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IN-SITU INCORPORATION OF COTTON CROP RESIDUE INTO SOIL TO IMPROVE YIELD OF SUCCEEDING COTTON CROP–IMPACT THROUGH FRONTLINE DEMONSTRATIONS

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ABSTRACT

Cotton crop residue is continuously burnt after crop harvest, which poses ill effects on the atmosphere, soil and crop productivity. To promote a technology of *In-situ* incorporation of cotton stalks into soil with a rotary shredder and rotavator is a viable option to address this issue for higher cotton productivity, frontline demonstrations (FLDs) were conducted against farmers' practice of cotton stalk burning. The FLDs were conducted for three consecutive years at different locations in the semi-arid region. The results revealed that the practice of *in-situ* incorporation of cotton stalks into soil with rotary shredder and rotavator outperformed the practice of cotton stalks burning in all three years and recorded 8.5 to 10.5% yield increase and higher benefit: cost. The practice maintained to soil organic carbon content. However, technological gap, extension gap and higher technology index were present, indicating the need for further strengthening the transfer of technology for efficient adoption of the technology and realization of higher productivity and profits.

Keywords: crop residue recycling, Adilabad, yield gap, technology index, semi-arid.

Introduction

Cotton (*Gossypium hirsutum*) in India is a major commercial crop that largely drives the agrarian economy, especially in semi-arid regions. In India Since 1950s, Cotton area, production and productivity is continuously increased till 2023-24 to the tune of 12.68 million ha, 325.2 lakh bales and 436 kg lint/ha, respectively whereas, in Telangana, 1.82 million ha, 50 lakh bales and 475 kg lint/ha, respectively (DCD, 2026) owing to hybridization programs, genetic engineering, and adoption of improved crop management practices by the farmers. Cotton crop residue in the form of cotton stalks, leaves and dry bolls is obtained in huge quantities in the country and is estimated to be as much as 50 MT (Ratnam *et al*., 2020). In Telangana, most of the leftover cotton stalks are burnt in the field, and a small fraction is used for household cooking. Removal of the residue and its easy disposal is carried out to make the field ready for the next crop at the earliest. Burning of cotton stalks in the field poses several ill effects on the atmosphere, edaphic properties, and soil microflora. Further, these cotton residues contain a good amount of plant essential nutrients like nitrogen, phosphorus, potassium, sulphur, copper, iron, manganese and zinc (Bawane and Kedkar, 2018).

In-situ incorporation of these cotton stalks into the soil could be a suitable option to address the issue of loss of valuable nutrients and air pollution owing to burning. There are machinery and implements available to serve the purpose of *in-situ* incorporation of cotton stalks into soil after harvest of the cotton

(picking), those are disc ploughing with the standing cotton stalks, rotavators and shredding machines, vis-à-vis improvement in soil properties like available soil N, P, K, soil porosity and soil organic carbon (Senthilkumar and Thilagam, 2015). However, many farmers were not aware of this technology of *in-situ* cotton stalks shredding and its incorporation into soil (Savitha and Ravi, 2020). In this regard, considering a large cropped area in Adilabad district of Telangana state of India under cotton cultivation and the advantages of *in-situ* incorporation of cotton stalks into soil, frontline demonstrations (FLDs) of this technology were done on farmers' fields and findings are presented.

Material and Methods

The demonstrations were conducted for three consecutive years, i.e. 2016, 2017, and 2018 at three different farmers' fields per year in Adilabad district of Telangana State (India). The demonstrations were conducted by the District Agricultural Advisory and Transfer of Technology Centre (DAATTC) Adilabad, which worked under the administrative control of Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, Telangana. The frontline demonstrations were based on the On-farm testing (OFTs) of the technology of incorporating cotton stalks into soil for its suitability. The farmers having more than 2ha area (rainfed or irrigated) under cropping were selected. After harvest of seed cotton, the crop left with only stem, dried locules, dry bolls and dry leaves. The stalks were incorporated into the soil after crop harvest. Based on the results of OFTs and feedback from the farmers, tractor mounted shredding machine was selected to be the machinery used in *in-situ* incorporation of cotton stalks into soil for the frontline demonstrations. The FLDs consisting of two aspects: Demonstration: *In-situ* incorporation of Cotton stalks into soil with rotary shredder (Cotton stalks are incorporated into soil with rotary shredder and rotavator during January to April); and Check: Farmers Practice (Burning of cotton stalks). Other recommended crop production practices were common for both treatments. A Tractor (>45hp) mounted rotary shredder machine was deployed to shred the cotton stalks after harvesting was completed (January-March). The machine operates in a single row of the crop. The stem is cut at 07-10cm above ground level and shredded into small pieces of approximately 1inch and spread on the soil surface, leaving stubbles without uprooting. This operation was followed by the removal of stubbles through the Mould Board plough and clod crushing. As the last operation of land preparation rotavator was deployed criss-cross across the field. The succeeding cotton crop was sown on the commencement of south-west monsoon, and the crop was assessed for the performance of the demonstration.

