Recycling of Cotton Crop Residue for Sustainable Cotton Production in Vertisols of Andhra Pradesh, India

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A B S T R A C T

A field experiment was conducted on clay soils of Regional Agricultural Research Station, Lam, Guntur during kharif 2016-17, 2017-18 and 2018-19 to find out the the residual effect of recycling of cotton crop residues on succeeding cotton and impact of recycling of crop residues on yield, yield attributes, soil organic C, N, P, K and soil microbes in vertisols. The three years of the experimental data indicated that the application of RDF @ 150N:60P₂O₅:60K₂Okg ha⁻¹ recorded highest plant height (166.5 cm), number of bolls plant⁻¹ (52.9), seed cotton yield (4568.6 kg ha⁻¹) followed by 75% RDF + cotton crop residue incorporation + decomposed michorhiza (DM) and was significantly superior over other treatments tried and lowest was recorded with application of cotton crop residue only without any combination of fertilizers and decomposed michorhiza but highest soil microbes population was reported with the cotton crop residue incorporation + 75% RDF + decomposed michorhiza (DM)＠2 kg ha⁻¹ + FYM＠ 5tha⁻¹fallowed by cotton crop residue + 75% RDF + decomposed michorhiza (DM)＠2 kg ha⁻¹under the study. Further, reported that the major nutrient (N, P₂O₅, K₂O) availability status was significantly influenced by the treatments imposed and that the treatment of cotton crop residue incorporation + 75% RDF + decomposed michorhiza (DM)＠2 kg ha⁻¹ was significantly superior on the availability of soil N, P₂O₅ and K₂O respectively in the study.

Keywords
Cotton stalk incorporation, Recycling, Recommended dose of fertilizer, Decomposing Michorhiza (DM)

Introduction

The utilization of cotton crop residues as soil amendment may hold a good promise for improving the soil health, crop productivity and reduce the disposal problem. Cotton, the most important commercial fiber crop has been cultivated in India and Andhra Pradesh over an area of 126.55 and 7.36 L ha⁻¹ respectively (CCI, 2014-2015). Huge quantity of cotton stalks is left over in the field after harvest, which needs some valuable disposal solution. It is estimated that 50 MT of cotton stalks is available in India. Though, a portion of it is being utilized for fuel/fodder purpose, major portion of it is being burnt by the farmers in Andhra Pradesh especially in Krishna zone for early clearance of the land for taking succeeding crops. This results in loss of abundant organic matter and plant nutrients besides carrying environmental pollution through global addition of CO₂. Therefore, it is highly essential to explore the influence of direct incorporation of huge
quantities of crop residues into farm soil and its subsequent effect on soil properties and succeeding crop productivity. Tractor drawn shredders and terminator are available now and cotton stalk will be cut into pieces and easily incorporated in to the farm soil. However, the high C:N ratio and presence of polymers such as cellulose and lignin in the crop residues may act as natural barrier for its biological degradation. In such case, microbial interaction of specific microorganisms (cellulolytic and lignolytic) with soil and crop residue may be considered as an appropriate strategy for effective decomposition of added substrate. Hence, research for an alternative method of recycling of crop residues is necessary for their early decomposition and for improving soil health besides sustaining agricultural crop production.

The burning of paddy straw results in losses of N (up to 80 %), P (25 %), K (21 %) and S (4-60 %), air pollution @ CO₂13 t ha⁻¹, thereby depriving the soils of its organic matter content (Gaind and Nain, 2008). Increase in rice yield, improvement in soil physico-chemical and biological properties in rice-rice cropping system due to incorporation of paddy straw was observed by Rajkhowa (2012). Research results also indicated that fungi belonging Pleurotus sajor-caju, P. platypus and P. citrinopileatus are known to colonize coir fibre, cotton stalks and sorghum stover (Ragunathan and Swaminathan, 2003).

Residue recycling is a key measure to enhance the soil fertility and productivity in system of crop production. The plant nutrient availability in a soil is a measure of soil fertility, while the soil physical environment is the king pin regulating the retention and movement of soil moisture, air, nutrients and temperature. Keeping in view this investigation was designed and conducted in vertisols of Andhra Pradesh, with an objective to find the impact of incorporated cotton crop residue on succeeding cotton.

