selected as *in situ* applicator for incorporation of shredded cotton stalks in the field.

Fig.1. Tractor operated cotton stalk shredder cum *insitu* applicator

Measurement of soil physical and chemical properties

Pre and post experimental soil sampling was done using core sampler at different soil depths *viz*., 0-15, 15-30 and 30-45 cm and analyzed for soil physical properties such as saturated bulk density, hydraulic conductivity and total porosity by using the standard procedures described by Jackson (1973).

Soil Physico chemical properties such as pH, EC (Jackson, 1973) and nutrient status like Organic carbon (Walkley and Black, 1934), available N (Subbiah and Asija, 1956), available P (Watanabe and Olsen, 1965) and available K (Jackson, 1973)were determined at periodical intervals *viz*., 15, 30 and 45 days after incorporation of residues.

Experiments were conducted with following treatments:

T_1 - Disc ploughing with the standing cotton stalks (Conventional method)

T_2 - Operation with prototype cotton stalk shredder cum *insitu*applicator at 2.0 km h^{-1} forward speed

T_3 - Operation with prototype cotton stalk shredder cum *insitu*applicator at 2.5 km h^{-1} forward speed

T_4 - Operation with prototype cotton stalk shredder cum *insitu*applicator at 3.0 km h^{-1} forward speed

A total number of 4 experiments were conducted using the prototype cotton stalk shredder cum *in situ* applicator to assess the effect of incorporated shredded cotton stalk in to the soil. The influence of the soil physical and chemical properties were recorded for all the treatments during the investigation.

Results and Discussion

Incorporation of shredded stalks into the soil

The rotary cultivator or rotavator is considered to be the most important tool as it provides fine degree of pulverization enabling the necessary rapid and intimate mixing of soil. The benefits of rotavator includes effective pulverization of soil for good plant growth; stubble and roots are completely cut and mixed with the soil and proper ground levelling after the operation. Incorporation of crop residues in soil plays an important role in maintaining soil productivity through the process of decomposition and humification into humus which helps to improve the physical, chemical and biological properties of soil. Rotoslashing of post harvest cotton stubbles followed by incorporation through disc ploughing once is the best method cotton stalk incorporation as it creates favorable soil physical and chemical properties and enhanced the yield of succeeding crops (Kathirvel*et al.,*2004).

Table 1. Effect of incorporation of shredded cotton stalk on soil physical properties

Treatment	Bulk density						Hydraulic conductivity (cm hr						Porosity (%)					
	0 -15 cm		15-3		30-45 cm		0 -15 cm		15-30 cm		30-4!		0 -15 cm		15-30 cm		30-45 cm	
	Initial	30DA	Initial	30DAI	Initial	30DAI	Initial	30DAI	Initial	30DAI	Initial	30DAI	Initial	30DAI	Initial	30DAI	Initial	30DAI
T_1	1.33	1.30	1.37	1.33	1.37	1.37	1.42	1.85	1.30	1.40	1.15	1.30	25.64	24.62	30.15	31.75	23.72	24.95
T_2	**1.33**	**1.25**	**1.37**	**1.29**	**1.33**	**1.30**	**1.38**	**2.30**	**1.29**	**1.55**	**1.20**	**1.33**	**27.85**	**42.10**	**32.70**	**33.10**	**25.70**	**26.10**
T_3	1.29	1.29	1.33	1.30	1.42	1.42	1.40	1.98	1.32	1.36	0.95	1.10	25.16	36.35	31.10	32.40	23.25	24.80
T_4	1.33	1.29	1.33	1.30	1.42	1.42	1.42	1.90	1.30	1.34	1.25	1.29	25.14	33.40	31.25	32.50	22.10	23.25

Effect of cotton stalk incorporation on soil physical and chemical properties

Bulk Density

The recorded value of bulk density for all the treatments is furnished in Table 1.The bulk density is the most important physical property of the soil due to its control over root proliferation, air, water and nutrients movement. The value of bulk density decreased invariably in all the treatments up to 30 cm. The highest reduction of bulk density of 6 per cent was recorded in treatment T_2. Cotton waste applied as soil amendmentreducedthebulk density of soiland increased the infiltration rate and hydraulic conductivity (Ravikumar and Krishnamoorthy, 1983;Bharambe *et al.,* 2002).

