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Research Article

Comparative study on yield performance of *Pleurotus* species

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Article Info

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Abstract

The present study evaluates the yield performance of two oyster mushroom species, *Pleurotus florida* and *Pleurotus ostreatus*, cultivated on six distinct agro-residues, namely soybean straw, paddy straw, wheat straw, maize stalks, sugarcane bagasse, and banana leaves. The influence of substrate composition on biological efficiency and yield was systematically analyzed to identify the most suitable agro-waste for mushroom cultivation. Among the tested substrates, soybean straw supported the maximum yield for both species, recording 868.66 g/kg dry substrate for *P. florida* and 798.66 g/kg dry substrate for *P. ostreatus*. In contrast, the lowest yield of *P. florida* (688.66 g/kg dry substrate) was observed on banana leaves, while *P. ostreatus* exhibited the minimum yield (605.33 g/kg dry substrate) on maize stalks. A gradual decline in yield from the first to the third flush was consistently noted across all substrate types, indicating substrate nutrient depletion over successive harvests. The findings highlight the potential of soybean straw as a superior substrate for the commercial cultivation of *Pleurotus* species and emphasize the role of substrate selection in optimizing mushroom productivity and sustainability in agro-waste utilization.

Keywords: *Pleurotus florida, Pleurotus ostreatus, Picking,* mushroom cultivation, agro-waste substrates, sustainable agriculture, waste valorization.

1. Introduction

The cultivation of *Pleurotus* species, commonly known as oyster mushrooms, has gained significant global attention owing to their exceptional nutritional, medicinal, and economic importance [1-4]. Belonging to the family *Pleurotaceae*, these edible fungi are recognized as one of the most efficient bioconverters of lignocellulosic materials into protein-rich biomass [5, 6]. Globally, oyster mushrooms rank second in commercial production after *Agaricus bisporus* [7-10]. Their ease of cultivation, adaptability to diverse climatic conditions, and ability to utilize a wide range of low-cost agricultural residues make them ideal candidates for sustainable mushroom production systems [11-15].

Agricultural by-products such as rice straw, wheat straw, maize stalks, sugarcane bagasse, soybean straw, banana leaves, corn cobs, sawdust, cotton waste, and other lignocellulosic residues are often underutilized or improperly disposed of through open burning, contributing substantially to environmental degradation and greenhouse gas emissions [16-19]. The use of these wastes as substrates for mushroom cultivation represents an eco-friendly and economically viable solution to agricultural waste management [20-22]. Through the bioconversion process, *Pleurotus* species not only produce edible mushrooms but also generate nutrient-rich spent mushroom substrate (SMS), which can be further used as a soil conditioner, organic fertilizer, or animal feed additive [23-28].

The efficiency of *Pleurotus* species in utilizing complex plant polymers is attributed to their strong ligninolytic and cellulolytic enzymatic systems, which enable the degradation of cellulose, hemicellulose, and lignin [29-31]. This enzymatic versatility allows these fungi to colonize and fructify on a wide array of organic residues with minimal supplementation [32-34]. The general cultivation process involves substrate preparation (shredding, soaking, and pasteurization), spawning, mycelial colonization, and fruiting under controlled temperature and humidity [35-36]. Because of their modest infrastructural requirements and rapid growth rate, oyster mushrooms are particularly suited for small-scale rural enterprises and serve as a sustainable source of income and nutrition [37-39].

However, the biological efficiency and yield of *Pleurotus* species vary depending on the type of agro-waste substrate, its physicochemical composition, and the environmental conditions during cultivation [40, 41]. Substrates with balanced carbon-to-nitrogen (C:N) ratios, adequate moisture-holding capacity, and high carbohydrate content generally promote better mycelial growth and fruit body development [42, 43]. Therefore, selecting an optimal substrate is crucial for maximizing productivity, improving the economic feasibility of mushroom cultivation, and enhancing the valorization of agricultural residues [44-47]. Various agro-wastes, including corn sheath, corn cob, coir pith, paddy straw, ragi straw, and sugarcane bagasse, have been successfully employed for the cultivation of *Pleurotus* species [49].

