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A CASE STUDY

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Compost production and Oyster mushroom cultivation – A potential entrepreneurship for cotton growing farmers

V. MAGESHWARAN, VARSHA SATANKAR, HAMID HASAN, S.K. SHUKLA AND P.G. PATIL

ABSTRACT : Currently, the stalks generated after cotton harvest is burnt in the field itself which results in soil fertility deterioration and environmental pollution. ICAR-CIRCOT, Mumbai has developed technologies for on-farm utilization of cotton stalks to restore soil fertility and bring additional remuneration to farmers by preparation of bio-enriched compost and cultivation of oyster mushroom using cotton stalks. The chipped cotton stalks of 3-4 cm in length were used for compost preparation. The bio-enriched compost was prepared from cotton stalks using microbial consortium within two months. The NPK level of cotton stalks compost was three times higher than farm yard manure. The application of 2 tonnes of cotton stalks compost per acre could sufficiently replace the requirement of 5 tonnes of farm yard manure in integrated nutrient management practice. The cost of production of one tonne of cotton stalks compost was Rs. 3000/- while market cost of farm yard manure ranges from Rs. 3000 to 3500/- . Thus, on an average, a farmer can save Rs. 9000/- per acre by replacing farm yard manure with cotton stalks compost. The hot water treated chipped cotton stalks of 3-4 cm length were used for oyster mushroom (*Pleurotus florida*) cultivation. The mushroom was cultivated by hanging bag technique during July to September, 2016. The average cropping period of mushroom was 27 days. About 130 g of mushroom was harvested from one kg of cotton stalks. The cost of production of one kg of oyster mushroom is Rs. 50 including spawn cost. The market value of oyster mushroom is Rs. 150/-. As an entrepreneurial activity, a cotton farmer can earn minimum of Rs. 1000/- for compost preparation while, Rs. 10,000/- for oyster mushroom cultivation from one acre of land, besides utilizing stalks generated in the field.

KEY WORDS : Compost production, Mushroom, Cotton, Farmers

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MEMBERS OF RESEARCH FORUM

Address of the Correspondence : **V. MAGESHWARAN,** ICAR-Central Institute for Research on Cotton Technology, MATUNGA (E), MUMBAI (M.S.) INDIA
Email: mageshbioiari@gmail.com

Address of the Coopted Authors : VARSHA SATANKAR, HAMID HASAN, S.K. SHUKLA AND P.G. PATIL, ICAR-Central Institute for Research on Cotton Technology, MATUNGA (E), MUMBAI (M.S.) INDIA

INTRODUCTION

Cotton is a cash crop and grown in most parts of the world. India ranks second in cotton production next to China. The estimated cotton production in India during

the year 2016-17 was 6 million tonnes which constitute about 26 % of the world cotton production (Cotton Corporation of India, 2017). Though cotton is grown mainly for its fibre it produced, the other two major by-products generated by cotton during its cultivation and processing are cotton stalks and cottonseed. In India, cotton is cultivated in the area of 12 million ha and about 30 million tonnes of cotton stalks are generated every year (Hiloidhari *et al.*, 2014).Most of these stalks are burnt in the field while some are used for domestic fuel purpose. The burning of cotton stalks in the field causes deterioration of soil fertility due to increase in soil surface temperature and air pollution due to increased CO_2 inputs into the atmosphere. On an average, the farmers are spending Rs. 700/- per acre for uprooting of cotton stalks for the field preparation of next crop. Even then, the cotton stalks are not subjected for any purpose. Chemically, the cotton stalks comprise about 75-82 % hollocellulose, 24-26 % lignin, 12-14 % moisture and 6-8 % ether extractive. The chemical composition this ligno-cellulosic waste makes them use inindustrial applications, especially in the preparation of particle boards, pellets, briquettes, bioethanol etc. The prerequisite for utilization of cotton stalks for any purpose is chipping of these stalks into small pieces of 3-4 cm using any commercial shredder. The shredded cotton stalks itself find application in thermal power plants as white charcoal. A cotton growing farmer can sell these shredded cotton stalks into thermal power plant or briquettes or pellets industries. A recent unpublished study conducted at GTC of ICAR-CIRCOT showed a farmer can sell the shredded cotton stalks at the rate of Rs. 2000/- to the industries. However, the factors such as collection and logistics of cotton stalks and extent of accessibility to biomass based industries influences the farmer's interest in utilization of cotton stalks. To overcome these problems, ICAR-CIRCOT developed technologies for *in-situ* utilization of cotton stalks for the farmers having small holdings and inaccessibility to industries for supply of shredded cotton stalks. The principle of fermentation technology was used for on-farm value addition to cotton stalks. In this paper, the technologies of ICAR-CIRCOT on preparation of bio-enriched compost and cultivation of oyster mushroom using cotton stalks have been discussed.

