ECO FRIENDLY MEASURES OF CONTROL OF SOLID WASTES BY MUSHROOM CULTIVATION

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ABSTRACT

An experiment was carried out to select the best substrate for growth and yield of oyster mushroom. The agricultural wastes such as paddy straw, coconut leaf and sugarcane bagasse were tested to select best alternative substrates that support the growth, yield and biological efficiency of oyster mushroom. The results revealed that the substrates differed in their growth and biological efficiency with respect to substrate used. The maximum growth and biological efficiency were obtained with paddy straw followed by sugarcane bagasse and coconut leaf. Further, the minimum time taken for mycelium run, primordial initiation, number of fruiting bodies and yield were significantly superior in mushrooms from paddy straw. The sugarcane bagasse and coconut leaf support the growth and biological efficiency of oyster mushroom but the effect was far superior to paddy straw. Sugarcane bagasse was superior to coconut leaf with reference to growth and biological efficiency of oyster mushroom. The physical and chemical nature of substrate materials greatly affected the growth of oyster mushrooms.

Key words: oyster mushroom, cultivation, paddy straw, sugarcane bagasse, coconut leaf

I. INTRODUCTION

Mushrooms are also called as 'white vegetables' or 'boneless vegetarian meat'. It contains ample amounts of proteins, vitamins and fibre apart from having certain medicinal properties. Mushroom contains 20-35% protein which is higher than those of vegetables and fruits and is of superior quality. Mushrooms are now getting significant importance due to their nutritional and medicinal value and today their cultivation is being done in about 100 countries. Besides its delicious taste, it is known to be very nutritious and is recommended to control obesity and is reported to be beneficial for diabetes. Its low fat content makes it an ideal diet for the blood pressure patients.Though, about 2000 species have been reported to be edible and about four species are being cultivated on a commercial scale. These are, *Agaricus bisporus* (white button mushroom), *Volvariella* spp. (tropical or paddy straw mushroom), *Lentinus edodes* (Japanese mushroom) and *Pleurotus* spp. (oyster mushroom). *Pleurotus* spp. has the ability to grow on both fermented and unfermented materials/substrates. The Oyster mushroom grows during winter months only therefore, it needs proper preservation techniques to promote their consumption among common people and excess mushroom is processed into food products acceptable to consumers (Randive, 2012; Song, 2004).

Cultivation of mushrooms is an important biotechnological process which converts a wide range of agro-industrial residues into mushroom growing substrates and produces healthy food. Conventional cultivation of mushrooms is performed in composted straw, with chicken manure as the main source of nitrogen triggering the composting process. Anaerobically digested organic waste, i.e. food waste, is comprised of fibrous waste residues and anaerobic bacteria, high in nutrients. The digestate is a rich source of nitrogen, with high pH which is favorable for mushroom substrate preparation. Recent focus on renewable energy production has increased the interest in anaerobic digestion – recovering energy, rendering nutrients available for use in agriculture, which makes digestate an easily accessible waste material (Jasinska *et al*., 2016).

Large volumes of unused agro wastes are available in tropical and subtropical areas. These by-products are usually left to rot in the field or are disposed through burning. Using locally available lignocellulosic substrates to cultivate oyster mushroom is one solution to transform these inedible wastes into accepted edible biomass of high market and nutrient values (Tesfaw *et al.*, 2015; Rizki and Tamai, 2011). Mushrooms have the ability to convert cellulosic plant waste materials into highly nutritious fruit bodies (Quimio, 1998; Marimuthu, 1995). Therefore, agricultural and industrial organic wastes are used to grow commercially oyster mushrooms. Cultivation of oyster mushroom on different agro wastes like cotton stalks, waste paper, maize cobs, cotton waste, wheat and paddy straw are utilized for achieving higher bio-efficiency. The aim of the present study is to find the best substrate for effective cultivation of oyster mushrooms.

