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Performance Evaluation of Implements for Incorporation of Cotton Stalks

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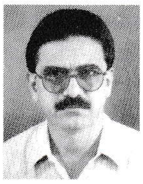

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Abstract

The soil fertility changes due to in-situ incorporation of cotton stalks and residual effect of crop residue management was investigated through a field experimental with post harvest stalks as standing crop. The treatments included operation with roto slasher followed by disc plough, operation of roto slasher followed by rotovator, operation of disc plough followed by rotovator and hand pulling of cotton stalks followed by disc ploughing and cultivator once. Tillage treatments were imposed as non-replicated and succeeding cowpea crop (Co.4) was raised in RBD with two replications. Pre- and post-experimental soil sampling was done using core sampler and were analyzed for physical properties such as saturated hydraulic conductivity, bulk density and total porosity at different soil depths, viz. 0-15, 15-30 and 30-45 cm. The chemical properties such as pH, EC, macro and micro nutrients were also analyzed at periodical intervals, viz. 10, 20 and 30 days after incorporation. Subsequently, the residual crop was sown and maintained till maturity. Treatments with a disc plough played a predominant role in lowering the bulk density and increasing the hydraulic conductivity and porosity. The residual effect observed showed that the pod and haulm yields of cowpea were maximum (10.38 and 55.2 q ha^{-1}, respectively) under roto slasher followed by disc plough (T_1). There was 21.6 percent increase in pod yield compared to farmers' practice. This was followed by disc plough followed by rotovator tilling (T_3). Farmers' practice (T_4) recorded the lowest pod and haulm yield (8.53 and 45.4 q ha^{-1} respectively) due to non-incorporation of cotton stalks. Roto slashing of post-harvest cotton stubbles followed by incorporation through disc ploughing once was the best as it recorded the favourable soil physical and chemical properties and recorded the maximum pod and haulm yield of the succeeding cowpea crop, suggesting its suitability for crop residue management for sustainable crop production.

Introduction

The area under cotton cultivation in Tamil Nadu is 250,000 ha with a production of 550,000 bales. In India, Tamil Nadu ranks ninth in position in respect of area as well as production. For the collection of information on the implements/machinery used by the farmers for performing the different operations in cotton cultivation, a survey was conducted with cotton growers. The requirement for the 770 mills in Tamil Nadu is around 5.0 to 5.5 million bales. Agricultural labour input is becoming increasingly costlier. Labour efficiency, turnover of work and duration of working hours are deplorably deteriorating, resulting in poor crop management, increasing cost of cultivation and poor income to the cotton farmers. Hence, farm mechanization is the need of the hour. The arduous operation of removal of cotton stalks from the soil and transporting the same to the yard manually is labour intensive.

Review of Literature

Rochester et al. (1997) conducted a study on effects of cotton stubble removal on and incorporation on lint yield and N fertilizer recovery of three consecutive cotton crops. Soil mineral N content prior to planting was slightly higher where stubble was removed, but N fertilizer recovery was reduced by 10 %, averaged over the three seasons. Lint yield tended to decline with successive crops with stubble removal compared with stubble retention and in the third crop yield was reduced by 10 %. It was concluded that stubble retention promotes a more biologically active soil system that is conducive to more efficient use of N fertilizer and maintains higher cotton yields. Tiwari et al. (1998) reported that incorporation of ground nut haulm at 7.5 Mg ha^{-1} significantly increased the grain and straw yields of wheat both at 50 and 100 kg levels of N application. There was considerable improvement in physical properties, viz. water holding capacity and bulk density of the soil. Ravendar Reddy et al. (2002) reported that the incorporation of crop residue like wheat straw at 5 t ha^{-1} in combination with fertilizer application and tillage operations resulted in improvement of soil physical properties along with available nutrient status (available nitrogen, phosphorous and potassium).

Methods and Materials

A field experiment was conducted in TNAU, Coimbatore between December, 2001 and April 2002 with post harvest stalks as standing crop.

The treatments selected were: T_1: Operation with roto slasher followed by disc plough, T_2: Operation of roto slasher followed by rotovator, T_3: Operation of disc plough followed by rotovator, T_4: Hand pulling of cotton stalks followed by disc ploughing and once (farmers' practice).

