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Influence of different substrates on growth and yield of *Pleurotus ostreatus*

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Abstract

Oyster mushroom (*Pleurotus ostreatus*) is the second most cultivated edible mushrooms worldwide after *Agaricus bisporus* and has more economic, ecological values and medicinal properties. Huge amounts of ligno-cellulosic agricultural crop residues by-products rich in organic compounds are annually generated. This study was conducted to compare effects of different agro residues on growth and bioconversion efficiency of oyster mushroom. *P. ostreatus* was cultivated on different treatment substrates *viz*., corn sheath + corn cob + coir pith (T1), paddy straw + ragi straw (T2) and sugarcane bagasse (T3) supplemented with 10 % wheat bran. Parameters such as spawn run days, primordia formation (days), harvest days, total yield and biological efficiency were evaluated. The best substrate was found to be T2 (paddy straw + ragi straw) in terms of spawn run (28 days), primordia formation (30 days), average number of fruiting bodies (108±1.3), stem length (7 cm) and cap diameter (9.5±0.085 cm). Total yield of *P. ostreatus* on different treatment substrates T1, T2 and T3 was found as 507±5 g, 317.7±3.1 g and 761±7.5 g, respectively. The biological efficiency of *P. ostreatus* was found high in T2 (92.08±0.89 %) followed by T3 (87.39±0.85 %) and T1 (72.37±0.7 %).

Key words: *Pleurotus ostreatus*, substrates, biological efficiency

Introduction

Pleurotus, a macro fungus with a distinctive fruiting body, is a unique biota which accumulates its food by secreting degradative enzymes. Oyster mushroom (locally known as Dhingri) is easy to grow in tropical and subtropical climate. The species of *Pleurotus* are characterized by the rapidity of their mycelial proliferation. There is no need of composting substrate for Oyster mushroom production. Oyster mushrooms are easily dried to provide for a longer shelf life and export possibilities (Maheswari *et al.*, 2019). *Pleurotus* species are rich source of vitamin C, B-complex (thiamin, riboflavin, folic acid and niacin), minerals (Ca, P, Fe, K and Na) and protein (Caglarirmak, 2007; Correa *et al.*, 2016). *Pleurotus* species makes mushrooms an ideal food for patients suffering from hyper-tension, heart diseases against hyper cholesterolemiac conditions, diabetes and cancer. More than 2000 species of edible mushrooms are known, out of which only few species have been cultivated commercially by preparing beds (Patil, 2012).

Cultivation of oyster mushroom has increased tremendously throughout the world because of their ability to grow at a wide range of temperature and utilizing various agro-based residues (Sardar *et al.*, 2017). Commercial production of fresh edible mushrooms is rapidly growing as industrial activity that can be carried out in a small or large scale. It is an efficient and relatively short biological process of producing food proteins from lignocellulosic materials, by degrading the substrates (Ediriweera *et al.*, 2015). *P. ostreatus* is characterized by its rapid growth on agro-wastes such as dried sugar cane leaves, saw dust, maize stover, banana leaves, palm cones, coffee husks and wheat bran (Ajonina and Tatah, 2012). These substrate materials can be supplemented with corn flour, rice bran, molasses, soya bean or kernel cake in accordance with the particular substrate material used (Rezania *et al.*, 2017). Even though there has been considerable research on the taxonomy and phylogeny of mushrooms, there has been far less research on their domestication (Thawthong *et al.*, 2014).

Many agricultural by-products and waste used in oyster mushroom cultivation such as corn sheath, corn cob, coir pith, paddy straw, ragi straw and sugarcane bagasse have high cellulose, hemi-cellulose and lignin contents, and low protein content and digestibility (Diego *et al.*, 2011). The present study focused to evaluate the growth, economic feasibility of small scale production and yield (bioconversion efficiency) of *P. ostreatus* using different agricultural waste such as corn sheath, coir pith, paddy straw, ragi straw and sugarcane bagasse which is an economic approach in agro industry as the residues are readily available, therefore the aim of this study was to investigate the feasibility of using locally available substrate for oyster mushroom cultivation. The study aimed on the comparison of different substrate with supplements for *P ostreatus* growth and yield.

