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Effect of Milky Mushroom (*Calocybe indica*) in Different Agricultural Residues with Different Casing Materials

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Present study entitled was carried out in field irrigation lab, Department of Agricultural Engineering, Aditya Engineering College, Surampalem. In the present experiment locally available agricultural substrate paddy straw, sugarcane bagasse and cocopeat were tested with black soil and farm yard manner as casing materials. For parameters such as days required for spawn run, pinhead formation, harvest days, total yield and biological efficiency were determined. Significant results were obtained for all the experimental parameters and also for the stem length and cap diameter. Best substrate found was the paddy straw in the recent experiment with days required for spawn run (14 days), pin head formation (11.2 days), days for first harvest(50 days), stem length (8.07 cm), capdiameter (8.67 cm), first harvest (489.45 gm), second harvest (453.68 gm), total yield (925.24 gm), biological efficiency (94.31%). The next best in the order was coco peat followed by sugarcane bagasse. Hence this study confirms the suitability of paddy straw for cultivation to mushroom growers and farmyard manure with 15 cm casing thickness as substrate for its cultivation for achieving higher yield. The benefit cost ratio was estimated as 1.57.

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1. INTRODUCTION

The organisms commonly known as fungi (sing. fungus) are a tremendously diverse group found in virtually all habitats. Mushroom belongs to the Kingdom Fungi. Mushroom with their great variety of species, constitute a cost-effective means of both supplementing the nutrition to human kinds. Mushroom are appreciated, not only for their flavor and texture but also for their chemical and nutritional characteristics. Food and Agriculture Organisation (FAO) has recommended mushroom as a food item that can contribute significantly to protein nutrition of people especially in the developing countries like India. Besides it is estimated that about 355 million tonnes of agricultural wastes are generated annually and about half (170 millons) of this residue is left out for burning and incorporating soil in manure form. Recently about 385 million Tons [1] of agricultural wastes are available in India and half of these agricultural wastes unused. Even if one percent of it is utilized to produce mushrooms, India will emerge as the major mushroom producing country of the world [2]. One such promising mushroom of the tropical region is the milky or summer mushroom [3]. Mushroom are appreciated, not only for their flavor and texture but also for their chemical and nutritional characteristics. The protein content of mushroom is less than that in animals but much more than that in plants. They have low fat content, high fibre, all essential amino acids and important minerals [4]. In addition, they contain vitamin B1, B2, C, E, K, nicotinic acid, pantothenic acid and biotin. The mushroom has an attractive white sporophore, robust size, excellent shelf life, ability to grow at temperature above 30°C, high biological efficiency (80%) and easiness in post-harvest handling.

Huge quantities of agricultural wastes and other organic wastes are generated annually through the activities of agricultural, forest and food processing industries. These agricultural wastes and other organic wastes are abundantly available in our country. In India, during 1993-94 production of wheat straw and paddy straw was approximately 110.6 million Tons and 153.6 million Tons respectively [5].

The success of any agricultural nation depends upon the ability of their people to sustainably convert the natural resources into economic wealth with judicious application of schemes and technologies without endangering the environment. The only solution to feed the coming generation without harming the environment is by organic farming cultivation. White button mushroom (*Agaricus bisporus*) and milky mushroom (*Calocybe indica*) is also growing seasonally by small and marginal farmers in rural area with good results. Oyster mushroom cannot grow in the month of April to July due to higher temperature in the hotter regions. Therefore milky mushroom can be fitted for cultivation in higher temperature. Milky mushroom (*Calocybe indica*) has become the third commercially grown mushroom in India subsequent to button and oyster mushrooms [6].

This species can be cultivated on a wide variety of lignocellulosic substrates like wheat, rice, corn, and sugar cane bagasse, at a high-temperature range of 30-38°C [7] and has an elongated shelf life of 5–7 days as compared to other commercially grown mushroom species in India [8]. The commercial cultivation of this species was made after late 1998. The major constituents of milky mushroom are water (87%), carbohydrates (6.8%), proteins (2.75%), lipids (0.6%), fibers (1.67%), and minerals (0.5%–1%) [9]. Milky mushroom contains vitamins and minerals, predominantly B complex vitamins (thiamine, riboflavin, pyridoxine, pantotene acid, nicotinic acid, nicotinamide, folic acid, and cobalamin); as well as ergosterol, biotin and vitamin A [10].