Tillage treatments were imposed as non-replicated and succeeding cowpea crop (Co.4) was raised in RBD with two replications. Pre- and post-experimental soil sampling was done using core sampler and were analyzed for physical properties such as saturated hydraulic conductivity, bulk density and total porosity at different soil depths, viz. 0-15, 15-30 and 30-45 cm. The chemical properties such as pH, EC, macro and micro nutrients were also analyzed at periodical intervals, viz. 10, 20 and 30 days after incorporation. Subsequently, the residual crop was sown and maintained until maturity.

Results and Discussion

i. Soil Physical Properties

Analysis of soil physical properties showed a decrease in bulk density, an increase in hydraulic conductivity and variation in total porosity due to tillage. Bulk density, the most important physical property of the soil due to its control over root proliferation, air, water and nutrient movement decreased invariably in all treatments up to 30 cm depth and was unchanged under the treatment with roto slasher followed by disc plough after 30 cm. Though tillage practices lower bulk density, the reduction was marked under roto slashing followed by disc ploughing (**Table 1**).

The soil strength was positively correlated with bulk density and the uptake of N, P and K decreased when the bulk density of the soil increased from 1.5 Mg m^{-3} for cowpea (Baskar et al., 1995). The saturated hydraulic conductivity increased in all tillage treatments and was more pronounced under roto slasher followed by disc plough -T_1 (from 0.76 to 1.83, 0.69 to 1.73 and 0.52 to 1.62 in 0-15, 15-30 and 30-45 cm depths, respectively, as furnished in **Table 2**. Variation in total porosity was observed at different depths. Reduction in bulk density and increase in hydraulic conductivity was observed under crop-residue management through tillage practices in alfisols (Vijayalakshmi and Saravanan, 2000).

Treatments with a disc plough played a predominant role in lowering the bulk density and increasing hydraulic conductivity and porosity.

ii. Soil Fertility Changes Due to In-situ Incorporation of Cotton Stalks

Changes in soil reaction, EC and available N, P and K and micronutrients Zn, Fe, Cu and Mn status are presented in **Table 3**. Incorporation of cotton stalks recorded a decrease

Table 2 Influence of tillage on the saturated hydraulic conductivity, mm ha^{-1}

Treatments	0-15 cm		15-30 cm		30-45 cm	
	Initial	30 DAI	Initial	30 DAI	Initial	30 DAI
Roto slasher + disc plough (T_1)	0.76	1.83	0.69	1.73	0.52	1.62
Roto slasher + rotovator (T_2)	0.75	1.10	0.69	0.95	0.51	0.80
Disc plogh + rotovator (T_3)	0.74	1.40	0.67	1.33	0.53	1.27
Farmers' practice (T_4)	0.82	1.48	0.72	1.26	0.46	1.05

Table 1 Influence of tillage on bulk density and total porosity of soil at different depths

Treatments	Bulk density, mg m^{-3}						Total porosity, %					
	0-15 cm		15-30 cm		30-45 cm		0-15 cm		15-30 cm		30-45 cm	
	I	F	I	F	I	F	I	F	I	F	I	F
Roto slasher + disc plough (T_1)	1.210	0.920	1.303	0.980	1.033	1.051	16.12	26.64	23.07	63.75	14.80	17.12
Roto slasher + rotovator (T_2)	1.208	1.035	1.302	1.370	1.033	1.395	12.55	9.31	23.38	45.32	15.53	45.24
Disc plogh + rotovator (T_3)	1.207	1.026	1.304	1.022	1.005	1.430	15.52	26.70	23.09	62.80	13.75	31.70
Farmers' practice (T_4)	1.314	1.110	1.378	1.240	1.173	1.372	19.65	9.85	16.01	40.40	18.06	44.50

in soil pH and slight increase in EC from its initial levels. An increase in soil pH and EC values were recorded in farmers' practice, which might be due to the complete removal of crop residue.

Progressive increase in macro and micro nutrient levels were observed in all cotton stalk incorporated treatments. Among the cotton stalk incorporated treatments, the increase in macro and micro nutrients were the highest for treatment T_1 (Rotoslasher + Disc plough). The percentage increase in macro and micro nutrients levels in this treatment when compared with farmers practice was 23.0, 21.0, 64.7, 15.35, 50.0, 19.5 and 9.4 for N, P, K, Fe, Zn, Mn and Cu, respectively.

a. Residual Effect of Crop Residue Management

The pod and haulm yields of cowpea were recorded at maturity and presented in **Table 4**.

