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Cultivation of Oyster mushrooms (*Pleurotus* spp.) on various agro-forest wastes in Arunachal Pradesh

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Six species of oyster mushrooms, *Pleurotus sajor-caju*, *P. sapidus*, *P.flabellatus*, *P. citrinopileatus*, *P. ostreatus* and *P. florida* were cultivated on paddy straw (PS) alone, PS with wild bamboo chips (BC) in 3:1 ratio, PS with wood shavings (WS) in 1:1 ratio, and PS with wild whole banana plant (BL) in 1:1 ratio in outdoor conditions to assess their potential as substrates. The biological efficiency (BE) and first flush yield (FFY) were significantly influenced by the type of substrates, *Pleurotus* species and their interaction. Average BE of all *Pleurotus* species on PS and PS + BL was equal (93%) followed by PS+BC (84%) and PS+WS (81%). PS+BL was best substrate for *P. citrinopileatus* (BE 112%) and equally good as PS for *P. sapidus*, *P.flabellatus* and *P. florida* (BE ≥ 95%). FFY was better on PS+BL and PS+BC in comparison to PS. The study finds PS+BL as potential substrate, PS+BC as slightly inferior but alternate substrate and PS+WS as a poor substrate for*Pleurotus* cultivation.

Key words: *Pleurotus,* substrates, outdoor cultivation, biological efficiency, yield

Oyster mushrooms (*Pleurotus* spp.) are the second largest commercially cultivated edible mushrooms in the world (Royse, 2014). They are the easiest, fastest growing and the cheapest cultivable mushrooms having high nutritional and therapeutic properties. Their cultivation needs less preparation time, minimum space and very low economic investment and most importantly, require moderate climatic conditions for growth and fruit body production. Owing to a simple and low cost production technology, their cultivation is very popular in Asia and Europe particularly among small and medium scale growers both in indoor and outdoor conditions (Mane *et al.* 2007). Under a moderate range of temperature, they show their excellent ability to synthesize lignocellulolytic enzymes (Kuforiji and Fasidi, 2008; Kurt and Buyukalaca, 2010) and produce sporophores on various lignocellulosic agro-forest wastes Hence, cultivation of *Pleurotus* spp. offers an opportunity to utilize renewable lignocellulosic agro-forest wastes in the production of consumable, highly nutritive, protein-rich food.

Arunachal Pradesh offers a highly conducive environment for mushroom cultivation due to a moderate temperature range (15-30^{0}C) and high humidity (70-80%) prevailing throughout the year. However, due to scarcity of paddy straw in the open market, mushroom cultivation could not emerge as a popular agri-business in the state which produces merely about 5 tonnes oyster mushrooms annually (Wakchaure, 2011). Since selection of substrates for mushroom cultivation depends on the abundance and cost of substrates (Liang *et al*. 2009), therefore, in the present study, some locally available lignocellulosic substrates, namely, wild banana plant (*Musa ornata*), wild bamboo (*Dendrocalamus hamiltonii*) and wood shavings

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mixed with paddy straw in different ratio were evaluated for their potential to serve as alternate substrate by cultivating six species of oyster mushrooms in outdoor conditions.

The experiment was carried out during winter season in an outdoor mushroom house (8x5x5m) constructed out of locally available cheap materials. The starter cultures of six selected strains of *Pleurotus* namely: *P. sajor-caju* (PL-1140), *P. sapidus* (PL-40), *P.flabellatus* (PL-50), *P. citrinopileatus* (PL-100), *P. ostreatus* (PL-20) and *P. florida* (P-I) were procured from the culture bank of Directorate of Mushroom Research, Solan, Himachal Pradesh. Pure cultures of *Pleurotus* spp. were maintained on Potato Dextrose Agar (PDA) and Malt Extract Agar (MEA) at 25±2 ^{0}C.

The spawn was prepared on whole wheat grains in polypropylene bags following standard techniques. Substrates for cultivation used in the study were: whole wild banana - *Musa ornata* (BL), culms of wild bamboo - *Dendrocalamus hamiltonii* (BC) and wood shavings (WS). Paddy straw (PS) was used as control. Properly sun dried substrates chopped into small pieces (1 cm) were mixed with paddy straw in following ratio on dry weight basis: PS+BL (1:1), PS+BC (3:1), PS+WS (1:1) Substrate sterilization was done by chemical methods using 500 ppm formalin and 75 ppm carbendazim. Spawning was done @3% (w/w) by layering method in polypropylene bags containing 1 kg wet substrate. Five replicates were kept for each treatment.

The ambient condition during spawn running was: RT 11-22 ºC; RH 60-86%; Av RH 69%. For pinhead formation and cropping, it was: RT 13-20 ºC; RH 66-90%; Av RH 76%. Moisture was maintained inside the cropping room by watering twice daily. Completely colonized bags were peeled open for fructification. Fruit bodies were harvested for three successive flushes from each bag and the biological efficiency (%) of substrate was calculated as gross fresh weight of mushrooms produced per kg dry weight of substrate. Statistical analysis of data was done by 2-way ANOVA.

The time taken in substrate colonization and pinhead formation on various substrates by six *Pleurotus* species was almost similar with an average difference of ±1 day. Neither the type of substrates nor the species of *Pleurotus* under cultivation showed any effect on the time taken for mycelial colonization of substrate, pinhead formation and flush duration.