To determine the technical viability, the percent increase (Raut *et al.*, 2021), Technology Index and assessments of technology and extension gap were employed (Samui *et al*., 2000).

$$\text{Percent increase (\%)} = \frac{\text{Demonstration yield (kg/ha)} - \text{Farmers yield (kg/ha)}}{\text{Farmers yield (kg/ha)}}$$

Technological gap (kg/ha) = Potential yield (kg/ha) -Demonstration yield (kg/ha)

Extension gap (kg/ha) = Demonstration yield (kg/ha)-Farmer's plot yield (kg/ha)

$$\text{Technological Index (\%)} = \frac{\text{Potential yield (kg/ha)} - \text{Demonstration yield (kg/ha)}}{\text{Potential yield (kg/ha)}} \times 100$$

Results and Discussion

Yield and economics

In all three years the respective farmers witnessed improvement in the yield owing to proper adoption of the demonstrated technology i.e. *In-situ* incorporation of Cotton stalks into soil with rotary shredder (Cotton stalks are incorporated into soil with rotary shredder and rotavator during January to April) over their conventional practice of post harvest uprooting of cotton stalks and burning on the field (Table 1). Seed cotton yield was reported as increased by 8.4, 10.5 and 10.1% in 2016-17, 2017-18 and 2018-19, respectively, over burning of cotton stalks after harvest. The Soil organic carbon content showed an increment under demonstrations at all locations (0.58%) over check fields (0.51%). This was because of the *in-situ* incorporation of cotton stalks for past the 3-5 years into the soil. Blaise and Ravindran (2003) reported the increment in soil organic carbon attributed to soil amendment with crop residue over 5 years. The continuous increment in the yield in demonstration could be attributed to the increase in soil organic carbon, available macro and micronutrients supplied by cotton stalks (Senthilkumar and Thilagam, 2015) after mineralization by the microbes (Ratnam *et al.,* 2020).

The demonstration at all locations fetched higher net income to the farmers, which could be attributed to higher yields and savings on the quantity and cost of chemical fertilizers per unit area (Table 1). Benefit: cost indicated that farmers fetched Rs. 0.77, 0.62 and 0.66 more on expenditure of 1 rupee through cotton stalk incorporation over the practice of burning cotton stalks in 2016-17, 2017-18 and 2018-19, respectively.

Farmers also replied that during continuous rainfall events, treatment plots showed no or less water stagnation compared to check plots. This might be the result of improved soil structure due to the incorporation of cotton stalks for 2-3 years. The intervention received appreciable response from farmers. However, the farmers expressed that the rotary shredder could be modified to perform two operations i.e., shredding and uprooting the stubbles in a single go.

Table 1 : Impact of *in-situ* incorporation of cotton stalks into soil on yield and economics of seed cotton for the consecutive three years.

Year	No. of farmers	Area (ha)	Yield (kg/ha)		Percent increase (%)	Benefit : Cost	
			Demo	Check		Demo	Check
2016-17	03	2.4	2643	2438	8.4	3.24:1	2.47:1
2017-18	03	7.6	3000	2714	10.5	3.34:1	2.72:1
2018-19	03	6.0	2500	2270	10.1	3.30:1	2.64:1

Yield gap analysis

Data presented in Table 2 showed that the promoted technology in the frontline demonstration influenced the technological gap, extension gap and technology index in consecutive three years of demonstrations. The difference between the potential yield of the cultivar and the obtained actual yield in a particular season are represented as a technological gap. The technological gap was estimated as 617, 260 and 760 kg/ha for the years 2016-17, 2017-18 and 2018-19, respectively. This finding indicated that the potential performance of cultivar RCH-659 with respect to seed cotton yield was not realized even under the practice of *in-situ* incorporation of cotton stalks into soil. This could be attributed to various factors like weather during critical growth stages, low soil fertility, sub-optimal crop management practices and biotic stress. This gap could be narrowed with the help of overcoming the associated factors.

Extension gap assesses the variation between the achieved yield with the introduced intervention i.e., demonstration, and the yield obtained by following the farmers' practice. The extension gap was ranged from 205 kg/ha to 286 kg/ha during three years of demonstration. In 2017-18, the extension gap was highest, while in 2016-17 it was minimal. However, when an average was observed, it was positive i.e., 240kg/ha. This enthusiastically suggested that the technology of *in-situ* incorporation of cotton stalks with a rotary shredder and rotavator has the potential to realize higher cotton productivity and monetary benefits in the long term for the cotton farmers of Telangana.

The technology index denotes the deviation of the yield under demonstration from the potential yield. Technology index percentage ranged from 7.9% in 2017-18 to 23.3% in 2018-19. This highlighted the need for better transfer of technology and efforts for its efficient adoption by the cotton farmers. This could be achieved by capacity building programs, real-time advisory regarding weather, incidence of abiotic and biotic stresses.

Table 2 : Yield gap analysis and technology index through *in-situ* incorporation of cotton stalks into soil

Year	Technological gap (kg/ha)	Extension gap (kg/ha)	Technology index (%)
2016-17	617	205	18.9
2017-18	260	286	07.9
2018-19	760	230	23.3
Average	545	240	16.7

Conclusion

Finding of frontline demonstrations revealed that the technology of *in-situ* incorporation of cotton stalks into soil with a rotary shredder and rotavator outperformed the unsustainable practice of uprooting and burning of cotton stalks in the field, produced higher yield and fetched profit, and maintained soil organic carbon. However, the demonstration could not achieve the yield as similar as the potential yield. The yield gap could be narrowed by emphasizing the transfer of technology with effective means and methods for the adoption of recommended practices for higher yield and profit.

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