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Innovative Containers for Oyster Mushroom Cultivation

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Abstract: *In an attempt to identify an innovative container system to hold processed paddy straw for oyster mushroom cultivation, polypropylene bottles (150G) measuring 1800 ml capacity (18 cm height; 10 cm width) and laminated carton boxes measuring 36 x 18 x 12 cm have been evaluated along with polypropylene bags (100 G) measuring 60 x 30 cm; 45 x 30 cm; 35 x 25 cm and 25 x 10 cm sizes for the cultivation of oyster mushroom species viz., Hypsizygus ulmarius (var. CO2), P. eous (var. APK1), P. florida and P. platypus. Spawn running period, days for first harvest, yield and productivity in terms of biological efficiency (%) have been recorded for individual species and the results compared. Among the containers, polypropylene bottles were found to be significantly superior and recorded 1484.3, 1158.3, 1096.3, 1324.1 g of yield per kg of substrate (dry weight), which accounted to 148.4, 115.8, 109.6, 132.4 per cent bio efficiency in case of Hypsizygus ulmarius var. CO (OM) 2), P. eous var.APK 1, P. florida and P.platypus, respectively followed by laminated carton boxes. Moreover, use of polypropylene bottles ensured repeated usage, easy handling and environmentally benign. This type of containers will be suitable for home growing, small scale to large scale automated systems of oyster mushroom production.*

Keywords: *Oyster mushroom cultivation, Containers, PP Bottles, Carton box, Yield, Biological efficiency.*

INTRODUCTION

Oyster mushroom (*Pleurotus* sp) is the second largest cultivated mushroom around the world recording 27 per cent of world production (Royse, 2014). Due to its rich biodiversity, wide adaptability, simplicity and flexibility of cultivation, this mushroom has assumed a rapid growth rate over years. Selection of the best substrates and innovative containers will have a greater stake hold, while designing home growing to large scale production systems for oyster mushrooms. Cultivation of oyster mushrooms (*Pleurotus* spp.) was first initiated in Germany during 1917 on tree stumps and wood logs (Upadhyay and Sing, 2010). Zadrazil (1978), Chang and Miles (1989), FAO (1990) have reported varied production systems for growing oyster mushrooms. However, in India, over years mostly, poly bags of varied sizes are used for the cultivation of this mushroom utilizing boiled or steam treated paddy straw or wheat straw

(Banu and Srivastava, 1962; Kurtzman,1979; Sivaprakasam, 1980; Bisaria *et al.*, 1989; Pandey *et al.*, 2014). After the crop cycle, worn out polypropylene or polyvinyl chloride container bags are most often burnt. This practice is not environmentally benign and suffocates soil biotic entities. Further, such containers cannot be repeatedly used, which may result in increased cost of production. Although a few studies indicate the utilization of reusable plastic bottles (Rodrigues-Estrada, 2008) for the production of King oyster mushroom (*Pleurotus eryngii* (DC.) Qul., such information is lacking in India. Hence, studies on comparative evaluation of different container systems for the cultivation of four different oyster mushroom species *viz*., *Hypsizygus ulmarius* (var. CO2), *P. eous* (var.APK1), *P. florida* and *P.platypus* have been conducted utilizing paddy straw as substrate and the results are discussed.

MATERIALS AND METHODS

Different species and varieties of oyster mushroom cultures *viz*., *Hypsizygus ulmarius* var. CO (OM) 2, *Pleurotus eous* var. APK1, *Pleurotus florida* and *Pleurotus platypus* maintained in the Mushroom Research Laboratory, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore, India have been used in the study.

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Spawn production

Pure cultures maintained in PDA medium were used for the preparation of sorghum grain spawn. Cleaned grains were thoroughly washed and soaked in water for 30 min and half cooked in an open vessel for 20 min. After draining the excess water, the grains were mixed with calcium carbonate at the rate of 20 g per kg of grains (dry weight), filled in autoclavable polypropylene bags (25 x 10 cm size) and sterilized at 1.42 kg / cm^2 pressure in an autoclave for 1.5 hrs. After cooling, the bags were aseptically inoculated with the pure cultures of the respective mushroom fungus, incubated at room temperature (25 ±3^{0}C) for 15 d and used for spawning the paddy straw substrate.

Substrate preparation

Dry paddy straw used as substrate was cut into small pieces of 3-5 cm and thoroughly soaked in potable water for 5 hrs. After draining the excess water, the substrate was dipped in boiling water maintained at 80^{0}C for 60 min. The partially sterilized straw bits were shade dried until the moisture content of the substrate was 60 per cent and used for spawning.

