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Cotton Residue Management: The Step toward Waste to Wealth

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Cotton is one of the world's most important fibers and cash crops. It is the most widely used natural fiber in the world. Nearly 250 million people including smallholder farmers and their families across the world are depending on the cotton crop and its by products for their livelihood. In India, it provides direct livelihood to 6.0 million farmers and indirectly to 40-50 million people in the cotton trade and processing. India ranks first in the world in area under cotton cultivation (12.69 million ha). It is also the largest cotton producer in the world with 35.332.52 million tonnes in 2023-24. Cotton is the major crop of Gujarat and cover around 25% of total sowing area. Sowing area of cotton crop was 2.68 million hectares in the year of 2023.24. Gujarat was also second highest raw cotton producer with share of 28.43% in total lint production of the country *i.e.* 9.25 million tonnes in the year of 2023-24.

Cotton residues and their management

Of the total crop residue of 683 MT generated in India, only 178 MT of surplus crop residues are available and 12.7% of total residue or 48.9% of surplus residue being burnt across the country. In India and Gujarat, cotton crop generates nearly 25-30 MT and 4.50-6.50 MT of stalks, respectively with an average stalk production of 2-3 t ha^{-1}. Lion's share of cotton stalks is being burnt except 15% as fuel. Cotton stands third (9.8) in terms of air pollution emission intensity (PM2.5) next to sugarcane (12.0), maize (11.2) followed by rice (9.3) and wheat (8.5) (TERI, 2019). The major areas under cultivation of cotton are rainfed i.e. 65 percent of total area. Cotton crop produces residue like stalks, locules of bolls, leaves and roots. So, huge quantity of cotton residue is left in the field after the harvest of cotton. The general practice is to remove the stalks manually and burn them. This present practice of burning the cotton stalks in the field results in emission of GHGs. In order to avoid such a consistent environmental degradation by burning of cotton stalks every year after harvest, an effective utilization of the cotton stalks will save the environmental pollution and reduce the dependency of chemical fertilizers. The cotton stalk is rich in nutrients having 51.0, 4.9, 1.0, 0.61, 0.08, 0.43 and 0.12 per cent C, H, N, K, P, Ca and Mg, respectively. Cotton stalk contains about 67.3% holocellulose, 24.3% - 28.2% lignin, and 5.9% - 8.3% ash. Nutrients content in cotton stalk (%) and depletion of elements from soil by cotton plants is given in Table 1.

Table 1. Nutrients content in cotton stalk (%) and depletion of elements from soil by cotton plants

Elements	Nutrients content in cotton stalk (%)	Depletion of nutrients from soil by plants
Nitrogen	0.62% - 1.0%	100 - 150 kg/acre
Phosphorus	0.08% - 0.1%	10 - 20 kg/acre
Potash	0.61% - 0.68%	140 - 250 kg/acre
Calcium	0.43%	-

Elements	Nutrients content in cotton stalk (%)	Depletion of nutrients from soil by plants
Magnesium	0.12%	-
Sulphur	0.15%	10 - 20 kg/acre
Mangenase	147 ppm	25 - 100 gm/acre
Ferrous	324 ppm	200 - 800 gm/acre
Zinc	27 ppm	30 - 50 gm/acre
Copper	9 ppm	15 - 25 gm/acre
Boron	21.8 ppm	20 - 30 gm/acre
Molybdenum	1.6 ppm	5 - 10 gm/acre

In the recent days, farmers are becoming aware of worst events for humankind such as climate change, global warming, adverse effects of chemical fertilizers and agro-chemicals on public health. So, farmers are using advanced machinery for *in-situ* incorporation of crop residue and various techniques of *ex-situ* composting to convert agricultural bio-wastes into efficient inputs *i.e.* organic manures. Through latest machineries, cotton stalks are chopped into small pieces and can also be used as organic mulch that conserve soil moisture and reduce evaporation. Cotton stalks can also be used as organic manures, as a bio fuels, in the manufacturing of panel board/hard boards, paper making etc.

