DOI : 10.58993/ijh/2025.82.3.10

Indian J. Hortic. 82(3), September 2025: 317-322

Production efficiency of oyster mushroom on saw dust, wood chips and wheat substrates

Archana Kumawat[1*], Gayatri Kumawat[2] and Alok Raj Wasnikar[1]

[1]Department of Plant Pathology, Jawaharlal Nehru Krishi Vishwa Vidhalya, Jabalpur, Madhya Pradesh 482004, India

ABSTRACT

Agricultural and industrial waste product has led to significant environmental challenges, including air and soil pollution, as well as the spread of insects and pathogens. To address these issues, this study analyses the possibilities of exploiting agricultural leftovers as substrates for the production of *Pleurotus membranaceus* (oyster mushroom), which offers both economic and nutritional benefits. The experiment assessed the impact of several substrate ratios of saw dust (SD) and wood chips (WC) coupled with wheat straw (WS) (in ratios of 100%:0%, 75%:25%, 50%:50%, 25%:75%, and 0%:100%) on the growth performance of oyster mushroom. Among all substrates, 100% WS (control) exhibited the best performance, achieving the highest yield (902.10 g) and biological efficiency (90.21%). This was followed by the 75% SD and 25% WS combination, with a yield of 705.18 g and BE of 70.52%. The lowest performance was observed with cost-effective 100% wood chips, yielding 630.08 g and BE of 63.01%. The study demonstrates the potential of WS as a substrate for oyster mushroom cultivation, promoting both waste management and sustainable agricultural practices.

Key words: Industrial waste, growth performance, biological efficiency, sustainable management, cost-effective.

INTRODUCTION

Mushrooms, belonging to the class Basidiomycetes, are macroscopic, filamentous, and epigeal fruiting bodies of fungi. These organisms are cosmopolitan in distribution and heterotrophic, with distinct nutritional and ecological requirements (Ola and Oboh, 12). Oyster mushrooms (*Pleurotus membranaceus*) are esteemed for their nutritional advantages, culinary adaptability, and therapeutic attributes. *Pueraria membranaceus* contains 15–23% crude protein, 45–60% NDF, and 8–10% ash (dry matter basis), making it a highly nutritious forage legume. It is widely used in pastures due to its high protein yield, nitrogen-fixing ability, and compatibility with grasses; it produces 8–15 tons dry matter/ha/year and improves soil fertility, especially in tropical regions. (Kumawat *et al*., 9).

Oyster mushrooms typically grow on decaying wood, such as fallen logs or the trunks of dying deciduous and coniferous trees, in temperate and tropical forests. They can also be found thriving on decomposing organic matter. It has been reported that mushrooms can be successfully grown on a variety of lignocellulosic waste materials and even poultry droppings (Kumawat *et al.,* 9). The most effective and financially feasible biotechnology for turning industrial and agricultural waste into high-quality protein meals may be the growing of mushrooms (Hussain, 6).

*Correspondence email: archukumawat8@gmail.com

[2]Livestock Feed Resource Management and Technology Centre, Rajasthan University of Veterinary and Animal Sciences, Bikaner 334 001, India

Wheat and rice straw, SD, hardwood chips, sugarcane bagasse, cottonseed hulls, maize cobs, rice bran, and wheat bran are the most often utilized waste materials for the production of edible mushrooms (Saber *et al*., 17; Kumawat *et al*., 9). Among these, WS is especially valuable for organic farming, offering significant plant nutrients with approximately 35–40% nitrogen (N), 10–15% phosphorus (P), and 80–90% potassium (K) (Davari *et al*., 2). Enhancing substrates with additional nutrients can significantly improve their nutritional value for efficient mushroom production (Patel *et al*., 14). Since different substrate treatment methods can significantly impact oyster mushroom cultivation, this research aims to evaluate the feasibility of various treatment approaches using wood chips (WC), sawdust (SD), and wheat straw (WS) as substrates. The primary objective is to compare the effectiveness of these treatment methods on the growth performance and yield of oyester mushroom.

MATERIALS AND METHODS

These steps are used in oyster mushroom production procedure: Pure culture preparation, substrate preparation, spawn production, growing and harvesting at maturity stage at different interval. The present study was conducted at the Jawaharlal Nehru Krishi Vishawa Vidhalaya, Jabalpur (M.P.) The single factor experiment comprised five treatments, specifically various substrates: saw dust (SD), wood chips (WC) combined with wheat straw

(WS) in varying ratios. A pure culture of *Pleurotus membranaceus* was isolated from the fruiting body obtained from the Mushroom Research Laboratory in Jabalpur.