II. MATERIAL AND METHODS

2.1 Substrate preparation

Oyster mushroom was grown on various substrates like paddy straw, coconut leaf and sugarcane bagasse. The substrates were chopped into 3-5 cm pieces and soaked in fresh water for 8-16 hours and excess water from straw was drained off. Heat treatment by sterilization of substrate results in minimizing contamination problem and gives higher and almost constant yields. Water was boiled in a wide mouth container and the wet substrate was filled in gunny bags. The filled bag was boiled in hot water of for about 30 minutes.

2.2 Spawning and Spawn running

The substrate was cooled down to room temperature and it was ready for filling and spawning. Polythene bags (35 x 60 cm) were used for cultivation. For seed bed preparation, substrate moisture content was about 70 per cent. One bottle spawn (250 g) used for 2 beds. Spawning can be done in layer spawning or through spawning. In case of layer spawning, substrate was filled in bag, pressed to a depth of 8-10 cm and broadcasted with a handful of spawn above it. Similarly, 3-4 layers of substrate were put and simultaneously after spawning.

The spawned seed beds were stacked on racks in spawning room of cultivation room. In the spawning room, temperature 25-30°C and humidity 70-85% were maintained by spraying water twice a day on floor as well as in the wall. After 15- 20days, seed beds were fully covered with white mycelium.

2.3 Cropping and Harvesting of mushrooms

After complete cover of growth of mycelium (20-25 days), the seed beds were transfer from spawning room to cropping room in the mushroom centre. Mushrooms were grown in a temperature range of 20-30°C. Relative humidity was maintained by spraying water twice a day on the walls and floor of the centre. Mushrooms were plucked before they shed spores to maintain quality. After 1st harvest, the outer layer of the beds were removed which helped to initiate 2nd plucking which appeared after 10 days.

III. RESULTS

The present study was aimed to evaluate different substrates to get maximum yield of oyster mushroom with three substrates like paddy straw, coconut leaf and sugarcane bagasse.

3.1 SPAWN RUN

The result revealed that 18 to 22 days are required for completion of mycelia growth on different substrate. Treatments showed significant results in terms of days required for spawn run. Minimum days required for spawn run was on paddy straw substrate and it was 18 days, which was followed by sugarcane bagasse (20 days) and coconut leaf (22 days).

3.2 PRIMORDIA FORMATION

The results revealed that the days required for primordial formation varied with different substrates. Minimum days required for primordial formation was 20 days with paddy straw. The days for primordial formation for coconut leaf and sugarcane bagasse were 22 days and 24 days respectively.

3.3 NUMBER OF PRIMORDIA

The average number of primordia grown on different substrates differs remarkably. The highest number of primordia (45) per seed bed was found in paddy straw. The lowest number of primordia (30) was noted in coconut leaf.

3.4 NUMBER OF FRUITING BODY

An average number of fruiting body was observed in the seed beds prepared by paddy straw, coconut leaf and sugarcane bagasse. From the results, it was observed that the paddy straw produced 40 fruiting body an average, followed by sugarcane bagasse (35). The lowest number of fruiting body was observed in the seed beds prepared by coconut leaf as 31.

3.5 DAYS FOR FIRST HARVEST

The duration required for first harvest with different substrates was between 25 and 30 days. The results indicated that 25 days required for first harvest with paddy straw followed by 28 days with sugarcane bagasse and 30 days with coconut leaf.

3.6 SIZE EFFECTIVE FRUITING BODY

The effect of substrates on the size of the fruiting body was significantly differed. The diameter, thickness of pileus, length and diameter of stalk were the parameter for the measurement of size of the fruiting body. These size effective parameters were observed in the seed beds prepared with different types of substrates (Fig 1). The maximum pileus diameter was recorded in paddy straw (8.0 cm) and lowest diameter (4.0 cm) in coconut leaf. The pileus produced from the paddy straw showed highest thickness (0.6 cm), in the case coconut leaf only (0.4 cm) thickness. There was a remarkable difference was observed in the length and diameter of stalk of the fruiting body. The maximum diameter of stalk was observed as 1.5 cm in the paddy straw while the lowest diameter (0.6 cm) was found in the coconut leaf. The highest stalk length was found to be 5.0 cm with the paddy straw followed by 4.0 cm in sugarcane bagasse and 3.0 cm in the coconut leaf.

