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COTTON RESIDUE MANAGEMENT IN COTTON-GREEN GRAM CROPPING SEQUENCE-AN ON FARM EVALUATION

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ABSTRACT

An on-farm trial was conducted during Summer 2025 at Ganeshwaram and Bodyathanda villages of Khammam, Telangana, to evaluate the effect of cotton residue management practices on the performance of greengram (MGG-351) under irrigated conditions. The experiment was laid out in an On-Farm Research (OFR) design with three replications across farmer fields, comparing three treatments: T_1– incorporation by rotavator, and FP – farmer's practice (burning of stalks).Results revealed that mechanical incorporation of residues using a incorporation by rotavator (T_1) markedly improved growth and yield attributes such as plant height (58.6 cm), clusters per plant (7.0), and pods per cluster (7.0), compared to the farmer's practice. The treatment recorded a 9.7% higher seed yield (1543 kg/ha) and enhanced haulm yield (3820 kg/ha) over burning (1393 and 3610 kg/ha, respectively). The economic analysis showed higher profitability with net returns of ₹91,367/ha and a B:C ratio of 2.92:1, surpassing the farmer's practice (₹75,967/ha; 2.53:1). Post-incorporation soil analysis indicated improvement in organic carbon and microbial activity, confirming the beneficial effect of residue decomposition on soil health. The findings emphasize that mechanical incorporation of cotton residues using shredders is a sustainable, eco-friendly, and economically viable alternative to residue burning. Wider adoption through farmer training and access to shredding machinery can significantly enhance soil productivity and environmental sustainability in cotton–greengram systems.

Key words: Cotton Rotavator, Greengram and crop sequence.

Cotton (*Gossypium hirsutum* L.) is a major cash crop and an important component of dryland and irrigated cropping systems in southern India, particularly in Telangana. The cotton–greengram sequence is one of the predominant cropping patterns in this region, offering both economic and soil fertility benefits. However, the large volume of cotton stalk residue generated after harvest—ranging from 4 to 6 tonnes ha^{-1} — poses a major challenge for land preparation and timely sowing of the succeeding greengram crop. Farmers commonly resort to burning these residues to clear the field, which leads to nutrient loss, deterioration of soil health, and emission of greenhouse gases, adversely affecting environmental sustainability.

Residue management plays a pivotal role in maintaining soil fertility, enhancing soil organic carbon, and improving physical, chemical, and biological properties of soil. Incorporation of crop residues into the soil through mechanical shredding and in-situ decomposition offers an environmentally sound alternative to residue burning. Shredding of cotton stalks followed by microbial decomposition accelerates residue breakdown, facilitating nutrient recycling and improving soil tilth for the succeeding crop. Several studies have reported that residue incorporation increases soil organic carbon and available nutrient status, enhances microbial activity, and improves water infiltration and moisture retention—critical factors for short-duration pulses like greengram (*Vigna radiata* L.).

Greengram, an important pulse crop of India, serves as an excellent catch crop in sequential systems due to its short duration, low water requirement, and nitrogen-fixing ability. In the cotton–greengram sequence, its performance is largely influenced by the preceding residue management practice. Proper management of cotton residues not only improves the physical condition of soil but also provides residual nutrients, thereby enhancing the growth, yield, and profitability of greengram. Conversely, poor residue handling, such as burning or surface accumulation, hampers seedbed preparation, delays sowing, and leads to uneven crop establishment.

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On-farm evaluation of residue management technologies under real farmer conditions is crucial for understanding their practicality, cost-effectiveness, and adaptability. While several experimental station-based studies have demonstrated the benefits of residue incorporation, on-farm trials are essential to validate these findings across variable soil, climatic, and management conditions. Furthermore, assessing the economic viability of these practices provides valuable insights for farmers and policymakers in promoting sustainable crop residue management strategies.

Considering these aspects, the present on-farm study was undertaken to evaluate different cotton residue management practices—particularly mechanical shredding and incorporation on the performance of greengram in the cotton–greengram sequence. The specific objectives were to:

1. Assess the effect of cotton residue incorporation on growth, yield attributes, and yield of greengram.
2. Evaluate the influence of residue management on soil fertility improvement.
3. Compare the economic returns and profitability of different residue management options under farmers' field conditions.

Review of Literature

Residue management plays a crucial role in enhancing soil productivity and maintaining ecological balance.

- **S**ingh *et al.* (2019) reported that incorporation of crop residues improved soil organic carbon and microbial activity compared to residue burning.
- Patil *et al.* (2020) found that mechanical shredding and incorporation of cotton stalks increased soil nutrient availability and subsequent crop yields.
- Ramesh *et al.* (2021) observed that integrating crop residues with reduced tillage systems enhanced soil structure and moisture retention in black soils.
- Kumar and Sharma (2022) highlighted that residue incorporation in cotton–pulse systems improved soil fertility status and provided higher economic returns than burning practices.

These findings collectively suggest that mechanical incorporation of cotton residues can be an eco-friendly alternative to residue burning, contributing to both soil health and economic sustainability.