In recent years, several comparative studies have been conducted to determine the most suitable substrate–species combinations to improve yield efficiency and resource utilization [50]. Such investigations not only optimize mushroom production but also support circular bioeconomy models by converting agro-residues into value-added products [51]. In this context, the present study was undertaken to compare the yield performance of *Pleurotus florida* and *Pleurotus ostreatus* cultivated on six different agro-wastes—soybean straw, paddy straw, wheat straw, maize stalks, sugarcane bagasse, and banana leaves—aiming to identify the most productive substrate for sustainable oyster mushroom cultivation.

2. Materials and Methods

2.1 Experimental Site and Design

The present experiment was conducted under controlled laboratory conditions in a mushroom production facility specifically designed for the cultivation of oyster mushrooms. The objective of the study was to evaluate the growth and yield performance of Pleurotus florida and Pleurotus ostreatus cultivated on various agro-residues. A Completely Randomized Design (CRD) was employed with six substrate treatments and three replications for each treatment. All cultivation parameters, including temperature, humidity, and ventilation, were carefully monitored and maintained throughout the experimental period to ensure reproducibility and uniformity.

2.2 Culture and cultivation: Pure cultures of *Pleurotus florida* and *Pleurotus ostreatus* were procured from the National Collection of Industrial Microorganisms (NCIM), National Chemical Laboratory (NCL), Pune, India. The stock cultures were maintained on 2% malt extract agar (MEA) slants and stored at 4 ± 1 °C for preservation. Regular sub-culturing was carried out every 15 days to ensure the viability and vigor of the mycelia for experimental use.

2.3 Spawn Preparation: Spawn was prepared using sorghum grains as the carrier medium following a modified protocol of Bano and Srivastava (1962). Whole sorghum grains were boiled in a 1:1 (grain:water) ratio for 10–15 minutes to achieve partial softening. The grains were subsequently drained and mixed with 4% (w/w) calcium carbonate ($CaCO_3$) and 2% (w/w) calcium sulfate ($CaSO_4$) to prevent clumping and provide pH buffering. Approximately 250 g of the prepared grains were filled into autoclavable polypropylene bags (200 × 300 mm) and sterilized at 121 °C for 30 minutes. After cooling to room temperature, each bag was aseptically inoculated with actively growing mycelial discs from MEA slants. The inoculated bags were incubated in darkness at 25 ± 2 °C for 10–15 days until complete mycelial colonization of the grains was achieved.

2.4 Cultivation: Six different agro-wastes-soybean straw, paddy straw, wheat straw, maize stalks, sugarcane bagasse, and banana leaves-were collected from nearby agricultural fields and used as substrates. The substrates were chopped into 2–3 cm pieces, soaked overnight in water for proper hydration, and excess water was drained off the following day. The moistened substrates were sterilized at 121 °C for 20 minutes in an autoclave and then allowed to cool.

Cultivation was performed in 35 × 45 cm polypropylene bags using the multilayer spawning technique. Each bag contained 1 kg of dry substrate, and spawning was carried out at a rate of 2% (w/w) of the wet substrate weight. The inoculated bags were incubated at 25 ± 2 °C under 80–90% relative humidity with adequate ventilation and diffused light. Complete mycelial colonization (spawn run) occurred within 18 days. After colonization, the polythene bags were removed to allow the initiation of fruiting. Pinhead formation was observed within 3–4 days after bag removal, and fruiting continued up to the third flush, typically completed within 35 days of spawning. After each harvest, a thin layer of spent substrate was gently scraped from all sides to stimulate subsequent flushes. Each treatment was replicated three times.

2.5 Yield and Biological efficiency: The total yield of each treatment was determined by recording the cumulative fresh weight of all fruiting bodies harvested from three successive flushes. Biological efficiency (B. E.)-defined as the percentage of mushroom yield relative to the dry weight of the substrate-was calculated according to the method described by Chang *et al.* using the following formula [52]:

$$B.E.(\%) = \frac{\text{Fresh weight of mushroom}}{\text{Dry weight of substrate}} \times 100 \quad (1)$$

2.6 Statistical Analysis: All quantitative data recorded during the experiment were statistically analyzed following the procedure outlined by Panse and Sukhatme (1978). Analysis of variance (ANOVA) was used to determine the significance of treatment effects, and mean comparisons were performed using appropriate post-hoc tests at the 5% level of significance [53].

