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Review Article

A Review on Paddy-Straw Mushroom Production and Incidence of Contestant Moulds

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A B S T R A C T

Mushrooms are popular for their nutritive and flavored food value. Among all the edible mushrooms paddy straw mushroom (*Volvaiella volvacea*) is very popular for its flavor, taste, and high protein content. These mushrooms have huge demand in eastern states like Odisha and West Bengal. Favorable environment helps for mushroom production in that area. It needs temperature (25-35 ℃) and relative humidity 80-90% for proper growth and development. Various methods are used to enhance the biological efficiency of *Volvaiella volvacea*, but cage method is the best cultivation method. It has low production cost and cropping duration approximately of 15 days. It grows well in both outdoors and indoors conditions. However, various contestant moulds overrun the beds at different stages of crop growth and reduce productivity. *Aspergillus spp*., *Coprinus spp*. And *Rhizopus sp*. is frequently seen in mushroom beds in both outdoor and indoor conditions. There are different chemical methods to control these moulds. After the cultivation of mushrooms, the leftover can be used for compost or when used in soil it helps to prevent plants from the soil-borne pathogens.

Keywords

Volvaiella volvacea, Mushroom, *Coprinus spp.*

Introduction

The mushroom defined as "a macro fungus with an individual fruiting body, can be seen in the naked eye and to be picked up by hand" (Chang and Miles, 1992). Generally, mushrooms are different from plants. Mushrooms are heterotrophs in nature. They do not contain chlorophyll. They cannot create nutrients by photosynthesis, but take nutrients from their surroundings (Palitha Rajapakse, 2011). There are various types of fungi in the world, but only a few are edible. Nowadays, mushrooms gain popularity not in India but all over the world for their nutrient and medicinal value. It is used as a food, as a medicine, and also as a tonic (Chang, 2007). Mushrooms are good sources of sugars, fibers, minerals and also contain some essential amino acids. Mushrooms contain 80-90% water, 3% protein, 4% carbohydrates, 0.1% fats, 1% minerals and some quantity vitamins (Tripathy, 2010; Bolton and Blair, 1982). Mushroom cultivation gains huge impact in cottage industry due to its low input and higher return rate.

Several substrates rich in organic matters have been using for mushroom cultivation. Vegetable waste paddy straw, wheat straw, dried banana leaves have used as the substrate for mushroom cultivation (J.W Zakhary *et al.*, 1984). Wastes from food

industries and agricultural residues are available in increasing quantities in India. Cultivation of mushroom on such wastes increases the food supply and improves the nutritional value of agriculture waste for animal feeding.

Paddy straw mushroom (*Volvariella volvacea*), are generally known as the rice straw mushroom, or the Chinese mushroom. It belongs to the family Pluteaceae of the Basidiomycetes (Singer, 1961). Paddy straw mushroom is also known as warm mushroom as it grows in relatively higher temperature. It is an edible mushroom in eastern states like Odisha and West Bengal. It was first cultivated in China in 1822. (Ahlawat and Tewari, 2007) It is a fast-growing mushroom under favorable growing conditions. Total crop cycle is completed within 3-4 weeks. A wide range of cellulosic materials is used for this mushroom. The C: N ratio is needed to be 40 to 60, the C: N ratio for paddy straw mushroom is quite high as a comparison to other cultivated mushrooms. Eastern Indian states comprise of North Eastern region (Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Tripura, Sikkim and Assam), West Bengal, part of Bihar, Jharkhand and Odisha has good potential and scope for paddy straw mushroom cultivation due to the wide availability of basic substrate (paddy straw) and favorable temperature. The high-temperature requirement 26°C to 30°C for mycelium development and 34 to 37°C for fructification, relative humidity 70-90% also make it, a good choice for adoption in round the year cultivation of mushrooms (Biswas *et al.,* 2014). Various substrates are used, for cultivation of paddy straw mushroom (*Volvariella* spp.) Some of these agricultural wastes include banana leaves, rice bran, wheat bran, sugarcane baggage (Tripathy, 1999), wheat and rice straw (Cangy and Peerally, 1995). After the production of mushroom, the leftover is generally used for animal feed. Due to the production of mushrooms, the wastes are composed of the most quantity of nutrients and have more digestibility capacity (Chandra and Chaubey, 2017)