Reasons for crop residue burning

Farmers perceive that,

- It is easy for them to burn the cotton stalks to quickly prepare the land for sowing of succeeding crop.
- Short time lags between existing crop harvest and sowing of next season crop(s). Thus, farmers do not find time to manage the cotton stalks.
- Cotton stalks are resistant to microbial attack due to its wider C/N ratio and high lignocellulose content; hence, decomposition takes 4-6 months.

Impact of crop residue burning

Burning any crop residue in general and in cotton is cumbrous, time consuming and costly (Rs. 4375 ha-1 for cotton). It also affects the human health by polluting surrounding air.

In general, *in-situ* burning leads to huge losses of carbon (almost 100%) N (up to 80%), P (25%), K (21%) and S (50-60%), thereby depriving the soils of its organic matter (Mandal *et al.* 2004). Burning of residues resulted in loss of soil organic matter, which is ultimate threat for sustainability of cotton-based cropping system.

Burning leads to significant emissions of greenhouse gases like CO_2, NO_x, SO_x, NH_3 and volatile organic compounds (VOCs). It affects air quality and visibility in the urban areas because of already existing pollutants due to vehicular and industrial pollution. Finally, it leads to global warming and climate change.

Methods of cotton residue management

There are two significant methods of cotton residue management. Which are discussed below:

A) *In-situ* incorporation

Instead of manual removal of cotton stalks followed by burning, the wide-ranging machinery available can be used for removal or chopping and incorporation of organic waste such as rotavator, cotton stalk choppers, disc plough, disc harrow, tractor drawn cotton stalk puller-cum-chipper, multi crop shredders etc.

Advantages of in-situ incorporation of cotton stalk:

- Fastest, easiest and efficient way of cotton stalks management.

- A crop yielding 1.5-2 t stalk/ha can give back 12.4-20 kg N, 1.6 kg P_2O_5, 12.2-13.6 kg K_2O per hectare and other micro elements can be recycled.
- Increases organic matter content, which ultimately enhances soil physical properties like soil structure, soil porosity etc.
- Improve soil aeration and water holding capacity
- Enhance microbial activities in rhizosphere of succeeding crop.
- The pink bollworm is the major cotton pest that passes the winter in crop residue. So, cotton stalk incorporation in soil is providing a significant solution for eradication of pink bollworm**.**

B) Composting

Composting is a microbiological and non-polluting safe method for disposal and recycling of wastes by converting them into organic fertilizer. During composting, microbial populations convert organic wastes into humus. Many microorganisms with cellulosic activities such as *Aspergillus sp., Fusarium sp., Trichoderma sp.* as fungi; *Bacillus sp., Pseudomonas sp., Achromobacter sp., Vibrio sp.* as bacteria and *Streptomyces sp., Nocardia sp.* as actinomycetes have been reported which has significant role in decomposition of organic waste and formation of amorphous substances *i.e.* humus.

The ex-situ composting of cotton stalk can be done by two methods which are discussed here:

- **By vermicomposting:** Vermicomposting is an effective method of converting the mixed farm wastes and domestic garbage with chopped cotton residue into useful manure with the help of earthworms to recycle decomposable organic waste such as animal excreta, kitchen waste, farm residue, forest litter, etc.
- **By rapid composting:** The conventional composting process takes 3 to 6 months. Hence, rapid composting using microbial consortium can complete the process in 45 days for wet and 60 days for dry cotton stalks. The NPK content of this compost is 1.43:0.78:0.82% as compared to 0.5:0.2-0.4:0.3-0.5% of FYM. Thus, decomposed and enriched cotton compost has higher NPK value compared to normal composting which finally leads to better soil health and also reduces chemical fertilizer use. Sutaria *et al.* (2016) reported decomposition of cotton stalks with a mixture of cow dung + urea + compost culture + rock phosphate + castor and neem cake + *Azotobacter* and PSM culture. While, Seoudi (2013) recommended inoculation of cotton stalks with both *Phanerochaete chrysosporium* and *Azotobacter chroococcumgave* for obtaining desirable compost with narrow C/N ratio but high nitrogen content.