Bio-enriched compost from cotton stalks :

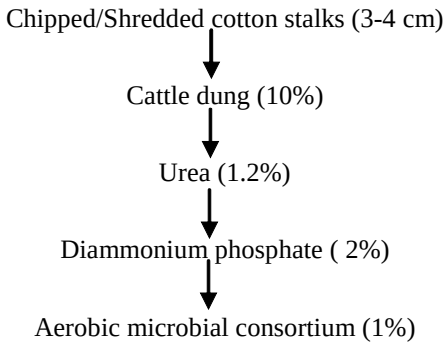
Composting is the process in which complex molecules such as lignin, cellulose, hemicelluloses, lipids is converted into simpler molecules (Summerel and Berges, 1989). During the composting process, besides the final product in the form of humus, heat, compounds of nitrogen, oxygen, phopshours, CO_2, H_2O and a significant amount of microbial biomass is created (Tiquia *et al.*, 2002). Many factors like temperature, moisture content, oxygen concentration and nutrient availability affects the rate of decomposition of organic matter. These factors in turn affect the structure and diversity of the microbial community, microbial activities and the physical and chemical characteristics of the compost (Miller, 1993). Although considerable work has been done on composting of organic waste, composting of high lignin content organic material like cotton stalks within shorter period is still a challenge. The moisture content of cotton stalks immediately after uprooting was 40 – 50 per cent and the same was found drop from 50 to below 20 per cent when the stalks were left in the field, after uprooting for three weeks (Gemtos and Tsiricogiou, 1999). The cotton stalks are normally uprooted in central and southern parts of country when the plant is almost dry, while the stalks are uprooted immediately after the harvest of cotton in northern parts of India (Anonymous, 2010). The moisture content of wet and dry cotton stalks were 30 and 12 percentages, respectively. Bio-enriched compost was prepared from wet and dry cotton stalks and compared (Mageshwaran *et al.*, 2015).

Microbial consortia :

Microbial consortia consisted of aerobic consortium and plant growth promoting microorganisms (PGPM). The aerobic consortium consisted of mixture of microbial strains *viz.*, *Bacillus stearothermophilus*, *Pleurotus flabellatus* and *Phanerochaete chrysosporium*.The aerobic consortium was added at initial compost preparation (0^{th} day) for accelerating the composting process by enhancing the degradation of lignin content of cotton stalks. The PGPM *viz.*, *Azospirillum*, *Azotobacter*, *Fluorescent Pseudomonas*, *Phosphobacteria* and *Trichodermaviridie* was added at the cooling period of composting period (after 30 days) to enrich the compost with biological agents to have additional properties of nutrient mobility and biocontrol ability.

Protocol for preparation of bio-enriched compost

from cotton stalks :



The ingredients mentioned in the flow chart was sequentially added to the chipped cotton stalks, mixed well and the heaps were made above the clean ground. Each heap was made with 1.7 tonnes of cotton stalks.The initial moisture content maintained was 50 per cent including the moisture content of raw cotton stalks. The heaps were covered with polythene bags and to provide aeration. Six perforated hollow Poly Vinyl Chloride (PVC) tubes (one inch dia) were randomly inserted to the heaps. This action will save the labour cost of periodical mixing of heaps for compost preparation. At 30 days, PGPM (all microbes) was mixed at the rate of 0.1% to the heap.