Cultivation of paddy straw mushrooms has generally done in outdoor conditions. Use of non-pasteurized paddy straw leads growth of various contestant moulds. Various contestant moulds have seen in the straw mushroom beds during the fruiting stage. A large number of competitors moulds such as *Coprinus* spp. *Mucor* sp. *Aspergillus flavus*, *Penicillium* spp., *A. niger*, and *Rhizopus oryzae* have been recorded in the beds. *Coprinus* spp. Growth is more in both outdoor and indoor farming conditions. However, outdoor farming recorded more bed contamination (46.8%) as compared to the indoor one (27%) (Chinara *et al.,* 2014). Use of 2 % calcium carbonate solution for a pre-soaking substrate for eight hours was significantly superior among the treatments in giving a higher yield with a corresponding biological efficiency of 14.52 %.use of streptomycin (0.01%) and benomyl (0.2%) reduce the emergency of *Corprinus spp*. (Mohapatra and Chinara, 2014) Different chemical and biological methods are also used to control various contestant moulds (Table 1 and 2).

Physical characteristics and life cycle of paddy straw mushroom

Generally, there are six different stages in paddy straw mushroom cycle (Samarawira, 1979). When mycelium starts to develop, the mushroom begins its first stage of development called the *pinhead stage* (Ahlawat and Tewari, 2007) the whole structure is a group of hyphal cells. It has characterized by tiny white clusters with a web of hyphal cells. *Tinybottom stage*, only the top of the veil is brown, while the rest is

white. Both the tiny button and pinhead stages have formed from the weave of hyphae. It has followed by the *button stage* in which buttons have egg-shaped structure and covered with a layer of tissue (Thuc *et al.*, 2019). The stalk (stripe), gills (lamellae) and cap (pileus) are seen inside the button when it is cut lengthwise. In this stage, the mushrooms have sold in the market at a premium price. At *egg stage*, the pileus is coming out of the veil, and the veil remains as Volva. The size of the pileus is very small at this stage. The *elongation stage* occurs when volva starts to rupture, exposing the stalk and the cap. This stage is smaller than the mature stage. The last, stage *maturity* has characterized by the fully opened cap with the brownish-pink gills of its lower surface. (Sahoo *et al.,* 2012) At the maturity stage, the spawns (basidiospores) begin to discharge to the environment (Ahlawat and Tewari, 2007).

Different methods of bed preparation

Generally, four methods of bed preparation used for mushroom cultivation. i.e., bed method; heap method, cage method and spiral method. It mainly depends upon the farmer what method of bed preparation is easy to cultivate. Cage method is one of the best methods of bed preparation as it has commonly used by many farmers.

Bed method

It is the simplest method of bed preparation (Akinyele *et al.,* 2005). For making these beds, four paddy straw bundles were placed side by side on the bamboo stage and another four bundles placed similarly but from the opposite direction so that, the open ends of all the bundles should overlap each other. The same method is followed for the second; third, fourth layer. Up to 500 gm. of spawn is used per bed. Spawns are used in layers, leaving some margins (Biswas and Mrinmoy Layak, 2014).

Cage method

In this method, well drain soaked straws are used. Ten bundles of straw placed uniformly in the cage at the bottom layer (1.00m x 0.50m x0.25m). In the same manner, the second layer bundles were placed. The same process is followed up to six layers. Spawn is placed between layers. After that a transparent polyethylene sheet is covered and tied it with jute string. (Mohan Kumar Biswas, 2014).

Heap method

In this method, a straw bundle is placed in the zig-zag method. This method is much similar to the cage method. Six layered of straw and a depth of 2 feet was prepared. Spawning was done between all six layers. The bed was compacted and watered if needed to maintain the moisture.

Spiral method

Water-soaked bundles are bound with a thread. Then 500 gm of spawn is mixed with the bundles to prepare the bed. The spawned substrate was then covered with a thin polythene sheet (Ahlawat and Tewari, 2007).