Hydraulic conductivity

From the results (Table 1) it is inferred that the hydraulic conductivity increased in all the treatments and more pronounced under treatment T_2 (from 1.38 to 2.30, 1.24 to 1.55, &1.20 to 1.33 for 0-15,15-30 and 30.45 cm depths, respectively). Cotton waste when applied as compost significantly increased hydraulic conductivity from 0.4 to 0.5 cm hr^{-1}in vertisols (Mathan 1999).

Porosity

It is observed that the porosity increased up to the depth of 15cm (Table 1). There was no much change in porosity at depths below 15 cm. Out of the treatments tested, T2 recorded the highest porosity (27.85 to 42.10 per cent) at 0-15 cm depth.Same result was recorded by Ravikumar and Krishnamoorthy (1983).

Available nitrogen (N)

Changes observed in available nutrient status of the soil are presented in Table 2. Progressive increase in N at 45 days after incorporation was noticed in all the treatments. The highest change in available nitrogen was recorded in T_2 (26.6per cent) followed by T_3 (10.25 per cent), T_4 (9.50 per cent) and T_1 (6.2 percent).

Available phosphorus (P)

The available P content in soil increased with all the treatments of cotton stalk incorporation. It was also noted that T2 would increase the availability of phosphorus at a higher rate of 59.5 per cent with in 45 days after incorporation of shredded cotton stalks followed by T1(46.0 per cent), T3 (37.7 per cent) and T4 (19.8 per cent). This result might be due to the minimum length of shredded stalk, which decompose quickly rather than the lengthy stalks.

Table 2. Effect of incorporation of shredded cotton stalk on soil nutrient status and physic chemical properties

Treatment	Available nitrogen (kg ha^{-1})				Available phosphorus (kg ha^{-1})				Available potassium (kg ha^{-1})			
	Initial	15 DAI	30 DAI	45 DAI	Initial	15 DAI	30 DAI	45 DAI	Initial	15 DAI	30 DAI	45 DAI
T_1	193.0	194.0	200.0	205.0	11.3	12.6	14.2	16.5	536.0	547.0	580.0	590.0
T_2	199.0	212.0	231.0	252.0	12.6	15.2	18.2	20.1	541.0	585.0	622.0	640.0
T_3	195.0	197.0	210.0	215.0	12.2	13.8	15.4	16.8	549.0	568.0	595.0	605.0
T_4	201.0	202.0	212.0	220.0	13.1	14.2	14.9	15.7	542.0	565.0	590.0	598.0

Table 2. continue

Treatment	Organic carbon (%)				Soil pH				Electrical conductivity (dS m^{-1})			
	Initial	15 DAI	30 DAI	45 DAI	Initial	15 DAI	30 DAI	45 DAI	Initial	15 DAI	30 DAI	45 DAI
T_1	0.36	0.33	0.39	0.39	8.70	8.70	8.70	8.70	0.32	0.32	0.33	0.34
T_2	0.36	0.36	0.48	0.54	8.70	8.60	8.50	8.50	0.32	0.35	0.42	0.49
T_3	0.33	0.33	0.36	0.39	8.70	8.70	8.60	8.60	0.31	0.33	0.35	0.38
T_4	0.36	0.36	0.36	0.39	8.60	8.70	8.70	8.60	0.32	0.32	0.37	0.35

Available potassium (K)

The available K content of soil increased with all the cotton stalk incorporation treatments. However, the increase was found to be higher (18.29 per cent) for treatment T_2 followed by T_4 (10.3 per cent), T_3 (10.2 per cent) and T_1 (10.0 per cent). The crop residues after incorporation in soil underwent decomposition and results in addition of nutrients and increased solubility of soil nutrients due to liberation of organic acids (Thangavel and Prabakaran, 2003).