3.7 TOTAL YIELD AND BIOLOGICAL EFFICIENCY

The result revealed that the total yield and biological efficiency of *Pleurotus sajor-caju* was significantly differed with respect to different types of substrates used for mushroom cultivation. The highest yield was obtained with paddy straw as substrate (1650 g) followed by sugarcane bagasse (1360 g) and coconut leaf (1050 g). Maximum biological efficiency (80 %) was observed in paddy straw and minimum biological efficiency (50 %) was recorded in coconut leaves.

IV. DISCUSSION

Mushroom cultivation is one of the efficient ways by which biological residues can be recycled. *P. ostreatus* grown on different substrates are nutritious with high protein, fiber and low fat. It may also offer economic incentives for agribusiness to examine these residues as valuable resources and develop new enterprises to use them to produce nutritious mushroom products. Therefore, the mushroom cultivation may become one of the most profitable agribusiness that could produce food products from different substrates and help to dispose them in an environment friendly manner.

Almost all mushroom producers use rice straw for the production of *P. osteratus*, which is also one of the best substrate for growth of mushroom. Therefore, use of a variety of the substrates is essential. Although the amount of yield is vary in rice straw, other substrates such as rice straw plus wheat straw, rice straw plus paper and sugarcane bagasse can also be used as alternative substrates with supplement in the cultivation of *P. osteratus.* Cultivation of oyster mushroom (*Pleurotus ostreatus*) has increased tremendously throughout the world because of their abilities to grow at a wide range of temperature and utilizing various agro-based residues. *Pleurotus* species are efficient lignin degraders, which can grow on different agricultural wastes with broad adaptability to varied agro-climatic conditions (Jandiak and Goyal., 1995). Growing oyster mushrooms convert a high percentage of the lignocellulosic substrate to fruiting bodies increasing profitability. Of them, *Pleurotus ostreatus* demands few environmental controls, and their fruiting bodies are not often attacked by diseases and pests, and they can be cultivated in a simple and economic way (Kues and Liu, 2000). It requires a short growth time in comparison to other edible mushrooms. All this makes *P. ostreatus* cultivation an excellent alternative for production of mushrooms when compared to other mushrooms (Kausar, 1998).

Five different types of substrates were investigated to determine the growth and yield of *P. ostreatus*. The fastest mycelia extension was observed in rice straw substrate followed by mixture of rice plus wheat straw, sugarcane bagasse, mixture of rice straw plus paper and sawdust, respectively. Mycelial growth is a preliminary step that creates suitable internal conditions for fruiting. Thus, outstanding growth of mycelium is a vital factor in mushroom cultivation (Pokhrel *et al.*, 2009). Colonization of the substrate was completed in between 22.40-26.00 days of incubation. Similarly primordial initiation on various substrates was also observed in between 26.40-31.60 days of incubation. The total day for the first harvest of mushroom took between 32-37 days, depending on substrate used. The fastest colonization period (22.40 days), primordial formation time (26.40 days) and first harvest period (32.40 days) were also recorded from rice straw (Sharma *et al.*, 2013).

The main function of rice straw is to provide a reservoir of cellulose, hemicelluloses and lignin which is utilized during the growth and fructification. This might be because rice straw contained sufficient amount of necessary nutrients for the growth of *P. ostreatus* (Yildiz *et al.*, 2002). Mushrooms have the ability to convert cellulosic plant waste materials into highly nutritious fruit bodies (Quimio, 1998). Therefore, agricultural and industrial organic wastes are used to grow commercially oyster mushrooms. Cultivation of oyster mushroom on different agro wastes like cotton stalks, waste paper, maize cobs, cotton waste, wheat and paddy straw are utilized for achieving higher bio-efficiency (Marimuthu, 1995).

The pinhead formation was observed following the invasion of substrates by mycelia growth. The pinheads appeared fastest in grass and cardboard (17.20 days) than other substrates. There is difference in the appearance of pinheads of different substrates. The time required for the formation of pinheads is comparable with other similar studies. Ahmed (1998) reported pinhead formation of oyster mushroom cultivated in different substrates to be between 23 and 27 days from spawning, while Fan *et al*. (2000) reported it to be 20-23 days. Tan (1981) recorded 23-26 days for the appearance of pinheads and 20-24 days on paddy straw Patra and Pani (1995).