3. Results and Discussion

The results of the present investigation revealed significant variations in yield and biological efficiency (B. E.) of *Pleurotus florida* and *Pleurotus ostreatus* when cultivated on six different agro-residues (Table 1). The data indicate that the choice of substrate had a marked influence on mycelial growth, fruit body formation, and overall productivity of both *Pleurotus* species. Three successive pickings (flushes) were obtained from all substrates, and a progressive decline in yield was observed from the first to the third flush, irrespective of the substrate type. Such a reduction is commonly attributed to nutrient depletion and the gradual loss of substrate moisture and structure during successive harvests.

3.1 Yield Performance of *Pleurotus florida*

Among all the tested agro-wastes, soybean straw supported the highest yield of *P. florida* (868.66 g/kg dry substrate), followed by paddy straw (824.66 g/kg), sugarcane bagasse (772.33 g/kg), wheat straw (740.62 g/kg), maize stalks (699.33 g/kg), and banana leaves (688.66 g/kg). The superior performance of soybean straw may be ascribed to its optimal carbon-to-nitrogen (C:N) ratio, balanced nutrient composition, and favorable physical structure that promotes aeration and mycelial penetration. Soybean straw is known to possess higher nitrogen, cellulose, and hemicellulose contents than most cereal residues, providing both nutritional and structural advantages for fungal colonization.

The high yield of *P. florida* observed on soybean straw also reflects the species' strong ligninolytic and cellulolytic enzyme system, which facilitates the degradation of complex plant polymers into simple carbohydrates readily utilized for biomass production. *Pleurotus* species secrete extracellular oxidative enzymes such as laccases, manganese peroxidases, and lignin peroxidases that play a crucial role in lignin breakdown, thus enhancing the digestibility of the substrate. Rapid colonization and efficient substrate utilization lead to faster fruiting initiation and higher yields. Similar findings were reported by Patil (2013), who demonstrated that *P. sajor-caju* achieved a biological efficiency of 83.33% when cultivated on soybean straw, indicating that leguminous residues serve as excellent substrates for *Pleurotus* cultivation.

The comparatively lower yield of *P. florida* obtained from banana leaves and maize stalks can be attributed to their low nitrogen and high lignin contents, which hinder enzymatic degradation and mycelial spread. In addition, the compact structure and poor porosity of these substrates may have restricted air circulation, resulting in suboptimal conditions for fruit body development. Lakhe *et al.* also reported similar observations, confirming that soybean straw is a superior substrate for *P. florida* cultivation due to its favorable physicochemical and nutritional characteristics [54].

3.2 Yield Performance of *Pleurotus ostreatus*

A similar trend was observed in *P. ostreatus*, though the absolute yields were comparatively lower than those of *P. florida* on all substrates. The maximum yield of *P. ostreatus* (798.66 g/kg dry substrate) was recorded on soybean straw, followed by paddy straw (723.66 g/kg), sugarcane bagasse (715.66 g/kg), wheat straw (700.66 g/kg), banana leaves (612.33 g/kg), and maize stalks (605.33 g/kg). These results are consistent with earlier findings by Menon *et al.*, who reported significant substrate-dependent variations in *P. ostreatus* yield, highlighting the role of substrate composition and aeration in influencing biological efficiency [55].

The superior performance of *P. ostreatus* on soybean and paddy straws can be explained by the readily available carbohydrates and nitrogenous compounds present in these residues, which facilitate active mycelial colonization and rapid fruiting. Moreover, the porous and fibrous texture of these substrates enhances oxygen diffusion and moisture retention—both critical factors for mushroom morphogenesis. Patil (2012) observed similar outcomes while studying *P. sajor-caju* on various substrates, noting that soybean straw not only produced the highest yield but also resulted in mushrooms with greater protein content compared to those grown on cereal straws or stalks [56].

3.3 Comparative Performance and Substrate Suitability

Overall, *P. florida* outperformed *P. ostreatus* on all tested substrates, indicating species-specific differences in metabolic adaptability and enzyme expression profiles. *P. florida* is known for its faster substrate colonization and greater tolerance to variable environmental conditions, which may explain its relatively higher biological efficiency. The results corroborate previous reports that *Pleurotus* species differ significantly in their ability to utilize lignocellulosic wastes depending on enzyme secretion patterns, substrate composition, and ecological preferences.