The cost of cultivation is increasing day by day due to high cost of fertilizers, fungicides, insecticides, seeds, labour and irrigation. Fertile land under cultivation of crops is reducing due to urbanization, globalization and industrialization. Due to which many of the farmers becoming landless laborers'. Those farmers don't have land unable to purchase it for crop cultivation because of huge increment in the cost of fertile land. Climate change and environmental degradation too are playing a substantial role. The world is losing between 5 and 10 million hectares of agricultural land annually due to severe degradation. About 592,000 sq.km of India's land has already deteriorated and this is likely to affect 177 million people.

Marginal land holding farmers unable to purchased all the agricultural and essential

inputs because of their higher cost and try to find out an alternative over these problems by getting loans from either by government or private sectors. Due to unfavorable environmental conditions crop failure occurs this leads to suicides of farmers, malnutrition, poverty, hunger, unemployment. India can make rapid progress in mushroom industry by cultivating and commercializing of temperate and tropical mushrooms. But, they are still cultivated on small scale in some pockets on a specific substrates and yield potential is not satisfied due to specific substrates materials. There are need to evaluate various substrates and different casing materials for enhancing better growth behaviour and yield potential of mushrooms. Therefore, present investigation was on effect of substrates on growth behaviour and yield potential of milky mushroom.

As a result, the objectives of the study are to: 1) Evaluate the performance of milky mushroom in different agricultural residues; 2) Assess the casing materialfor milky mushroom cultivation; and 3) Analyze the cost economics of milky mushroom farming in the study area.

2. MATERIALS AND METHODS

In this head, the material required and process of milky mushroom cultivation by using different agricultural residues was described below:

2.1 Substrate Preparation

In order to study the effect of different substrates on the growth and yield of*C. indica*, an experiment was carried out with three different substrates viz., paddy straw, sugarcane bagasseand coco peat. These selected paddy straw and sugarcane bagasse chopped into 3-5 cm pieces by using grass cutter.

(a) Paddy straw

(b) Sugarcane bagasse

(c) Coco peat

Fig. 1. Different agricultural substrates

2.2 Soaking

The substrates were soaked in water for 18-24 hr and then excess water was drained off from substrates. This period can be reduced when sterilization is to be done by steam. Main purpose of soaking is to saturate the substrate with water. It is easier to soak if straw is filled in gunny bag and dipped in water.

2.3 Fermentation of Substrates

Fermentation in mushroom cultivation can be defined as the converting by microorganisms of the nutrients of substrates into proteins. Various raw materials are subjected to lactic fermentation (paddy, cocopeat, sugarcane bagasse), which yields food products with high nutritional and dietary value.

2.4 Hot Water Treatment

The purpose of sterilization is to kill harmful microbes. Water was boiled in a wide mouth container such as tub or drum. The wet substrate was filled in gunny bags. In general, a sterilization requires a minimum of 121°C for about 15-20 minutes at 1 atm pressure [11]. To avoid floating, it was pressed with some heavy material or with the help of a wooden piece.

2.5 Spawning

It is the process of introducing the spawn into the substrate with the aim of achieving rapid growth for production of fruit bodies. For the process of spawning, transparent polythene bags were taken and filled with alternate layers of the substrate and spawn (layer spawning) up to 3/4th of their capacity. Small holes were then made in the bags and their necks were closed with rubber bands so as to form cylindrical shape.A temperature of 30±2°C was maintained in the mushroom house for spawn running, which refers to the growth of the spawn in the substratum. This is the vegetative phase of the life cycle, that is, white cottony mycelium spreads to cover the substrate surface. The spawn run takes place within 10-15 days.

2.6 Casing

Casing means covering the top surface of bags after spawn run is over with pasteurized casing material in thickness of about 3-4 cm. Casing provides physical support, moisture and allows gases to escape from the substrate. Milky mushroom needs casing for fruit body initiation.After completion of spawn run ormycelial growth in the beds, bags were cut into two halves, opened and casing layer spread on the surface of mushroom bed at three different thickness of 15, 30 and 45 mm and sprinkled with water whenever it is necessary. These casing materials were prepared by sterilized black soil and farm yard manure. The physical characteristics of the casing material like water holding capacity (%), bulk density (g/cm^3), pH, EC (dS/m) and the texture of different casing materialswere studied.