Cultivation technology of paddy straw mushroom (*Volvariella volvacea*)

Traditionally cultivated of mushroom was done with uncomposed and unpasteurized bundles of banana leaves (Belewu, 2005) (CHUA *et al.*, 1973) or paddy straw (Banik and Nandi, 2000) tied at both ends and laid one on top of the other two ends for the formation of beds. After the formation, beds are covered with plastic sheets (Palitha Rajapakse, 2011)

However, the yield on mushroom beds is unstable and irregular due to microbial contamination and fluctuating environmental

conditions. To improve the productivity indoor cultivation of paddy straw mushroom using rice straw as the main substrate was started (Zikriyani, 1951).

Rice straw or stubble is generally used as bedding materials or substrates. (Khan, S. M. 1991) These Materials collected from the field must be sun-dried to maintain the moisture of straw. (Royse *et al.*, 1991) They are tied into bundles then cut into the required size. There are mainly three methods which improve the productivity of mushroom cultivation.

Soaking

Required size bundles are taken and soaked in water for 8-10 hours. Some amount of lime is added to the solution to maintain the pH. Bundles are taken out of solution and then kept in an inclined manner to remove excess water. Then the process of formation of beds starts after 2 hours (Renato Reyes, 2016).

Composting

The composting period generally takes 14 days. During the first seven days of composting, the bed is covered with plastic sheets to induce the growth decomposers. (Choudhary *et al.*, 2009) In this period, mycelia growth started. 8-10 days time period there is the growth of pinheads of mushroom. (KNisa *et al.*, 2019).

Fruiting and harvesting

Mainly three stages of fruiting are seen. These are at bottom stage, egg stage and elongation or mature stage. Harvesting of mushroom generally done at the bottom stage. Profitability is more when mushrooms are harvested at bottom stage (Tripathy and Sahoo, 2010).

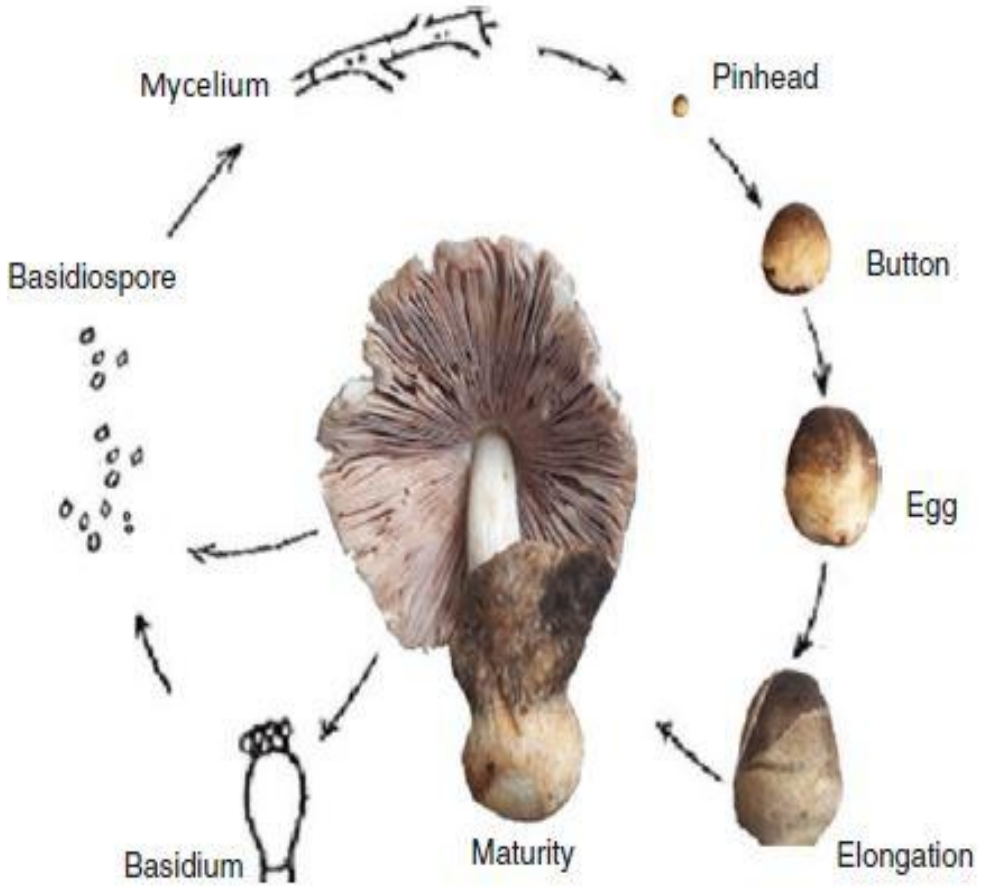
Table.1 Level of incidence of different moulds (Adapted from K.B mohapatra and chinara 2014)