**Materials and Methods**

A field study was carried at Regional Agricultural Research Station, Lam Farm located at Guntur (Latitude: 16°18', Longitude: 80°29', Altitude:33 MSL). The climate is subtropical with mean annual rainfall of 950 mm. The soil of experimental field was clay loam in texture, alkaline in reaction (pH 8.3), non saline. Low in available N (226 kg ha⁻¹), high in P₂O₅ (82.1kg ha⁻¹) and high in K₂O (1220 kg ha⁻¹) and low in organic carbon (0.49%) respectively. The experiment was conducted for three successive kharif seasons i.e., 2016-17, 2017-18 & 2018-19 in Krishna agro-climatic zone of Andhra Pradesh.

The experiment consisting of eight treatments viz., T₁ - Recommended dose of fertilizers (RDF150 -60 - 60), T₂ - Cotton crop residue only, T₃ - Cotton crop residue +75% RDF, T₄ - Cotton crop residue +75% RDF + DM, T₅ - Cotton crop residue +50 % RDF, T₆ - Cotton crop residue +50 % RDF + DM, T₇ - Cotton crop residue + DM and T₈ - Cotton crop residue + DM @2kg/ha + FYM @ 5t /ha were randomly allocated and replicated thrice and adopted randomized block design (RBD) for three years of the experimentation. Recommended dose of N, P and K for cotton was applied as entire P as basal, N and K in three splits (30, 60 and 90 DAS) by pocketing.

Three years of the experimentation was conducted in same field, at the end of the season cotton stalks (stubbles) were shredded with the tractor drawn terminator and that shredded particles were incorporated into the soil during the fallow period (after harvest of cotton lint), Decomposing mychorrhiza which consisting of Azospirillum+VAM+ K
solubilizing bacterial strain developed at Agriculture Research Station, Amarvathi, ANGRAU was incorporated into the soil by mixing with FYM @5kg per 2kg of DM after shredding the cotton stakes..

The data pertaining to yield attributes, yield, available NPK and microbial population were collected after harvesting of the cotton crop. Statistical analysis for yield, yield parameter, available soil nutrients, available soil microbial population were done by following the analysis of variance technique for RBD as suggested by Gomez and Gomez (1984).

**Results and Discussion**

**Available OC**

Pooled analysis of three years data on available organic carbon content of the experimental soils were not significantly influenced by recycling of cotton crop residue along with the combination of chemical fertilizers, FYM and DM. Numerically higher OC content was reported with the T3 & T4 treatment during the experimentation (Table.1). This clearly indicated that the built up of OC content in soil through the recycling of cotton residue may require sufficient time to synthesize and added the OC to the soils.

**Available soil N, P₂O₅ and K₂O**

Soil samples were collected at 75 DAS and at harvest were analyzed for available soil nitrogen, phosphorous and potassium that the pooled analysis found that the availability soil phosphorous and potassium were found significant but nitrogen was found non-significant. Significantly more available P₂O₅ and K₂O were recorded with the treatment T4 i.e., incorporation of cotton crop residue followed by the application of 75% RDF and decomposed michoryza @ 2kg/ha at 75 DAS and harvest. This might be due to the balance in the availability of organic and inorganic nutrients to cotton crop during the experimentation.

**Soil microbial population**

Soil samples were analyzed at Agricultural Research Station on microbiology at Amaravathi and estimated the microbial population at 75 DAS and at harvest. Among the microbial population, the bacterial population (_x10⁶CFU/g) was found significant but fungi were non-significant at 75DAS and harvest. Maximum bacterial population (171.5 and 45.6 x10⁶CFU/g) was significantly reported with the treatment combination of cotton crop residue + DM + FYM @ 5t /ha during the experimentation. This might be due to the availability of organic matter content which will be suitable for feeding the bacterial population for their servility.

**Yield attributes and seed cotton yield**

The data pertaining to plant height and number of bolls plant⁻¹ and seed cotton yield were statically analyzed and that the experimental results indicated that the significantly more plan height, more number of bolls plant⁻¹ and higher seed cotton yield were reported with treatment T₁ i.e., RDF which was on a par with treatment 4 i.e., incorporation of cotton crop residue followed by the application of 75% RDF and decomposed michoryza @ 2kg/ha⁻¹