Fig. 2. Casing with black soil and farmyard manure

2.7 Cropping

It takes about 10 days for mycelium to reach on top of casing layer when fresh air is introduced. Mushroom beds were sprayed regularly with water to maintain sufficient moisture level in the casing surface. Light should be provided in long time. The changes thus made in environment, will intiate the fruiting bodies within 3-5 days in the form of needle shape which mature in about a week. Pinheads appear ranged between 44 to 52 days after spawning and they were ready for harvest within another one week. Mushrooms 7-8cm diameter are harvested by twisting, cleaned and packed in perforated polythene/polypropylene bags for marketing. Mushrooms can also be wrapped in klin film for longer storage. After the first harvest, the casing medium is gently ruffled, slightly compacted blank, sprayed daily with water.

2.8 Observation and Measurement

Growth behaviour such as spawn run period, initiation of pinhead and harvesting of fruit bodies

were observed in days. The morphological parameters of fruit bodies and yield of mushroom were also measured during investigation.

A. **Time taken in days:** Spawn run period, initiation of pinhead and harvesting of flushes
B. **Morphological parameters of fruit bodies:** Cap diameter (cm), pielus breadth (cm) and stem length (cm)
C. **Yield in gm:** Yield of different flushes and total yield

Biological Efficiency: It is a practical estimate of the ability of mushrooms to convert substrate into fruiting bodies, which may be greater than 100%. Biological efficiency (BE) was calculated as per the following formula:

$$Biological\ efficiency = \frac{Yield\ of\ fresh\ mushroom\ (gm)}{Total\ weight\ of\ dry\ substrate\ used\ (gm)} \times 100 \quad (1)$$

2.9 Time Duration for Production

Every agricultural product needed certain time duration for the production.Through a previous study, it was observed that Spawn running period 24-28 days and Total cultivation cycle of 57-60 days. Mushrooms can be harvested in 2 flushes after which the entire cycle is repeated.As time duration for mushroom cultivation varies from types of mushrooms per the study area.As most of the farmers have been farming same species of mushroom so they normally start harvesting their product by three weeks.

A. Production per Bag

As the mushroom cultivation study was done in plastic bag and found out that average per bag production is 5 kg. Though mushroom production can be vary on the basis of quality of hay, environment of shed, amount of water supply and bag size.

B. Cost per kg during Production

For example, according to the previous studies, it was found out that average cost of mushroom per kg is Rs.300 while cost rises up to Rs.400 after adding transportation cost while transporting product to the product. While if farmers get price more than Rs.400 then they starts to get profit if their products get less than Rs.400 then it's loss as breakeven point of the product is Rs.400.

C. Manpower Supply

No agricultural activities can be done without the proper supply of man power, so in terms of mushroom cultivation too enough supply of man power is needed in order to achieve desired goal. On the basis of surrounding responses of the farmers, it was found that at least 5 people per day is needed to look after the farm.

D. Transportation

Road transportation is one of the easiest and accessible ways to reach the main market. It is easy to supply from four wheeler vehicle in our city anywhere, any time. Mostly production sold on local markets and some samples at malls and restaurents.

3. RESULTS AND DISCUSSION

3.1 Effect of Substrates on Growth Behaivour of Milky Mushroom (*Calocybe indica*)

The data presented in the (Table 1) indicated that spawn run period was very fast on Paddy straw substrate, where it took in (14 days) followed by cocopeat (15.7 days) and Sugarcane bagasse (16.8 days). This conclusion is corroborated by the fact that average time period recorded for spawn run of C. indica on all the tested agricultural wastes did not exceed 17.2 days. In addition, CO_2 concentration, temperature range and humidity existing within the substrate bag are also important.