Residual effect observed showed that the pod and haulm yields of cowpea were maximum (10.38 and 55.2 q ha^{-1}, respectively) under roto slasher followed by disc plough (T_1). There was 21.6 percent increase in pod yield compared to farmers' practice. This was followed by disc plough followed by rotovator tilling (T_3). Farmers' practice (T_4) recorded the lowest pod and haulm yield (8.53 and 45.4 q ha^{-1}, respectively) due to non-incorporation of cotton stalks.

Conclusion

The chemical properties such as pH, EC, macro and micronutrients were also analyzed at periodical intervals viz. 10, 20 and 30 days after incorporation. Subsequently, the residual crop was sown and maintained until maturity. Treatments with a disc plough played a predominant role in lowering the bulk density, increasing the hydraulic conductivity and porosity. The residual effect observed showed that the pod and haulm yields of cowpea were maximum (10.38 and 55.2 q ha^{-1}, respectively) under roto slasher followed by disc plough (T_1). There was 21.6 percent increase in pod yield compared to farmers' practice. This was followed by disc plough followed by rotovator tilling (T_3). Farmers' practice (T_4) recorded the lowest pod and haulm yield (8.53 and 45.4 q ha^{-1}, respectively) due to non-incorporation of cotton stalks. Rotoslashing of post-harvest cotton stubbles followed by incorporation through disc ploughing once was the best as it recorded decrease in bulk density and increase in hydraulic conductivity, porosity, and micro, macro nutrient levels and recorded the maximum pod and haulm yield of the succeeding cowpea crop, which suggested its suitability for crop residue management for sustainable crop production.

Table 4 Residual effect of tillage implements on pod and haulm yield (q ha^{-1}) of cowpea

Treatments	Pod yield	Haulm yield
Roto slasher + disc plough (T_1)	10.38	55.20
Roto slasher + rotovator (T_2)	9.14	50.50
Disc plogh + rotovator (T_3)	9.96	52.20
Farmers' practice (T_4)	8.53	45.40

Table 3 Influence of tillage on bulk density and total porosity of soil at different depths

Treat.	Roto slasher + disc plough				Roto slasher + rotovator				Disc plough + rotovator				Farmers' practice			
DA1	Initial	10	20	30	Initial	10	20	30	Initial	10	20	30	Initial	10	20	30
P^H	8.8	8.8	8.7	8.6	8.8	8.8	8.7	8.7	8.8	8.7	8.7	8.6	8.8	8.9	8.9	8.9
EC, dsm^{-1}	0.32	0.36	0.42	0.45	0.36	0.36	0.36	0.37	0.32	0.36	0.4	0.49	0.32	0.36	0.49	0.49
N, kg/ha	170	165	210	227.5	177.5	177.5	190.0	220.0	177.5	177.5	190.0	190.0	185.0	180.0	185.0	185.0
P, kg/ha	11.0	11.0	13.0	14.0	11.0	11.0	12.0	12.5	10.5	10.5	12.0	12.5	10.5	10.0	11.5	11.5
K, kg/ha	687.5	780.0	975.0	1,050	675.0	690.0	735.0	832.0	682.5	715.0	800.0	800.0	670.0	625.0	605.0	637.5
Fc, ppm	6.26	6.26	6.76	6.76	6.26	6.26	6.78	6.48	6.48	6.48	6.32	6.52	6.48	6.26	5.92	5.86
Zn, ppm	1.32	1.42	1.80	1.80	1.30	1.30	1.72	1.72	1.32	1.46	1.78	1.78	1.28	1.30	1.20	1.20
Mn, ppm	5.86	5.86	6.12	6.36	5.82	5.82	6.10	6.10	5.76	5.82	6.26	6.24	5.52	5.40	5.32	5.32
Cu, ppm	2.14	2.14	2.22	2.32	2.14	2.14	2.22	2.32	2.20	2.22	2.32	2.28	2.20	2.20	2.14	2.12

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