Physico-chemical properties of cotton stalks compost :

Experimental trials of composting of cotton stalks were taken during the last five years (2011-2016) at Institute farm and Farmers field. The trials were conducted at Nagpur, Sirsa and Coimbatore representing central, northern and southern parts of the country. The large scale composting trial taken at Sirsa during 2013 is depicted in Fig. 1a. The effect of microbial consortia on composting period of wet and dry cotton stalks was studied. The physico-chemical characterization of cotton stalks compost was done during the different intervals such as 0, 45, 60, 75 and 90 days. The results showed that carbon:nitrogen (CN ratio) was reached near to 20 at 60 and 45 days of initiation of composting in dry and wet cotton stalks respectively. CN ratio is one of the important criteria used to measure the maturity of compost ready for application in the field. In this study, good quality compost was prepared in 45 and 60 days from wet and dry cotton stalks, respectively. The conventional method of preparation of farm yard manure requires minimum of six months duration. Hence, the present method saves significant duration for preparation of organic compost and could be a best substitute for farmyard manure. Since, the availability of farmyard manure is highly reduced among the famers due to decline in animal populations in the rural areas. The NPK content of bio-enriched compost was about three times higher than farmyard manure. The NPK content in farmyard manure is 0.5, 0.2 and 0.5 percentages, respectively. The nutritive properties of compost prepared from wet and dry cotton stalks are presented in the Table 1. The compost prepared from cotton stalks is depicted in Fig. 2a.

Effect of cotton stalks compost on growth and yield of cotton :

Field experiments were conducted at ICAR-Central Institute for Cotton Research farms at Nagpur, Sirsa and Coimbatore to evaluate the effect of cotton stalks compost on growth and yield of cotton during 2012-14. The field evaluation trial taken at Sirsa during 2013 is depicted in Fig. 1b. The present integrated nutrient management (PINM) of three different regions was compared with the modified integrated nutrient management (MINM). In MINM, the recommended dose of 12.5 tonnes of farm yard manure was replaced with 5 tonnes of bio-enriched cotton stalks compost. The consolidated results of seed cotton yield (kg/ha) of PINM and MINM treatments of three different regions are presented in the Table 2. The results showed that seed cotton yield was not significantly different between PINM and MINM. Thus, 12.5 tonnes of farm yard manure could be sufficiently replaced by 5 tonnes of cotton stalks compost. Thus, a farmer can

Table 1 : Physico-chemical characterization of compost prepared from wet and dry cotton stalks

Sr. No.	Physico-chemical parameters	Compost from wet cotton stalks	Compost from dry cotton stalks
1.	pH	7.1	7.3
2.	Organic carbon (%)	22.2	30
3.	Total nitrogen (%)	1.1	1.6
4.	Total phosphorus (%)	0.9	0.8
5.	Total potassium (%)	0.8	1.5

replace six tones of farmyard manure with two tones of cotton stalks compost per acre while the cost of compost and farmyard manure is similar (Rs. 3000 per tone). Hence, Rs. 9000/- per acre could be saved by preparation of cotton stalks compost.

Table 2 : Effect of cotton stalks compost on seed cotton yield

Treatment	Seed cotton yield (kg/ha)		
	Nagpur	Sirsa	Coimbatore
PINM	3280	2272	2602
MINM	3274	2318	2510

PINM- Present integrated nutrient management;
MINM- Modified integrated nutrient management

Economics of compost production from cotton stalks :

The cost of production of one tone of cotton stalks compost is Rs. 3000/- (Table 3). Generally twenty per cent of weight of the material has been lost during composting process. The selling cost of bioenriched compost is Rs. 5/- kg. Thus a farmer can get return of Rs. 4000/- considering the considering the yield of 800 kg. Thus, the benefit cost ratio (BCR) is 1.14. As an entrepreneurial activity, a farmer can earn a minimum of Rs. 1000 per acre by preparation of bio-enriched compost from cotton stalks. About one tone of cotton stalks are generated from an acre of land.