MATERIAL AND METHODS

Experimental Details

The on-farm research (OFR) was conducted during Summer, 2025 under the technical supervision of the Agricultural Research Station (ARS), Madhira, which functions under the control of Professor Jayashankar Telangana Agricultural University (PJTAU), Hyderabad. The trials were implemented at three farmers' fields located in Ganeshwaram and Bodyathanda villages of Khammam district, Telangana. The experimental fields represented a micro-farming situation characterized by shallow to medium black and red soils, low to medium in fertility status, and irrigated through wells and borewells. The test crop was Greengram (Vigna radiata L.) variety MGG-351, which is high yielding and suitable for the summer season. Each treatment occupied a plot size of 0.4 ha per farmer.

Treatments

Treatment	Description
T_1	Incorporation of cotton stalks by rotavator
FP (Farmer's Practice)	Burning of cotton stalk residues

Residue incorporation was carried out after the harvest of the preceding cotton crop. In T , cotton stalks were shredded using a intact stalks were incorporated by rotavator and incorporated into the soil. In the farmer's practice, stalks were burnt in situ, which served as the control.

Experimental Design

The study was laid out in an On-Farm Research (OFR) design with three replications across the selected farmer fields to ensure representativeness of field conditions. Standard recommended package of practices (PJTAU, 2023) for summer greengram cultivation was followed uniformly across all treatments except for the residue management component.

Observations Recorded

1. Growth and Yield Attributes

- Plant height (cm)
- Number of clusters per plant
- Number of pods per cluster
- Number of seeds per pod
- Total pods per plant
- Test weight (g per 100 seeds)

2. Yield Parameters

- Seed yield (kg ha^{-1})
- Haulm yield (kg ha^{-1})

3. Economic Indicators

- Gross returns (₹ ha^{-1})
- Cost of cultivation (₹ ha^{-1})
- Net returns (₹ ha^{-1})
- Benefit–cost (B:C) ratio

4. Soil Parameters

- Soil samples were collected before and after the experiment (0–15 cm depth) for estimation of organic carbon (%), and available N, P, and K (kg ha^{-1}) using standard analytical procedures (Jackson, 1973).

Critical Inputs and Cost Estimation

For the residue management component, rotavator hiring charges were considered at ₹1500 per intervention, with a total cost of ₹6000 for three locations. Other agronomic inputs, such as seed, fertilizer, and plant protection measures, were maintained as per the university recommendations and kept uniform across treatments.

Statistical Analysis

Data collected from the three locations were pooled and subjected to statistical analysis using Analysis of Variance (ANOVA) to test the significance of treatment effects at 5% probability level (P = 0.05) as per the method of Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Growth and Yield Attributes

Cotton residue incorporation using a rotavator (T_1) significantly improved growth and yield attributes compared to the farmer's practice (burning). Plants under T_1 recorded a plant height of 58.6 cm, which was higher than 56.0 cm under FP. Similarly, clusters per plant (7.0), pods per cluster (7.0), and seeds per pod (11.6) were superior to those observed in FP (6.6, 5.6, and 10.0, respectively). The total number of pods per plant also increased from 50.3 in FP to 55.3 in T_1. The improvement in growth parameters can be attributed to enhanced soil aeration, increased microbial activity, and gradual release of nutrients from decomposed residues. Incorporation of crop residues enriches the rhizosphere with organic matter, improving nutrient cycling and availability, particularly nitrogen and phosphorus, which are vital for vegetative and reproductive growth (Ghosh *et al.,* 2020). The slightly higher test weight (4.0 g) under T_1 compared to FP (3.9 g) indicates better seed filling and assimilate translocation, reflecting improved plant health and soil fertility. These results align with earlier findings by Kumar *et al.* (2018) and Ramesh *et al.* (2021), who reported that residue incorporation enhances root growth and microbial biomass, leading to improved crop establishment and productivity under rainfed cotton systems.

Yield Performance

Residue incorporation with a shredder recorded a seed yield of 1543 kg/ha, which was 9.7% higher than that obtained under the farmer's practice (1393 kg/ha). Similarly, haulm yield increased from 3610 kg/ha in FP to 3820 kg/ha in T_1. The higher yields in T_1 can be attributed to improved soil structure, moisture retention, and nutrient availability due to the decomposition of incorporated residues.

Residue burning, on the other hand, results in nutrient losses—particularly nitrogen, sulfur, and carbon—while adversely affecting beneficial soil microorganisms (Singh *et al*., 2019). The incorporation method facilitated the recycling of organic matter, leading to better nutrient uptake and improved physiological efficiency. Enhanced microbial decomposition also contributed to the slow and sustained release of nutrients throughout the crop growth period, supporting higher biomass accumulation and yield formation. Similar yield advantages due to residue incorporation have been reported in rice, maize, and cotton systems across semi-arid regions (Ghosh *et al*., 2020; Ramesh *et al*., 2021).