Mondal *et al*. (2010) reported that the duration of colonization, fruiting and harvesting of oyster mushroom was lower in banana leaves in comparison to rice straw and the stipe length, pileus diameter and total yield of mushroom was higher in rice straw than in banana leaves. Biswas and Biswas (2015) reported the completion of spawn running on wheat straw waste to be 14 days, while, Lalithadevy *et al*. (2014) recorded between 16-25 days on paddy straw. The difference in days for full mycelia running on different substrates might be due to variation in their chemical composition and C:N ratio as reported by Bhatti *et al*. (1987). The results recorded on spawn running on different substrates were almost similar to the findings of Shah *et al*. (2004). Tan (1981) reported that the spawn running took 16-25 days after inoculation. The variation in the number of days taken for a spawn to complete colonization of a given substrate is a function of the fungal strain, growth conditions and substrate type.

Similarly biological efficiency (BE) also varied significantly among the different substrates used. Bhatti *et al*. (1987) observed the highest yields from with shortest incubation period in case of wheat straw. It was generalized from the data that first flush yield was highest in all treatments followed by second and third flush. Jiskani (1999) reported that one kg of dry substrate can produce one kg of fresh mushroom which is the 100% substrate dry weight. The difference in results between this finding and other workers may be due to environmental factors, physiological requirements, controlled, semi controlled conditions, *e.g.* constant humidity, light temperature etc. The difference in time was observed for the formation of pinheads, maturation of fruiting bodies, period between flushes, number of flushes and yield. Similar by-products have variable may be due to fungal species, spawn rate and the use of supplement added to the substrates.

Various agricultural by-products are being used as substrates for the cultivation of the oyster mushroom. Some of these wastes include banana leaves, peanut hull and corn leaves, mango fruits and seeds, sugarcane leaves, wheat and rice straw (Cangy and Peerally, 1995). The widely used substrate for cultivation of the oyster mushroom is rice straw (Thomas *et al*., 1998). It is also considered the best substrate in terms of yield and high protein content. The majority of these substrates can be used as animal feed. However, their low digestibility, low protein content and high lignin content render them unpopular and unacceptable. Moreover, due to an increased demand on these substrates for biogas production, composting and non-availability in some areas, it becomes necessary to find cheap alternative sources.

Sugarcane bagasse gave maximum number of primordia and fruiting bodies, and fresh weight followed by rice straw and the lowest in mustard straw. The yield difference was significant in this experiment. The variations were probably occurred due to the difference of bulk density and constituents of the substrates used. Sivaprakasam (1986) found that the yield of mushroom was correlated positively with cellulose content and cellulose**:** lignin ratio, but negatively with lignin and ortho-dihydroxy phenolics content. Quimio (1987) stated that cellulose rich organic substance has been reported to be of good substrates for the cultivation of mushrooms. Substrates with high lignin and phenolic content decreased the activity of cellulase, but less lignin would enhance enzyme activity and thus ensure higher yield of mushrooms (Sivaprakasam, 1980).

V. CONCLUSION

Mushrooms are able to grown on paddy straw, sugarcane bagasse and coconut leaf. To find out the comparative yield of all he substrata mushroom was grown separately in different substrata. Among them, mushroom grown on paddy straw was found to be better growth and yield when compared with the other selected substrata. The results proved that any biodegradable waste can be used as substrata for growing mushroom. The present study proved almost all the substrata showed have nutritive values and support the growth of mushroom. But the growth, development and biological efficiency vary based the substrates used. Therefore, locally available agro wastes can be recycled by Oyster mushroom cultivation.

VI. ACKNOWLEDGEMENT

The authors are thankful to the Management and the Principal of Ayya Nadar Janaki Ammal College, Sivakasi, Tamil Nadu for providing laboratory facilities and financial assistance to carry out this research work.

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Fig. 1. Cultivation of Oyster mushrooms from agro wastes

A- Paddy straw; B - coconut leaf; C - sugarcane bagasse