Organic carbon

The results on organic carbon content of the soil are furnished in Table 2. The organic C content increased up to 45 days after incorporation of shredded cotton stalks in all the treatments. T_2 recorded 50.0 per cent increase in organic carbon followed by T_3 (18.18), T_4 (8.3) and T_1 (8.3). The content was higher in treatment T_2,which mightbe due to quicker decomposition of shredded cotton stalks. Crop residue application facilitates the return of carbon to soil and maximize the yield of crops (Bharambe *et al* 2002).

Soil pH

Incorporation of shredded cotton stalks decreased in soil pH in all the treatments (Table 2). There was no change in soil pH for the treatment T_1. The reduction of soil pH was more pronounced in the treatment T_2(8.70 to 8.50), when compared to other treatments.

Electrical conductivity (EC)

An increased trend in Electrical conductivity was observed (Table 2). The increase was more in the treatment T_2 (53.1 per cent) followed by T_3 (22.6 per cent), T_4 (9.3 per cent) and T_1 (6.2 per cent).

Conclusion

A front mounted tractor operated prototype cotton stalk shredder and a rotavator were used for *in situ* shredding and incorporation of cotton stalks in to soil. Operation with prototype cotton stalk shredder cum *in situ* application at 2 km h^{-1} forward speed was the best among the treatments tested as it recorded favourable increase in hydraulic conductivity (1.38 to 2.30 cm hr^{-1}), decrease in bulk density (1.33 to 1.25 Mg m^{-3}), increased available N (199.0 to 252.0 kg ha^{-1}), P (12.6 to 20.1 kg ha^{-1}), K (541.0 to 640.0 kg ha^{-1}) and organic carbon content (0.36 to 0.54 kg ha^{-1}) of the soil.

References

Bharambe, P.R., Tajuddin, A.H.,Oza S.R and Shelke, D.K. 2002. Effect of irrigation and crop residue management on crop and soil productivity under soya bean- sorghum cropping system. *J. Indian Soc. Soil Sci.,* **50(3):** 233-236.

Hiloidhari, M. Das, D. Baruah, D.C. 2014. Bioenergy potential from crop residue biomass in India. *Renewable and Sustainable Energy Reviews*. **32:** 504-512.

Jackson, M.L. 1973. Soil chemical analysis, Printice Hall, New Delhi

Kathirvel, K. Aravinda Reddy, Manian, R. and Senthilkumar, T. 2004. Performance evaluation of implements for incorporation of cotton stalks. In *Proc* XXXVIII Annual convention of ISAE, Dapoli, p-110.

Mathan, K.K. 1999. Physical changes induced by mineral, organic and industrial amendments on a *vertisol* and its effect on yield of fingermillet. *Madras Agric. J.*, **86 (10-12):** 546-549.

Pavithra B.S. and Kunnal, L.B. 2013. Performance of cotton crop in non-traditional areas of Karnataka- An economic analysis. *Karnataka J. Agric. Sci.,* **26 (2)** : 243- 246

Ravikumar, V. and Krishnamoorthy, K.K.1983. Efficient utilization of industrial and farm wastes as soil amendments. In *Proc* National Seminar on utilization of organic wastes, Madurai, p.147-150.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the determination of available nitrogen in soils. *Curr. Sci.,* **25** :259-260.

Thangavel, P. and Prabakaran, J. 2003. Exploring the possibility of crop production in magnetite mine spoils with amendments. *Advances in Plant Sci*., **(16)** :155 -160.

Watanabe, F.S. and Olsen, S.R. 1965. Test of ascorbic acid method for determining phosphorus in water and sodium bicarbonate extracts of soil. *Soil Sci. Soc. Am. Proc.,* **29**: 677-678.

Walkley, A. and Black, I. A. 1934. An Examination of Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method. *Soil Sci.*, **37**:29-37.

Received after revision: February 10, 2015; Accepted: April 10, 2015