Oyster mushroom cultivation :

Mushroom are the fleshy sporophores of fungi known to grow in nature on decaying cellulosic materials, dead wood, soil and manure pits. Majority of these fungi belong to the class Baidiomyctoina and a few to the class Ascomycotina. Edible fungi are classified under the order Agaricales and the families Agaricaceae, Polyporaceae and Pluteaeceae have been under commercial cultivation. The edible mushrooms are delicacy in food and form one of the choicest table dishes. They are rich in protein and an excellent source of vitamins and minerals. Most

Table 3 : Cost of production of one tone of cotton stalks compost

Sr. No.	Input	Requirement	Cost (Rs.)
1.	Chipped cotton stalks*	One tonne	1000
2.	Cow dung	100 kg	200
3.	Urea	12 kg	70
4.	Di ammonium phosphate	20 kg	400
5.	Aerobic microbial consortium	10 litres	100
6.	Plant growth promoting micro-organisms	1 kg	100
7.	Labour charges	2 man days	600
8.	Miscellaneous		530
	Total		3000

*The cost of chipped cotton stalks includes collection and chipping charges

(a) Composting trial at Sirsa (2013) **(b) Field evaluation trial at Sirsa (2013)**

Fig. 1 : Large scale composting and field evaluation trial taken at Sirsa (2013)

of the mushroom have very low starch content and can form an ideal food for diabetic patients. There are four major edible mushroom are cultivated on a commercial scale. They are, *Agaricus bisporus* (white button mushroom), *Volvariella* spp. (tropical mushroom or paddy straw mushroom), *Lentinus edodes* (Japanese mushroom) and *Pleurotus* spp. (Oyster mushroom). The button mushroom requires low temperature and grows on fermented substrates, whereas paddy straw mushroom grows on unfermented substrates and at an elevated temperature of 35°C. The Japanese and oyster mushrooms could grow on unfermented substrates at temperature of around 20°C and 30°C, respectively.

Agro-residues are commonly used for artificial cultivation of oyster mushroom. The most common agro-residues used are wheat straw, rice straw and pearl millet straw. Soybean straw has also been reported as promising substrate for oyster mushroom cultivation (Deshmukh and Deshmukh, 2016). ICAR-CIRCOT developed a technology for oyster mushroom cultivation using cotton stalks as substrate (Balasubramanya and Khandeparkar, 1989 and Sundaram *et al.*, 1989). *P. sajor-caju* was cultivated in chopped cotton stalks and yield of mushroom was reported as 250 – 400g per kg of dry cotton stalks. Mushroom cultivation is highly efficient method of disposing agriculture wastes and simultaneously producing nutritious food. The degradation of lignin, cellulose, hemicelluloses and tannin in the lignocellulosic residue during mushroom cultivation makes the spent cotton stalks as an ideal animal feed. Among the different substrates tested, cotton stalks and leaves was found significantly higher yield in respect of number and weight of sporophores (Tupatkar and Jadhao, 2006) while, Dundar *et al.* (2009) reported that mushroom grown on cotton stalks had higher vitamin content.

Protocol for oyster mushroom cultivation using cotton stalks using poly bag technique :

Initially, the bags were kept at 25 - 30°C at dark room until the white mycelium entangled completely in the cotton stalks. This mycelia development was taken place in 15 to 20 days. The polythene bag was removed carefully, by cutting using disinfected knife. After, two to three days, when the pin heads started appearing, the room was provided with ventilation with temperature not exceeding 30°C. Fruiting bodies started enlarging within three to five days and were harvested when they are just started folding inwards. Normally, two to three harvesting of mushroom takes place. Care was taken that during the entire process, the relative humidity was maintained at 55- 80 %.