Containers and spawning

Polybags

Polypropylene bags (100 G thickness) measuring 60 x 30; 45 x 30; 35 x 25 and 25 x 10 cm sizes were used as containers for the pretreated paddy straw substrate. Layer method or thorough spawning was done following the method suggested by Sivaprakasam (1980). For each size of the bag 500 g; 300 g; 250 g; 100 g substrate (dry weight basis), respectively was used. Fifteen days old sorghum grain spawn was used at the rate of 2 per cent to seed the substrate. The beds were arranged over wooden racks and maintained at 20-25^{0}C temperature and 80-90 per cent relative humidity for cropping. At the time of pinhead formation, sufficient fresh air circulation was given to lower the CO_2 levels.

Polypropylene bottles

Polypropylene bottles (150 G thickness) measuring 1800 ml capacity (18 cm height; 10 cm width) were used for filling the boiled and shade dried paddy straw. Each of the bottle contained 180 g of paddy straw on dry weight basis. Sorghum grain spawn at 2 per cent rate was thoroughly mixed with the treated substrate before filling in to the bottles. The bottles after spawning were capped and arranged in a plastic tray (16 bottles / tray) before transferring to the cropping room. After spawn running the lids placed at the top of the bottles were removed to induce fruiting bodies.

Carton boxes

Laminated carton boxes measuring 36 x 18 x 12 cm size were used as containers to fill the processed paddy straw substrate. For each of the box 650 g of paddy straw on dry weight basis was used. Sorghum grain spawn at 2 per cent rate was thoroughly mixed with the paddy straw before filling. The boxes were sealed on all sides. Six holes, each measuring one cm diameter were punched out in all the sides except at the top and bottom. The boxes were transferred to the cropping room for further observation.

Measurement of CO_2 and Temperature

CO_2 level in the polypropylene bottle and bag containers was measured 24 hrs after bed preparation; at the completion of spawn run and during first flush with the help of Shimadzu GC-2014 gas chromatograph available at the Department of Agro Climate and Research Centre, Tamil Nadu Agricultural University, Coimbatore. The bed temperature was measured at the centre of the bed at 24 hrs after bed preparation; at the completion of spawn run and during first flush. The wall thermometer was insert into centre of the bed and leave for few minutes then the temperature was recorded and the data presented in Table 3.

RESULTS AND DISCUSSION

The method of cultivation and substrate containers are known to have a positive influence on mushroom production (Smith, 1980). In tropical countries, smaller sized containers would be more preferable in order to maintain the required bed temperature at the centre of the beds (Zadrazil and Dube, 1992).In countries like Japan, China and USA, reusable polypropylene bottles are commonly used in the highly mechanized oyster mushroom farms (Royse, 2014). Among the different substrate containers used in the present study, polypropylene bottles were found to be significantly superior and recorded 1484.3, 1158.3, 1096.3, 1324.1 g of yield per kg of substrate (dry weight), which accounted to 148.4, 115.8, 109.6, 132.4 per cent bio efficiency in case of *Hypsizygus ulmarius* var. CO (OM) 2), *P. eous* var.APK 1, *P. florida* and *P.platypus,* respectively (Table 1 and Figure 1).

Table 1
Comparative evaluation of container systems for the cultivation of oyster mushroom species

Container	*Substrate quantity on dry weight basis (g)*	**Yield of mushrooms in paddy straw substrate (g /kg)* *H.ulmarius var. CO (OM) 2*		*P.eous var. APK1*		*P. florida strain PF*		*P. platypus strain PP*	
		Yield	*BE (%)*	*Yield*	*BE (%)*	*Yield*	*BE (%)*	*Yield*	*BE (%)*
PP bottle (1800ml)	180	1484.28	148.4	1158.33	115.8	1096.38	109.6	1324.06	132.4
Carton box (36x18x12 cm)	650	1216.15	121.6	1085.85	108.9	1054.62	105.5	1254.35	125.4
Polypropylene bags (60x30 cm)	500	1147.34	114.7	1022.00	102.2	1004.06	100.4	1203.00	120.3
Polypropylene bags (45x30 cm)	300	1165.33	116.6	1060.67	106.1	1005.00	100.5	1228.67	122.9
Polypropylene bags (35x25 cm)	250	1094.00	109.4	1041.72	104.2	1010.40	101.1	1205.32	120.5
Polypropylene bags (25x10 cm)	100	1203.30	120.3	1038.70	103.9	1006.60	100.7	1184.30	118.4
SED		26.96		20.38		20.78		26.16	
CD (p = 0.05)		58.73		44.42		45.27		57.00	

*Average yield obtained in each container has been converted to per kg of dry paddy straw irrespective of the substrate quantity used