Materials and methods

Preparations of mother spawn: The sorghum grains were soaked in water to remove chaffy and damaged grains. The grains were boiled in a vessel for about 30 minutes and spread evenly

on a clean surface to remove excess water. At 50 % moisture level, calcium carbonate was mixed with the grains @ 20 g/kg. The grains were then filled in a polypropylene bag @ 300 g, covered with cotton and sterilized under 20 psi for 2 h. The fungal culture from the petriplates was divided into two equal halves using an inoculation needle and one half was transferred to the polypropylene bag. Similarly, the other half portion of the culture was transferred to another polypropylene bag. The polypropylene bag was incubated, in a clean room, under room temperature for 10 days (Dawit, 2008).

Substrate preparation: The treatment consisted of corn sheath, corn cob, coir pith, paddy straw, ragi straw, sugarcane bagasse as basal substrate with the supplement of wheat bran. The experiments consisted of the following treatment: T1-corn sheath (200 g) + corn cob (100 g) + coir pith (300 g) +wheat bran (105 g); T2-paddy straw (100 g) + ragi straw (100 g) + wheat bran (145 g) and T3-sugarcane bagasse (871.3 g) + wheat bran (130.6 g)

The substrates (T1, T2 & T3) were soaked in fresh water for 24 h. Excess water was drained and subsequently the wet substrate was filled in polypropylene bags for sterilization in autoclave at 121°C for 2 h.

Mushroom bed preparation: Polypropylene bags of 29 × 17.5 cm size and 100 gauge thicknesses were used for filling 200 g (dry weight basis) of the substrate. Spawning was carried out at the rate of 5 %. Filled bags were incubated at 28 °C and relative humidity of 85 % was maintained under dark condition in cropping room for spawn run.

Harvesting of mushroom: Oyster mushrooms matured within 2-3 days after primordia initiation. The matured fruiting body was identified by cural margin of the cap, as described by Ruhul Amin (2002). Mushrooms were harvested by twisting to uproot it from the base. Mushrooms were harvested 3 times from the mushroom bed. After completing the first harvest again the packets were scraped at the place where the 'D' shaped cut had been done and were soaked in a bucket for five minutes and then placed in the culture house and water was sprayed regularly. The primordia appeared 9-10 days after first harvest and 7-8 days after second harvest. Water spraying was continued until the mushrooms were ready to be harvested.

At every harvest, the fruiting bodies were weighed and mushroom size was measured. The length and thickness of stipe, diameter of cap, and number of effective fruiting body per bunch were measured at the first, second and third flush and the means were also determined.

Yield and biological efficiency (BE): At the end of the harvest period, the accumulated data were used to calculate total yield and biological efficiency. The fruiting bodies harvested from polypropylene bags were recorded as total yield of mushroom. Biological Efficiency is ratio of fresh Oyster mushroom harvested (g) per g dry substrate and expressed as percentage (Pokhrel, 2016).

$$BE = \frac{\text{Fresh weight of the mushroom}}{\text{Dry weight of the substrate}} \times 100$$

Data analysis: Data was analysed by calculating the mean days required for each spawn run events obtained from three replications consisting of triplicates. Differences among the means of three treatments were assessed using Duncan's multiple range tests to compare the mean significant differences ($P < 0.05$) among treatments by using SPSS 20.0 for windows.

Results

Effect of different substrates on the moisture content of *P. ostreatus*: The results of moisture content (%) of different substrates are depicted in Table 1. Analysis of variance showed highly significant result ($P \leq 0.01$) in moisture content of oyster mushroom between different substrate used as treatment. Highest wet weight was obtained in T2 treatment followed by T3 and T1 treatment, respectively. Syed *et al.* (2009) found the maximum moisture content on paddy straw (92.45 %) followed by soybean + wheat straw (90.23 %). There was a slight variation with other substrates indicating that the moisture content is independent of the substrate in the cultivation of *P. ostreatus*.