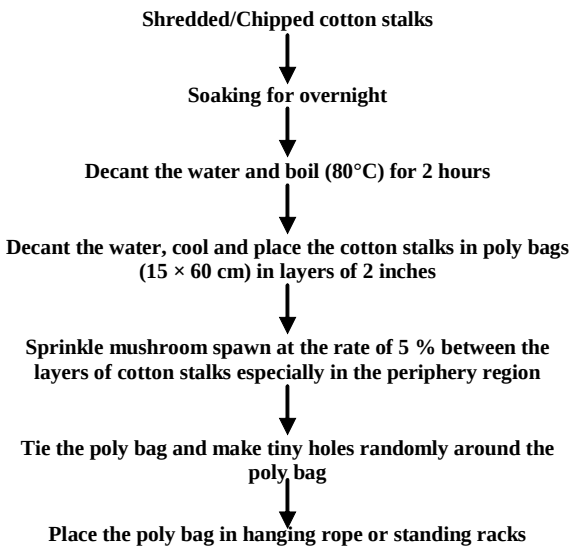


Fig. 2 : Flow chart for oyster mushroom cultivation

Oyster mushroom cultivation at GTC, Nagpur :

Experiments were conducted during the period July to September, 2016 at GTC, Nagpur for cultivation of oyster mushroom (*P. florida*). The cultivation was followed as per the protocol mentioned in Fig. 3. Five kg of shredded dry cotton stalks was used for each batch of cultivation. There were thirteen batches of oyster mushroom cultivation was taken. The oyster mushroom cultivated in cotton stalks and ready for harvested is presented in Fig. 3b. The results showed that 8.4 kg of mushroom was harvested from 65 kg of cotton stalks (Table 4). The average yield (g) from five kg of cotton stalks was 647. From the Table 4, it could be observed that the batches ten and thirteen had highest yield of 1467 and 1200 g, respectively from five kg of cotton stalks. This might be due to use of fresh spawn at these batches. In a similar study, twelve selected scientific cultivation practices were measured on yield of oyster mushroom. The results showed, the use of old spawn significantly affected the mushroom yield (Kushwah and Chaudhary, 2015). The short term storage of used spawn and long term storage of unused spawn under refrigerated conditions affects its viability. Thus, it is always

recommended to use fresh spawn during cultivation at one time.

Table 4 : Oyster mushroom cultivation using cotton stalks* at GTC, Nagpur

Batches	Cropping period	Yield (g)
1	25 days	526
2	26 days	574
3	27 days	557
4	31 days	375
5	26 days	397
6	28 days	421
7	29 days	427
8	29 days	369
9	29 days	422
10	24 days	1467
11	25 days	991
12	24 days	687
13	25 days	1200
Average	27 days	647

*5 kg of cotton stalks was used for each batch and distributed in five poly bags of (15 × 60 cm)

Economics of oyster mushroom cultivation :

The average cost of production of one kg of fresh oyster mushroom is Rs. 50/- while the major cost involved is spawn (Table 5). Also, the yield of mushroom is mainly depends on the quality of the spawn used. The selling price of fresh oyster mushroom ranges from Rs. 80 to 150/-. The selling price depends on marketing place, quality and other parameters. Thus, a farmer can earn a minimum of Rs. 30/- per kg of oyster mushroom produced. The benefit cost ratio is 1.6.On an average, a famer can generate additional income of Rs. 10,000/- by utilizing cotton stalks produced from one acre of land, considering one tone of cotton stalks is generated from an acre of land. The initial investment required here is thatched house of 20 × 20 feet dimension which costs to Rs. 20,000/-. The payback period is two years within which the initial investment could be recovered. In a similar study, oyster mushroom was cultivated in wheat straw + sugarcane substrate. The market rate of fresh oyster mushroom was Rs. 70/- per kg while the cost of production is R. 30 per kg (Sharma and Singh, 2014).