Soybean straw consistently emerged as the most suitable substrate for both species, followed by paddy straw and sugarcane bagasse. The enhanced productivity on these substrates could be attributed to their balanced nutrient profile, moderate lignin content, and excellent water-holding capacity, which together provide ideal conditions for sustained mushroom growth. Conversely, maize stalks and banana leaves, with their high lignin and wax content, lower nitrogen levels, and reduced moisture retention capacity, were less favorable for mushroom cultivation.

3.4 Trends Across Flushes and Biological Efficiency

In both species, yields declined gradually from the first to the third flush across all substrates. This trend is commonly observed in mushroom cultivation and is primarily due to progressive nutrient exhaustion and physical compaction of the substrate over successive harvests. During later flushes, reduced enzyme activity and diminished carbohydrate reserves limit further mycelial regeneration and fruiting potential. Similar yield decline patterns were described by Gebru *et al.* (2024) and Subedi *et al.* (2023) in *Pleurotus* cultivation studies [57, 58].

The calculated biological efficiency (B.E.) values closely mirrored yield trends, confirming the strong correlation between substrate quality and mushroom productivity. Soybean straw exhibited the highest B.E. for both *P. florida* and *P. ostreatus*, reinforcing its potential as a preferred substrate for commercial-scale oyster mushroom cultivation.

3.5 Implications for Sustainable Agriculture and Waste Management

The results of the present study emphasize the dual benefits of oyster mushroom cultivation: high-value food production and effective recycling of agricultural residues. Utilizing nutrient-rich agro-wastes such as soybean and paddy straws not only enhances mushroom yield but also mitigates environmental pollution associated with residue burning. Additionally, the residual spent mushroom substrate (SMS) can be repurposed as organic manure, soil conditioner, or animal feed ingredient, contributing to sustainable and circular bioeconomy frameworks.

Table 1: Effect of different substrate on mean yield of *P. florida* and *P. ostreatus*.

Substrate	Yield (gm) / Kg dry straw of *P. florida*					Yield (gm) / Kg dry straw *P. ostreatus*				
	I Picking	II Picking	III Picking	Total	BE (%)	I Picking	II Picking	III Picking	Total	BE (%)
SS	410.00	363.66	95.00	868.66	86.86	335 66	285.00	178.00	798.66	79.86
PS	372.00	315.33	137.33	824.66	82.46	350.00	265.33	108.66	723.66	72.36
WS	350.00	258.62	132.00	740.62	74.06	320.33	265.33	115.00	700.66	70.06
MS	345.33	240.00	114.00	699.33	69.93	290.00	210.33	105.00	605.33	60.53
SB	352.33	248.00	172.00	772.33	77.23	325.33	272.00	118.33	715.66	71.56
BL	350.66	250.00	108.00	688.66	68.86	285.33	205.00	122.00	612.33	61.23
S.E. ±	10.50	12.15	6.75	-	-	12.50	7.25	4.38	-	-
C.D. (5%)	32.30	37.39	22.35	-	-	43.10	21.15	13.15	-	-

SS=Soybean straw, PS= Paddy straw, WS= Wheat straw, MS= Maize stalk, SB= Sugarcane bagasse, BL= Banana leaves.

3.6 Discussion Summary

The results of this study clearly demonstrate that both species selection and substrate

composition significantly influence the yield and biological efficiency of Pleurotus mushrooms. Among the tested combinations, *P. florida* cultivated on soybean straw exhibited the highest productivity and efficiency, slightly outperforming P. ostreatus under identical conditions. These findings are consistent with earlier reports suggesting that straw-based substrates provide an optimal medium for Pleurotus cultivation owing to their balanced nutrient composition, porous texture, and superior moisture retention properties.
Furthermore, the use of locally available agro-wastes as substrates not only enhances mushroom yield but also promotes waste valorization, income generation, and environmental sustainability in rural areas. By carefully selecting substrates and refining cultivation practices, mushroom growers can achieve substantial improvements in productivity, profitability, and resource efficiency-supporting the broader goals of sustainable agriculture and circular bio-economy.

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