Table 2
Comparative Evaluation of Spawn run, Flushing and Crop cycle

Oyster mushroom species	*Bottle*				*Carton box*				*Polybag (60x30 cm)*			
	DFSR	*DFPF*	*DFFH*	*Crop cycle (days)*	*DFSR*	*DFPF*	*DFFH*	*Crop cycle (days)*	*DFSR*	*DFPF*	*DFFH*	*Crop cycle (days)*
Hypsizygus ulmarius (CO2)	8.0	15.6	18.3	30.0	10.0	18.3	20.0	40.0	12.0	22.6	24.0	48.0
Pleurotus eous (APK1)	6.5	11.3	13.2	25.0	7.6	13.2	15.3	32.0	9.2	15.0	17.2	35.0
Pleurotusflorida (PF)	9.2	15.0	17.0	28.0	11.0	21.2	22.3	35.0	12.5	22.0	23.5	42.0
Pleurotusplatypus (PP)	5.0	7.0	9.0	22.0	6.0	9.0	11.0	30.0	7.2	11.0	13.0	36.0

- DFSR-Days for spawn run
- DFPF-Days for pinhead formation
- DFFH-Days for first harvest

In addition to the enclosure of substrate, the containers used for mushroom production should be sufficiently strong allowing repeated usage. It should not break or puncture easily during handling. The container must not allow excessive loss of moisture from the bed surface. Self heating of the container will impede with spawn running and primordial initiation. Sometimes opaque or semi transparent containers with limited light passage will be helpful to encourage quick spawn run. Sivaprakasam *et al*.(1987) concluded that polybag containers would prevent evaporation and maintain the required levels of carbon dioxide inside the beds during spawn run and fruiting. However, in the present study excess bed temperature and high level of CO_2 evolution were observed inside 60 x 30 cm size polypropylene bag containers during spawn run and primordial initiation (Table 2) when compared to bottles. Thus, comparative yield reduction in bigger sized polythene bag beds is indirectly attributed to the possibility of excess heat development and accumulation of more CO_2 Zadrazil and Dube (1992) correlated these factors to the alteration in chimney effect inside the mushroom beds and insisted that 33°C temperature should be uniformly maintained at the centre of oyster mushroom beds for better crop production. Flegs (1985) reported that, when the bed size was big, the mushroom fungus had utilized the nutrients superficially from the top layers only. In such cases delayed fruiting and wastage of substrate was much

evident. In the present study, the quantity of paddy straw (on dry weight basis) varied with the capacity of containers used. Polypropylene bottle required less quantity of substrate as compared to other containers. Also in this case the spawn run and primordial initiation was very quick. Moreover, the total crop cycle could be substantially reduced (Table 3) resulting in the reduced maintenance cost. The bottles could also be repeatedly used for several crops. In addition to the increased recurring cost, the plastic bags are not environmentally friendly and suffocate soil biotic entities (Mamiro *et al*., 2014). . Although laminated carton boxes were found to be better as compared to polypropylene bags, the cost of such containers was much high and they were not useful for repeated usage.

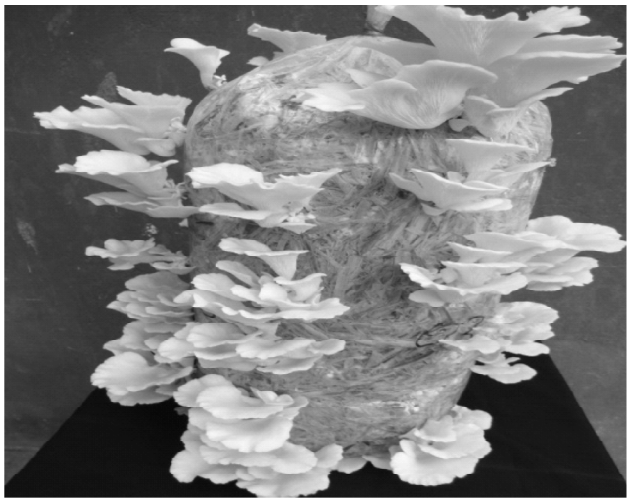
Table 3
CO_2 Concentration and temperature in mushroom beds

Stage of growth	*CO_2 level (ppm)*		*Bed temperature (^{0}C)*	
	PP Bottle (1800 ml)	*PP bag (60 x 30 cm)*	*PP Bottle (1800 ml)*	*PP bag (60 x 30 cm)*
24 hrs after spawning	26534	34319	28.3	31.6
At the completion of spawn run	12422	16520	30.2	32.8
During first flush	5811	9649	27.5	30.2

Based on the results, it is concluded that reusable polypropylene bottles (150G) measuring 1800 ml capacity (18 cm height; 10 cm width) could be the best alternative substrate containers for oyster mushroom production. This system will be environmentally benign, cost effective and may be helpful to design flexible automated oyster mushroom production systems under Indian condition. Bottle and carton box

Polypropylene bottles (1800 ml capacity)

Laminated carton box (36x18x12 cm)



Polypropylene bag (60x30 cm size)

Polypropylene bag (45x30 cm size)

Figure 1: Cultivation of oyster mushroom species in different container systems

system of cultivation will also be useful for small scale home growing models under urban horticulture.

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