Sl. No.	Competitor moulds/ disease	Per cent incidence (Indoor)	Per cent incidence (outdoor)	Mean per cent incidence
1	Aspergillus flavus	6.00	11.00	8.50
2	A. Niger	13.90	17.80	15.85
3	Coprinus spp.	27.00	46.80	36.90
4	Mucor sp.	2.90	2.00	2.45
5	Penicillium spp.	6.60	12.00	9.30
6	Rhizopus oryzae	11.70	8.00	9.85
7	Sclerotium rolfsii	12.00	16.00	14.00
8	Trichoderma sp.	5.80	5.00	5.40
9	Bacterial button rot (Pseudomonas spp.)	13.00	9.00	11.00
	Mean	10.98	14.17	12.58

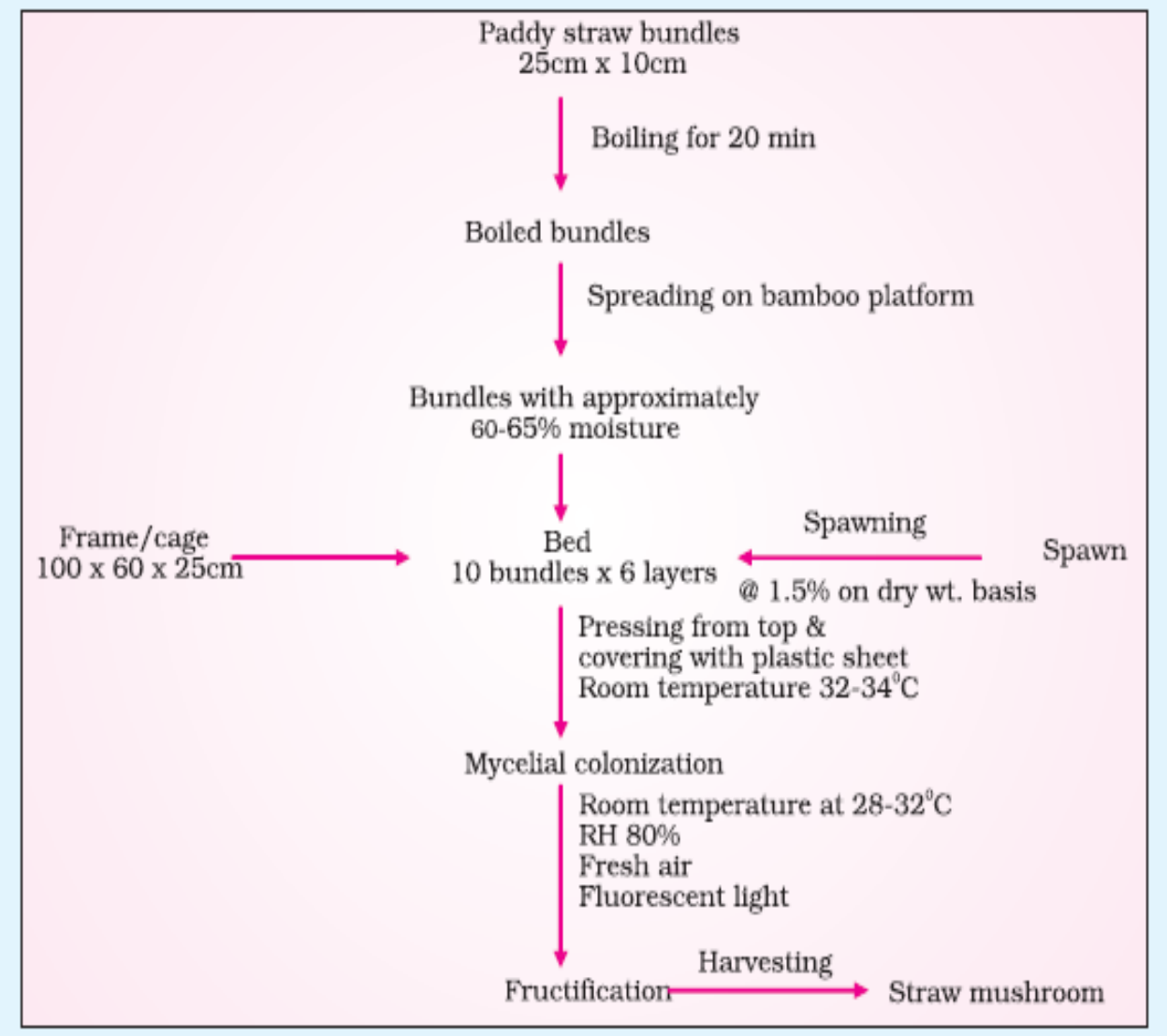
Table.2 Different control methods (Adapted from K.B Mohapatra and Chinara 2014)