From the experimental results it can be concluded that the cotton stalks can easily be recycled with tractor drawn terminator followed by easy decomposition of shredded cotton stalks by using the decomposed michorhiza there by improve soil bacterial population and sustain the cotton production in vertisols of Andhra Pradesh.
**Table 1** Effect of in-situ incorporation of cotton crop residue and fertilizers on yield attributes, yield, microbial population and nutrient status of the soil

| Treatments | Plant Height (cm) | No. of Bolls Plant\(^1\) | Seed cotton yield (Kg ha\(^{-1}\)) | Bacteria \(^6\) (\_x10\(^{6}\) CFU/g) | Fungi \(^4\) (\_x10\(^{4}\) CFU/g) | Organic carbon (%) | Avail. N \(^{1}\) (kg ha\(^{-1}\)) | Avail. P \(_{2}\)O\(_{5}\) \(^{2}\) (kg ha\(^{-1}\)) | Avail. K \(_{2}\)O \(^{3}\) (kg ha\(^{-1}\)) |
|------------|------------------|--------------------------|-----------------------------------|-------------------------------------|---------------------|------------------------|-------------------------|-------------------------------|-------------------------------|
| T\(_1\) - Recommended dose of Fertilizers | 166.5 | 52.9 | 4,568.6 | 115.7 | 31.2 | 36.8 | 16.3 | 0.333 | 0.453 | 333.0 | 291.6 | 81.7 | 76.3 | 838.6 | 1,063.6 |
| T\(_2\) - Cotton crop residue only | 141.1 | 30.9 | 2,646.3 | 136.1 | 35.9 | 39.2 | 20.7 | 0.370 | 0.273 | 257.0 | 223.3 | 47.1 | 44.3 | 748.6 | 910.6 |
| T\(_3\) - Cotton crop residue +75% RDF | 158.7 | 43.6 | 4,070.3 | 148.2 | 32.5 | 39.6 | 18.3 | 0.453 | 0.530 | 326.6 | 288.6 | 92.4 | 82.7 | 842.3 | 1,081.6 |
| T\(_4\) - Cotton crop residue +75% RDF + DM | 161.4 | 45.6 | 4,220.0 | 157.1 | 29.9 | 39.5 | 21.1 | 0.487 | 0.493 | 340.0 | 302.3 | 116.1 | 96.9 | 930.6 | 1,122.0 |
| T\(_5\) - Cotton crop residue +50% RDF | 154.9 | 39.9 | 3,783.0 | 154.6 | 34.3 | 45.3 | 21.3 | 0.467 | 0.363 | 296.6 | 258.0 | 73.7 | 60.0 | 836.6 | 1,009.3 |
| T\(_6\) - Cotton crop residue +50% RDF + DM | 153.9 | 41.0 | 3,965.0 | 149.3 | 34.3 | 46.0 | 29.1 | 0.480 | 0.387 | 322.0 | 268.3 | 87.5 | 59.6 | 876.6 | 1,099.3 |
| T\(_7\) - Cotton crop residue + DM | 148.5 | 36.6 | 3,115.3 | 146.0 | 35.8 | 47.3 | 22.7 | 0.370 | 0.373 | 271.3 | 242.6 | 54.7 | 55.9 | 805.0 | 907.6 |
| T\(_8\) - Cotton crop residue + DM + FYM @ 5t/ha | 155.1 | 40.2 | 3,463.6 | 171.5 | 45.6 | 50.3 | 26.9 | 0.453 | 0.453 | 293.3 | 219.00 | 62.6 | 66.2 | 848.6 | 987.0 |

Sem\(^+\) 2.50 1.85 193.63 7.33 1.80 4.18 3.46 0.04 0.06 22.60 26.29 10.35 5.89 29.40 39.44

CD (0.05) 7.66 5.66 593.03 22.45 5.51 NS NS NS NS NS 31.69 18.03 90.1 120.7

CV (%) 3.24 7.74 8.99 8.62 8.91 16.85 22.20 15.38 20.06 12.84 17.39 21.27 15.04 6.06 6.68
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How to cite this article:

Ratnam, M., P. Madhuvani, R. Lakshmipathi, S. Vindya and Subba Rao, G. 2020. Recycling of Cotton Crop Residue for Sustainable Cotton Production in Vertisols of Andhra Pradesh, India. *Int.J.Curr.Microbiol.App.Sci*. 9(08): 1585-1589. doi: [https://doi.org/10.20546/ijcmas.2020.908.182](https://doi.org/10.20546/ijcmas.2020.908.182)