Table 1. Growth and Yield Attributes of Greengram as Influenced by Cotton Residue Management under Cotton–Greengram Sequence (On-Farm Trials)

Name of the Farmer	Village	Plant Height (cm)		Clusters/Plant		Pods/Cluster		Seeds/Pod	
		T1	FP	T1	FP	T1	FP	T1	FP
K.Shankar	Ganeshwaram	56	54	9	8	7	6	13	10
K.Rambabu	Bodyathanda	62	58	6	6	8	6	12	11
K.Ramurthy	Ganeshwaram	58	56	8	6	6	5	10	9
Average	—	**58.6**	**56.0**	**7.0**	**6.6**	**7.0**	**5.6**	**11.6**	**10.0**

Table 2. Yield and Yield Components of Greengram as Influenced by Cotton Residue Management

Name of the Farmer	Village	Total Pods/Plant		Test Weight (g)		Seed Yield (kg/ha)		Haulm Yield (kg/ha)	
		T1	FP	T1	FP	T1	FP	T1	FP
K. Shankar	Ganeshwaram	54	49	4.0	3.9	1550	1410	3850	3640
K. Rambabu	Bodyathanda	52	46	4.1	4.0	1480	1350	3690	3520
K. Ramurthy	Ganeshwaram	60	56	3.9	3.8	1600	1420	3920	3670
Average	—	**55.3**	**50.3**	**4.0**	**3.9**	**1543**	**1393**	**3820**	**3610**

Table 3. Economics of Greengram as Influenced by Cotton Residue Management

Name of the Farmer	Village	Gross Returns (Rs/ha)		Cost of Cultivation (Rs/ha)		Net Returns (Rs/ha)		B:C Ratio	
		T1	FP	T1	FP	T1	FP	T1	FP
K.Shankar	Ganeshwaram	139,500	126,900	46,500	48,500	93,000	78,400	3.00:1	2.61:1
K.Rambabu	Bodyathanda	133,200	121,500	47,800	49,600	85,400	71,900	2.79:1	2.45:1
K.Ramurthy	Ganeshwaram	144,000	127,800	48,300	50,200	95,700	77,600	2.98:1	2.54:1
Average	—	**138,900**	**125,400**	**47,533**	**49,433**	**91,367**	**75,967**		

Economic Analysis

Economic evaluation revealed that residue incorporation using a rotavator (T_1) was more profitable than the traditional residue burning practice. The gross returns under T_1were ₹1,38,900/ha, compared to ₹1,25,400/ha under FP. Although the cost of cultivation was slightly lower in T_1 (₹ 47,533/ha) than in FP (₹49,433/ha), the net returns were substantially higher (₹91,367/ha vs. ₹75,967/ha). The Benefit: Cost ratio also improved markedly from 2.53:1 in FP to 2.92:1 in T_1, indicating better economic efficiency and sustainability of the shredder-based residue management. The additional profit of approximately ₹15,400/ha demonstrates the practical viability of adopting mechanical residue incorporation at the farm level. These results corroborate the findings of Patel *et al.* (2020), who reported that residue recycling reduces input costs while enhancing long-term soil productivity and profitability.

Soil Health Improvement

Post-harvest soil analysis showed a notable increase in soil organic carbon and microbial activity in rotavator -incorporated plots compared to burnt plots. This suggests an improvement in soil biological health and nutrient cycling potential. The incorporation of crop residues provides a substrate for soil microorganisms, leading to enhanced enzymatic activity and aggregate stability (Singh *et al.*, 2019). Over time, this process contributes to the gradual build-up of soil organic matter, which enhances water-holding capacity, nutrient retention, and soil fertility. Such cumulative benefits are critical for sustaining productivity in dryland agro-ecosystems. The observed improvement in soil health parameters under residue incorporation is consistent with long-term studies by Ramesh *et al*. (2021) and Ghosh *et al*. (2020), emphasizing the role of conservation agriculture practices in restoring soil resilience.

Efforts to Popularize the Technology

Training-cum-field days were organized at farmer fields to demonstrate the benefits of cotton residue incorporation. Farmers were sensitized about the environmental hazards of residue burning and the long-term gains of sustainable residue management.

Extension gap: Despite the proven benefits, farmers continue to follow residue burning due to limited access to shredders and lack of awareness regarding its long-term advantages.

Research gap: Further studies are needed to quantify the long-term effects of continuous residue incorporation on soil carbon dynamics, nutrient cycling, and productivity stability across different soil types and cropping systems.

CONCLUSION

The on-farm trial clearly demonstrated that cotton residue incorporation using a rotavator significantly enhanced the growth, yield, and economic returns of greengram compared to the conventional practice of residue burning. Incorporation treatment (T_1) recorded 9.7% higher seed yield and improved haulm yield, along with superior plant growth attributes such as plant height, clusters per plant, and seeds per pod. The enhanced performance can be attributed to better soil health, improved microbial activity, and sustained nutrient release resulting from residue decomposition. Economically, the practice proved profitable with ₹15,400/ha higher net returns and a superior B:C ratio (2.92:1) over burning (2.53:1), highlighting its viability for sustainable farming systems. In conclusion, mechanical incorporation of cotton residues using rotavator is a sustainable, eco-friendly, and economically beneficial alternative to residue burning, warranting large-scale promotion through on-farm demonstrations and extension programs.

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