3.2 Assessment of Casing Materials for Cultivation

Casing is an important cultural practice for the cultivation of certain mushrooms such as Agaricus, Lentinula and Calocybe. It means covering the cultivation substrate with a layer of soil or soil like material after spawn run, which improves the transformation of vegetative stage to reproductive stage. Therefore, it stimulates the pinhead formation and provides physical support to the mature fruit bodies. In fact, casing layer acts as a platform for initiation of uniform fructification and also provides anchorage and necessary reserves for developing sporophores of mushrooms. For the present investigation, two different casing materials viz., black soil and farm yard manure (FYM) were used for the Cultivation of *C. indica*. The physical characteristics of these

casing materials was shown Table 1 and the effect of their pinhead formation were evaluated.

Among the different casing materials evaluated for *C. indica* cultivation, farm yard manure (FYM) possessed the best physical characteristics like high water holding capacity (84.6%), low bulk density (0.48g/cm^3), low soluble salts and electrical conductivity (0.16 dS/m), almost neutral pH (6.98) and sandy soil texture.

3.3 Initiation of Pin Head Formation

After evaluating the physical characteristics of casing materials, the effect of casing types and their thickness on pinhead initiation were evaluated. Results shown in Fig. 3 indicates that FYM casing thickness of 15 mm was ideal for quicker primordial initiation. It was also observed that by increasing the casing thickness layer, there was a delayed appearance of pinheads. The mushroom pin head were first initiated from Paddy straw substrate followed by mixture of coco peatand sugarcane baggasse.

3.4 Combined Effect of Casing Material and Substrate on Productivity

During the present investigation, casing materials viz., black soil and farm yard manure and agricultural substrates (paddy straw, sugarcane baggasse and coco peat) were studied for their combined effect on biological efficiency.

Table 1. Physical characteristics of different casing casing materials

Casing materials	Water holding capacity (%)	Bulk density (g/cm^3)	pH	Electrical conductivity (dS/m)	Composition and textural class
Black soil	42.65	1.32	7.9	0.98	Sand (52%) Silt (13%) Clay (35%) Sandy clay
Farm yard manure	84.6	0.48	6.98	0.16	Sand (40%) Silt (18%) Clay (42%) Sandy clay loam

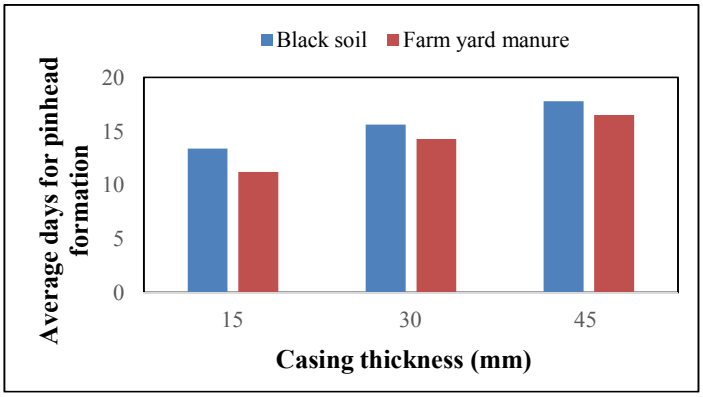

Fig. 3. Days for pin head formation

Table 2. Days required to harvest under different treatments

Substrates	Casing material	Harvesting of flushes	
		1st flush	2nd flush
Paddy straw	Black soil	56	74
	FYM	50	68
Sugarcane bagasse	Black soil	65	79
	FYM	58	75
Coco peat	Black soil	61	77
	FYM	56	72

3.5 Biological Efficiency

Perusal of data presented in table 3 shows that among the three different agricultural wastes tested and the two types of casing materials used, maximum yield of C. indica (471.56/500g of dry substrate) was obtained on paddy straw with farm yard manure as the casing material. This was followed in decreasing order by coco peat and sugarcane bagasse which yielded 441.07g, 291.94g, of sporophores respectively when encased with farm yard manure. Biological efficiency achieved on these agricultural wastes was in accordance with the yield, being maximum (94.31%) on paddy straw and minimum (50.0%) on sugarcane baggasse.Similar observations have been noted earlier by Chang and Miles [12].

The reason for low yield and biological efficiency on cocopeat and sugarcane bagasse may be due to less availability of necessary lignocellulosic compounds that may be required for fruit body formation. On the other hand, superiority of paddy straw as compared to many other substrates has been reported for *C. indica* by other workers also [13].