Sl. No.	Treatment	Days to pin head emergence	Days to first harvest	Weight of fruit bodies kg/100 kg substrate	Intensity of Coprinus
1	Control	8.00	13.00	9.00 (-)	+++
2	Benomyl (0.2 %)	10.00	15.00	10.38(+15.34)	+
3	Bleaching powder (0.02 %)	10.00	15.00	9.10(+1.11)	++
4	Streptocycline (0.01 %)	8.00	13.00	11.71(+30.15)	++
5	Benomyl (0.2 %) + Streptocycline (0.01 %)	9.00	15.00	13.47(49.73)	+
6	Benomyl (0.2 %) + Bleaching powder (0.02 %)	9.00	14.33	10.61(17.98)	+
7	Calcium carbonate (2.0 %)	9.000	13.66	14.52(61.37)	+
8	Formalin (500 ppm) + Bavistin (37.5 ppm)	10.00	15.00	9.28(3.17)	+
9	Boiled water (70-80°C)	7.00	13.00	11.28(25.39)	+
10	Tamarind leaf extract (4 %)	8.00	14.00	13.52(50.26)	+
	C.D. (0.05)	0.85	NS	-	-
	C.V. (%)	5.22	7.76	-	-

Paddy straw mushroom cycle (adapted from Le VinhThuc *et al.*, 2006**)**



Mushroom cultivation process (Ahlawat and Tewari, 2007)



Incidence of contestant moulds

The mushroom beds are subject to several destructive competitor Moulds during composting stage, namely *Coprinus* spp., *Sclerotium rolfsii*, *Aspergillus* spp. *Trichoderma harzianum*, *Penicillium* spp., and *Rhizopus oryzae* (Thakur *et al.*, 2013) growth of such contestant moulds leads to huge crop loss up to 40% (Mohapatra and Chinara, 2014) Competitor fungus-like *Coprinus* spp., and bacterial bud rot pathogen incidence is more in the crop (Yee and Chang-Ho, 1980). Bacterial button rot disease caused by *Pseudomonas* spp. is an emerging problem in the hot and humid coastal belt. *Coprinus* spp. was predominant of all in both outdoor and indoor farming situations. However, outdoor farming recorded more bed contamination (46.8 %) compared to the indoor one (27 %). Bacterial button rot disease was recorded to the tune of 9 and 13 % in outdoor and indoor situations respectively.

Control

Pre-soaking of the straw with calcium carbonate (2 %) for a period of six to ten hours (Renato Reyes, 2016) proved to be useful in suppression of contestant moulds as well as improvement of the yield standards. Application of phytoextract (Tamarind leaf extract @ 4 %) (Pani and Patra, 1997; Mohapatra and Chinara, 2014) has also good effect in controlling the moulds and enhancing the yield. Various antifungal chemicals also used to control the growth of such moulds. I.e., Benomyl, Streptocycline, Formalin, Carbendazim. A combination of both chemicals also works well at some stages (Rivera-Vargas and Hepperly, 1987).

In conclusion, producing paddy straw mushroom is a sustainable option for adding value to rice production (Zhang *et al.,* 2000) and reducing environmental harm through avoiding the burning of rice straw in the field. (Chandra and Chaubey, 2017) Growing outdoor paddy straw is a traditional practice with low investment costs but generates low yield and incurs high risk because it is strongly affected by changes in the weather. On the other hand, growing indoor paddy straw mushroom has higher investment costs but greater productivity and lower risks due to its well-controlled environment.

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