Challenges in crop residue management

The success of waste recycling depends mainly upon four factors: technology availability, accessibility, affordability and technology diffusion. SWOT analysis revealed that most of the challenges of waste management concern the lack of suitable equipment and infrastructure, inadequate data of waste-generation, lack of management and improper technical skills. In comparison to developed countries, the Indian scenario depicts that it is not actively involved in the recycling process, recycling plans and techniques. Moreover, little involvement of private sector, inappropriate choice of methods for waste recycling, lack of holistic policy measures and inadequate incentives/subsidies have resulted in poor outcome. Public attitude towards waste is also a major barrier to improving waste management in India. In the agriculture sector, *in-situ* burning of crop residues is the greatest threat against recycling them into the field. Scarcity of labour, high cost in removing and collection of the residues, lack of requisite machinery to incorporate crop residues in soil, and use of combine harvesters in rice, wheat and sugarcane-based cropping systems have made the problem more stringent.

Way Forward

Waste recycling could play an immense role for integrated nutrient management in natural farming-based practices. Therefore, a study to generate a database of waste material at the national scale is of utmost importance for future research and policy development. If recycling of waste really improves fertilizer use efficiency in the long term needs to be examined. Enrichment of compost with externally added nutrients and microorganisms could enhance the low-grade compost for better utilization. Though crop residues recycling is already recommended as an integrated part of conservation agriculture, farmers are facing a major challenge of slower decomposition of crop residues, which is leading to their burning. Thus, further pilot-scale research on *in situ* decomposition/management is the need of the hour.

Several technologies are available; they require some improvement to make them easily accessible by poor, low skilled farmers. Some of the areas where research activities could be taken up are: (1) Inventorization of amount of crop residue generated by different crops in different regions of the country, (2) Identification of the major uses of crop residues and comparative assessment of their competing uses, (3) Assessing the quality of crop residues and their suitability for various purposes, (4) Quantifying the permissible amount of residues of different crops which can be incorporated in the soil depending on cropping systems, soil types and climate without creating operational problems for the succeeding crop (5) Enhancing decomposition rate of residues for *in-situ* incorporation, (6) Analysis of benefit cost ratio and socio-economic impacts of residue retention or incorporation with conservation agriculture vis-a-vis residue burning (7) Developing complete package of practices of conservation agriculture for prominent cropping system in each agro-ecological region.

Problems with the crop residues are different in different region if India and are associated with the socio-economic needs of farmers. Therefore, policy needs to be formulated for each region separately as the policy in one region may not work in other region. There is also need to create awareness among farmer communities about the adverse impacts of burning and importance of crop residues incorporation for maintaining soil health and sustainable crop productivity. Further studies are needed to analyse the impact of the incorporation of cotton residues on the yield of succeeding crops, soil health and pest dynamics in the long run. Recycling of Crop residues has significant role in natural farming-based practices to maintain soil fertility status and soil physical properties for better crop production and productivity in long run.

References

1. Anonymous, 2025. District-wise Area, Production and Yield of Important Food & Non-food Crops in Gujarat State. Directorate of Agriculture, Krishibhavan, Sector-10 A, Gujarat State, Gandhinagar. Available at https://dag.gujarat.gov.in
2. Mandal, K. G., Mishra, A. K., Hati, K. M., Bandyopadhyay, K. K., Ghosh, P. K. and Mohanty, M. (2004). Rice residue management options and effects on soil properties and crop productivity. *Food, Agriculture and Environment*, *2*(1), 224-231.
3. Seoudi, O. A., Atalla, K. M. and Helmy, A. M. (2013). Bioconversion of some agricultural wastes into animal feed by *Trichoderma* spp.. *J. Am. Sci.*, 9(6): 203-212
4. Sutaria, G.S., Vora, V.D., Vekariya, P.D., Akbari, K.N. (2016). Technology for rapid composting of cotton stalk. *International Journal of Agricultural Science and Research*, 6(1), 211-216.
5. TERI (2019). Development of Spatially Resolved Air Pollution Emission Inventory of India. New Delhi: The Energy and Resources Institute.