The BE and FFY were significantly influenced by the type of substrates, *Pleurotus* species and their interaction ($p<0.05$). The average BE for six *Pleurotus* species on PS+BL and PS was 93%, PS+BC (84%) and PS+WS (81%) (Fig.1a). PS+BL proved to be the best substrate for *P. citrinopileatus* (BE 112%) and equally good as PS for *P. sapidus*, *P. flabellatus* and *P. florida* (BE ≥ 95%; $p>0.05$). PS+BC and PS were found to be equally good substrates for *P. ostreatus* and *P. sajor-caju* giving ≥ 90% BE. Similarly, PS+WS was found to be as good as PS for *P. sapidus*, *P. sajor-caju* and *P. flabellatus* (BE ~90%).

Comparing among the species, the highest average BE on different substrates used in this study was produced by *P. florida* (96%). Its average yield was significantly higher ($p<0.05$) than any other species which were on par with each other (83-88%). *P. citrinopileatus* and*P. florida* gave their best BE on PS+BL (112% and 108% respectively) which was significantly higher ($p<0.05$) than *P. flabellatus* and *P. sapidus* (~93% each). *P. sajor-caju* could not utilize PS+BL as efficiently as PS (BE 72% and 90% respectively).

Next to PS+BL, it was PS that gave 105% BE for *P. florida* which was significantly higher than the other species whose BE ranged between 85-93%.

PS+BC in comparison to PS+WS proved to be a relatively better substrate ($p<0.05$) for *P. sajor-caju* (BE 98% vs 82%) and *P. ostreatus* (BE 91% vs 72%); equally good for *P. citrinopileatus* (BE 76% vs 65%) and *P. florida* (BE 83% vs 89%); but comparatively poorer for *P. sapidus* (BE 78% vs 90%) and *P. flabellatus* (BE 76% vs 88%).

The ratio of FFY of all species to their BE on various substrates varied widely from 40-86% (Table 1). It was lowest for PS+WS (35-43%), moderate for PS (50-59%), high for PS+BL (60-77%) and very high for PS+BC (69-91%). Most of the *Pleurotus* species gave a better FFY on PS+BC and PS+BL in comparison to PS (Fig. 1b). The increase in FFY on PS+BC over PS was significant for *P. sajor-caju* and *P. ostreatus* ($p<0.05$) but not for rest of the species. Among all combinations of the substrate tested, the FFY of all species was the lowest on PS+WS (105-146 g).

Comparing PS+BC with PS+BL, *P. sajor-caju* and *P. ostreatus* gave more FFY on the former (197g vs 121g and 192g vs 153g respectively), *P. citrinopileatus* gave more FFY on the later (128 g vs 184g), and *P. sapidus*, *P. flabellatus* and *P. florida* gave almost a similar FFY ranging between 150-185g on both substrates.

The rate of utilization of substrates by six *Pleurotus* species varied widely showing their preference for a particular substrate (Table 1). In general, BE on PS and PS+BL was similar but significantly more in comparison to PS+BC and PS+WS ($p<0.05$). In our study, substrate prepared by using whole banana plant (a wild variety) with paddy straw (1:1) gave on average 93% BE which is in conformity with the findings of Reddy *et al.* (2000) for whole banana plant, Nivedita *et al.* (2009) reporting 87% BE for banana pseudostem and Mamiro and Mamiro (2011) reporting 98.5% BE on banana leaves mixed with paddy straw (1:1). Many other workers have also reported banana pseudostem (Siqueira *et al.* 2011) and banana leaves as good substrates (Masarirambi *et al.* 2011). Some workers have reported banana pseudostem (Rani *et al.*, 2008) and banana leaves as a poor substrates (Mondal *et al.* 2010).

In our study, addition of BC with PS in 3:1 ratio resulted in a decline in total yield of four *Pleurotus* spp., but enhanced the yield of *P. sajor-caju.*

Table 1 : Ratio (%) of First flush yield (FFY) to Total yield (BE) for *Pleurotus* spp. cultivated on various substrates

	Substrates			
Pleurotus species	PS	PS+BC	PS+WS	PS+BL
P. sajor-caju	58	81	43	66
P.sapidus	59	82	40	67
P.citrinopileatus	54	69	40	64
P.flabellatus	50	79	36	69
P.ostreatus	54	86	37	77
P.florida	58	91	35	60

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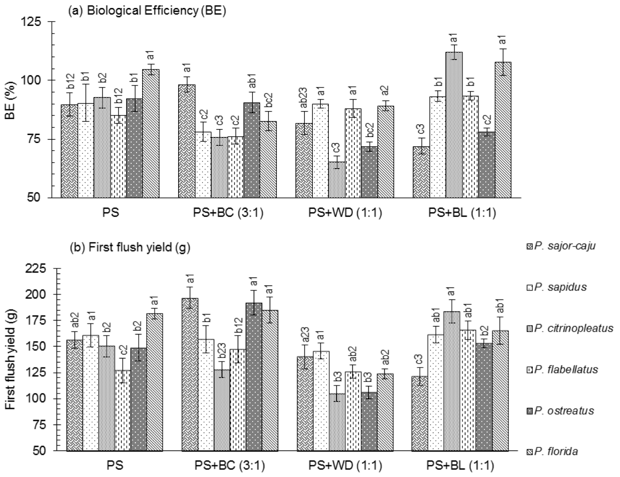

Results are mean ± SEM (n=5). Bars with different letters and numerals indicate a significant difference in BE ($p<0.05$) between *Pleurotus* species grown on the same substrate and between substrates used for cultivation of the same species respectively.

Fig. 1 : Yield of *Pleurotus* spp. on various substrates in outdoor cultivation

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