3.6 Analysis of Cost Economics in Milky Mushroom Farming

Production is the function of investment and its efficient use. The various items that constituted for the investment on equipment used in mushroom cultivation for 300 m^2 area are presented in Table 4.

The total production of mushroom is 65 kg per 300 m^2. The cost of mushroom in the market is Rs. 400 per kg. So, the total cost of production is Rs. 26,000. The net profit involved in mushroom cultivation is Rs. 9470. The benefit cost ratio was estimated as 1.57. This shows that large scale growers can efficiently use their resource to earn higher returns.

Fig. 4. Yield of milky mushroom

Table 3. Effect of substrates on growth parameters of milky mushroom

Substrates	Casing material	Stem length (cm)	Cap diameter (cm)	No. of fruiting bodies per bag	Yield of 1st flush (gm)	Yield of 2nd flush (gm)	Yield/500 gm of dry substrate	BE (%)	Total yield (gm)
Paddy straw	Black soil	7.24	7.80	14	422..64	410.33	416.48	83.29	832.97
	Farm yard manure (FYM)	8.07	8.67	16.25	489.45	453.68	471.56	94.31	925.24
Sugarcane	Black soil	6.50	7.05	10.48	288.56	211.51	250.03	50.00	500.07
bagasse	Farm yard manure (FYM)	7.36	7.65	12.37	343.56	240.32	291.94	58.38	583.88
Coco peat	Black soil	5.33	7.33	7.53	411.31	384.22	397.76	79.55	795.53
	Farm yard manure (FYM)	5.94	7.84	8.88	462.70	419.45	441.07	88.21	882.15

Table 4. Cost economics of Milky mushroom farming

S. no.	Particulars	Cost (Rs.)
1	Cost of racks	3200.00
2	Chopper	2000.00
3	Thermo hygrometer	1100.00
4	Black soil	1000.00
5	Boiling vessel	1500.00
6	Exhaust fan	910.00
7	Polythene bags	1000.00
8	Spawn	2600.00
9	Chemicals	700.00
10	Electricity	420.00
11	Labour charges	1600.00
12	Miscellaneous	500.00
	Total	16,530.00

4. CONCLUSION

Mushroom cultivation is the most appropriate technology for creating wealth and health from abundantly available wastes from plants, animals, and industries. Agricultural and other organic wastes generate massive amounts of waste each year as a result of the activities of the agricultural, forestry, and food processing industries. These agricultural wastes, as well as other organic wastes, are abundant in our country. The major parts of these agricultural wastes are burnt after harvesting, resulting multifaceted hazards including oxygen defiant environment, respiratory diseases such as allergic, bronchitis, asthama, tuberclusis and poor visibility at night. The useful insects, bio-agents, earthworm and soil microbe are also reduced due to burning of agricultural wastes and its heating on soil surface. According to survey, in some places these agricultural wastes are spreads on the cultivated land but it is not well decomposed and they created the problems during farming. The primary concern is to eliminate air pollution and soil pollution in order to protect the environment. This can be done by scientific utilization of resources and bioconversion for mushroom production.

Mushroom production seemed like an appealing way to improve the nutritional quality of lignocellulosic wastes for use as animal feed stock. Among the various physical, chemical and biological methods used for upgrading the digestibility and nutritive value of agricultural wastes, biodegradation by using white rot fungi including mushrooms have been found promising. There are need to evaluate various substrates for enhancing better growth behaviour and yield potential of mushrooms. As a result, the current study focused on the effect of substrates on the growth behaviour and yield potential of milky mushrooms. These studies will help to mushroom growers for selection of suitable substrates, for better growth behaviour and yield potential of milky mushroom.

For the mushroom cultivation, the paddy straw substrates are very suitable for the milky mushroom cultivation. The higher yield of quality mushroom depends upon proper maintenance of pure culture as well as purity and quality of the spawn used. Hence, low cost and quality spawn is the basic requirements for mushroom growers. For the prevention of various disease contamination, maintain the balanced temperature and humidity and avoid the direct entry into cropping room without sanitize.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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