Effect of different substrates on different stages of sporophore production of *P. ostreatus*: The correlation between different stages of sporophore on the production of *P. ostreatus* in different substrates was investigated and found to influence the spawn run, number of primordia formation, number and size of fruiting bodies and yield per bag (Table 2). The correlation was highly significant between harvest and primordia formation (days) between the substrate at P=0.01. Different stages of sporophore such as spawn run, primordia formation, average number of fruiting bodies, harvest (days), stem length and cap diameter on the production of *P. ostreatus* in T1, T2 and T3 showed positive correlation between the parameters. Different stages of sporophore on the production of *P. ostreatus* in T1, T2 and T3 is depicted in Fig. 1, 2 and 3, respectively. The average number of primordia formation on T1, T2 and T3 differed remarkably. The highest number of primordia per bag (34) was found in T1 (corn sheath+ corn cob+ coir pith +wheat bran), followed by 30 primordia formation in both T2 (paddy straw+ ragi straw + wheat bran) and T3 (sugarcane bagasse + wheat bran). The substrate of T2 produced (108) fruiting bodies on an average, followed by T1 (80) and T3 (20), respectively. The highest stem length (10±0.096 cm) and cap diameter (12±0.12 cm) was found in T3 followed by T2 [stem length (7±0.091 cm) and cap diameter (9.5±0.085 cm)] and in T1 [stem length (3±0.076 cm) and cap diameter (2±0.031 cm)], respectively. The biological efficiency and yield of mushroom is predicted by the spawn run, primordia formation, average number of fruiting bodies, stem length and cap diameter. Maheswari *et al.* (2018) reported that *Calocybe*

Table 1. Effect of different substrates (T1, T2 and T3) on the moisture content (%) of *P. ostreatus*

Substrate (g)	Dry weight (g)	Wet weight (g)	Moisture content (%)
T1-Corn sheath (200 g) + corn cob (100 g) + coir pith (300 g) + wheat bran (105 g)	700.5±6.4^{b}	2663.5±26.2^{c}	75.52±0.80^{c}
T2-Paddy straw (100 g) + ragi straw (100 g) + wheat bran (145 g)	345.0±2.9^{c}	2928.6±28.8^{b}	88.20±0.79^{a}
T3-Sugarcane Bagasse (871.3 g) + wheat bran (130.6 g)	871.3±8.5^{a}	4623±46.1^{a}	81.00±0.80^{b}

All values are mean±SD. Values in the column superscripted by different letters are significantly ($P< 0.01$) different from each other (Duncan's multiple range test).

Fig. 1. Sporophore formation and Fruiting bodies of *P. ostreatus* on T1 (Corn sheath+ corn cob + wheat bran)

Fig. 2. Sporophore formation and Fruiting bodies of *P. ostreatus* on T2-Paddy straw + ragi straw+ wheat bran

Fig. 3. Sporophore formation and fruiting bodies of *P. ostreatus* on T3-Sugarcane Bagasse + wheat bran

Table 2. Correlation between different substrate (T1, T2 & T3) in different stages of sporophore on the production of *Pleurotus ostreatus*

	Spawn run (days)	Primordia formation (days)	Average number of fruiting bodies	Harvest (days)	Stem length (cm)
Spawn run (days)	1				
Primordia formation (days)	0.500	1			
Average number of fruiting bodies	0.745	0.205	1		
Harvest (days)	0.500	1.000**	0.205	1	
Stem length (cm)	0.082	0.904	0.604	0.904	1
Cap diameter (cm)	0.277	0.971	0.435	0.971	0.980

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3. Effect of different substrate (T1, T2 & T3) on yield and biological efficiency of *P. ostreatus*