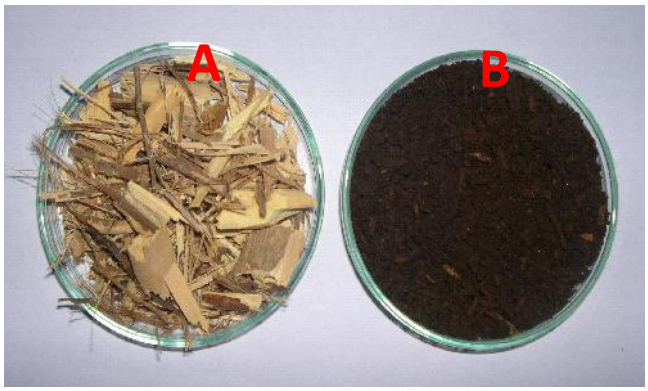
Farmers demonstration and training :

Considering the need of cotton growing farmers, these technologies were demonstrated among the farmers

Table 5 : Cost of production of one kg of fresh mushroom

Sr. No.	Input	Requirement	Cost (Rs.)
1.	Chipped cotton stalks*	5 kg	5
2.	Spawn	200g	30
3.	Labour	-	5
4.	Water and other miscellaneous cost	-	10
	Total		50

*The cost of chipped cotton stalks includes collection and chipping charges



a. Bioenriched compost from cotton stalks
A- Cotton stalks B- Cotton stalks compost

(b) Oyster mushroom on cotton stalks

Fig. 3 : Cotton stalks compost and oyster mushroom on cotton stalks

(a) Demonstration of compost preparation from cotton stalks at Tekoda Village, Asti Taluk, Wardha dist. (2015)

(b) Distribution of compost cultures to farmers (2017)

(c) Interaction with farmers at GTC, Nagpur (2017)

(d) Hands-on-training to farmers on oyster mushroom cultivation at GTC, Nagpur (2016)

Fig. 4 : Farmer's demonstration and training

for better on-farm utilization of cotton stalks and to generate additional income. Since, the year 2015, the activities on awareness, demonstration and training has been taken to make realize the benefits of these technologies among the farmers. Twenty villages in and around Nagpur and Wardha districts of Maharashtra was selected for transfer of these technologies. Two hundred and thirty eight farmers from the selected villages were given awareness about technologies on preparation of bio-enriched compost and oyster mushroom cultivation using cotton stalks. The interaction of farmers with scientists at GTC, Nagpur is presented in Fig. 4c. During this period, forty two selected farmers were given hands-on-training on preparation of bio-enriched compost from one tone of cotton stalks and oyster mushroom cultivation using five kg of cotton stalks at GTC, ICAR-CIRCOT, Nagpur. The farmers were demonstrated on preparation of compost is presented in Fig. 4a while a group of farmers acquainting knowledge on oyster mushroom cultivation is depicted in Fig. 4d. In order to promote the adoption of these technologies by the farmers at their farm, the farmers were distributed with compost cultures and oyster mushrooms spawn prepared by GTC, Nagpur (Fig. 4b). Also, GTC of ICAR-CIRCOT supplies compost cultures and oyster mushroom spawn to the farmers at nominal cost based on the requirement.

In a similar study, one hundred and ninety farmers were given training on oyster mushroom cultivation during 2012-13 at KVK of JNKV, Madhya Pradesh (Sharma and Singh, 2014). Mr. Y.N. Kabra, a progressive farmer from Asti Taluk, Wardha district, Maharashtra, had undergone training at GTC, Nagpur and now successfully

adopted these two technologies in his farm to add value to the cotton stalks generated in his field. Last year, he prepared compost from ten tonnes of cotton stalks using CIRCOT methodology and used in his own farm. He has been acting as a role model to other cotton growing farmers for on-farm value addition to cotton stalks. Dundar *et al*. (2009) also studied on the effect of *Pleurotus ostreatus* on yield, chemical composition and nutritional value of mushroom.

Conclusion :

Cotton stalks are annually available agroresidue having wide rural and industrial applications. To promote, on-farm utilization of cotton stalks, ICAR-CIRCOT developed technologies on preparation of bio-enriched compost and oyster mushroom cultivation.Farmer's can adopt these technologies as an entrepreneurial activity along with cotton farming to generate additional income. Furthermore, the problem of pollution arises due of burning of agroresidues in the field would be reduced and restores soil fertility.

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