Substrate	1st Harvest (g)	2nd Harvest (g)	3rd Harvest (g)	Total yield (g)	Biological efficiency (%)
T1-Corn sheath (200 g)+ corn cob (100 g)+ coir pith (300 g) +wheat bran (105 g)	220±2.13[b]	170±1.68[b]	117±1.13[b]	507±5[b]	72.37±0.7[c]
T2-Paddy straw (100 g)+ ragi straw (100 g)+ wheat bran (145 g)	155.1±1.5[c]	86.6±0.85[c]	76±0.74[c]	317.7±3.1[c]	92.08±0.89[a]
T3-Sugarcane Bagasse (871.3 g) + wheat bran (130.6 g)	340±3.3[a]	290±2.86[a]	131.5±1.28[a]	761.5±7.5[a]	87.39±0.85[b]

All values are mean±SD. Values in the column superscripted by different letters are significantly ($P< 0.01$) different from each other (Duncan's multiple range test).

indica took 6-0 days from primordia formation to mushroom fruit body after spawning on wood shavings. The first harvest was done after 10 days of spawning which had the piles breadth of 5.4 cm and stipe length of 8.9 cm. Chandra (2016) found the fastest colonization period (34 days) of *P. ostreatus* from available substrates, the primordia formation period (37.10 days) and first harvest period (40.20 days) were recorded from corn cob with rice bran supplement whereas the slowest colonization period (39 days), primordia formation period (44.80 days) and first harvest period (48.70 days) were found in vegetable residue (control) among all treatments. Hom *et al.* (2019) analysed four different substrate *i.e.*, paddy straw (100 %), maize cob + paddy straw (1:1), sugarcane bagasses + paddy straw (1:1) and sawdust+ paddy straw (1:1). The time for colonization and fruit initiation was found to be shorter in case of the paddy straw *i.e.,*18.25 days and 21.75 days, respectively. However, the length of stalk was highest (6.10 cm) in sugarcane bagasses + paddy straw (1:1) but the diameter of stalk and pileus were highest in paddy straw (0.80 and 7.90 cm, respectively). The biological efficiency was found to be highest in case of the paddy straw (96.29 %) followed by maize cob + paddy straw (1:1), sugarcane bagasses + paddy straw (1:1) and sawdust+ paddy straw (1:1), respectively.

Effect of different substrates on yield and biological efficiency

of *P. ostreatus*: The highest yield was obtained in T3 (761.5±7.5 g) followed by 507±5 g and 317.7±3.1 g in T1 and T2, respectively (Table 3). The maximum biological efficiency was found in T2 (92.08±0.89 %) as compared to T3 (87.39±0.85 %) and T1 (72.37±0.7 %). The enhanced yield and biological efficiency observed in T2 could be due to the presence of favourable nutrients such as cellulose and hemicellulose from paddy and ragi straw which were utilized better by *P. ostreatus*. The reduced amount of yield in T1 and T3 treatment could be attributed to rich lignin content and deprived stability of *P. ostreatus* to degrade lignin. The bioconversion efficiency of milky mushroom on wood shavings was found to be 62.5 % (Maheswari *et al.*, 2018). Syed *et al.* (2009) found the maximum yield of *P. florida* when cultivated on soybean straw (875.66 g/kg straw) with 87.56 % B.E. This was followed by yield on soybean + paddy straw (852.00 g/kg straw) with 85.20 % B.E. while the least was recorded with wheat straw+ paddy straw (723.66 g/kg straw). Pokhrel (2016) reported the biological efficiencies of *P. ostreatus* which ranged from 91.99 to 109.50 % in corn cob, 69.81 to 88.36 % in paper waste and 52.26 to 65.22 % in vegetable residue. In comparison to second flushes, yield was higher in the first flush in all substrates.

This study revealed that P. ostreatus cultivated on different substrates paddy straw + ragi straw was better in terms of spawn run, primordia formation and average number of fruiting bodies whereas the total yield of P. ostreatus was higher on sugarcane bagasse. The biological efficiency of P. ostreatus was found high in paddy straw + ragi straw

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