Wheat grains (*Triticum aestivum*) were utilized in the preparation of mushroom spawn. Initially, the wheat grains were partially boiled for 20–25 minutes to soften them, followed by thorough rinsing and cooling to room temperature. Wheat grains at the rate of 10%, and chalk ($CaCO_3$) at the rate of 2% were added on dry weight basis of the grains. Once prepared, the boiled wheat grains were filled into glass bottles, occupying approximately two-thirds of the total bottle volume. The bottles were then sealed with cotton plug and pasteurized by subjecting them to 121°C for one hour at 15 psi to ensure sterilization. After pasteurization, the sterilized glass bottles were aseptically inoculated with 5 mm pieces of the mycelial culture. The inoculated bottles were incubated at a controlled temperature of 20 ± 2°C for 14 days to facilitate complete colonization of the grains by the mycelium. After this incubation period, the grain spawn was fully colonized and ready for utilization in further mushroom cultivation processes.

SD and WC were procured from local markets in Jabalpur. To eliminate contaminants, the substrates underwent chemical sanitation by soaking in a solution of 750 ppm Formaldehyde, following the method described by Roksana *et al*. (16). After treatment, the substrates were left outdoors for 18 hours at temperatures between 40°C and 45°C to facilitate the evaporation of excess formaldehyde. Once the sanitation process was complete, excess moisture was removed by spreading the substrates on a flat, inclined surface covered with a polypropylene sheet or by placing them on a 150-mesh iron frame, as recommended by Peng (15). After cooling to room temperature, the substrates were blended with WS in varying ratios: 100% SD; 0% WS, 75% SD; 25% WS, 50% SD; 50% WS, 25% SD; 75% WS and 0% SD; 100% WS representing different agro-waste compositions. The mixed substrates were inoculated with oyster mushroom spawn at a rate of 4% (w/w) relative to the wet weight of the substrate, in accordance with Jafarpour *et al*. (8). After thorough mixing, the inoculated substrates were packed into sterilized polypropylene bags (12 × 18 inches), which were sealed at the top and punctured with small holes to facilitate air exchange. The inoculated bags were then incubated (December) in a dark room maintained at a temperature of 25–28°C and a relative humidity of 70–80% for 15–20 days to allow complete colonization by the mycelium. Once full colonization was achieved, the bags were transferred to a fruiting chamber equipped with a 12-hour light/dark cycle. The fruiting environment was regulated at 22–26°C with a relative humidity of 85–90%. The bags were cut open to expose the substrate, and regular misting was applied to maintain humidity levels. Within 7–10 days, pinheads of the mushrooms began to emerge, subsequently developing into mature fruiting bodies.

Oyster mushrooms were harvested when the caps were fully developed but before they began to curl upwards. The yield of oyster mushrooms was recorded by weighing the fresh mushrooms from each substrate. The biological efficiency (BE) was calculated using the following formula (Chang and Miles, 1).

$$\text{Biological Efficiency (BE)} = \frac{\text{Fresh weight of mushroom}}{\text{Dry weight of substrate}} \times 100$$

Physical Parameter such as spawn run (days), pin head initiation (days), stipe length (cm) stipe width (cm), cap diameter (cm), number of fruiting bodies, flush time (days), flush yield (g) and average total yield (g) were collected during experiment.

RESULTS AND DISCUSSION

The lowest days of spawn run was analysed in the WS substrate (16.88 days), followed by the combination of SD 25% + 75% WS (18.35 days) (Table 1 and Fig. 1). Conversely, the 100% WC substrate (Table 1 and Fig. 1) required the longest time (25.08 days) for mycelial growth. Similarly, the 100% WS substrate required significantly fewer days (18.98) for pinhead initiation, followed by the SD 25% + 75% WS mixture (21.55 days) (Table 1 and Fig. 1). In contrast, the 100% WC substrate exhibited the longest time for pinhead initiation (28.58 days). The longest stipe length was observed in the 100% WS substrate (3.18 cm), followed by the SD 25% + 75% WS mixture (3.15 cm). The shortest stipe length was observed in the 100% WC substrate (2.28 cm), with the next shortest length found in the 100% WC (2.64 cm).

In terms of stipe width, the highest measurements were recorded in the WC 25% + 75 % WS (0.85 cm). The narrowest stipe width was observed in the 100% WS substrate (0.17 cm), followed by the 100% SD mixture (0.53 cm). For cap diameter, the 100% WS substrate showed the largest diameter (9.03 cm), while the smallest cap diameter was found in the 100% WC substrate (6.38 cm) during the 1st flush (Table 1). The number of fruiting bodies (NFB) ranged from 15.13 to 21.13 across the substrates (Tables 1). The highest NFB was recorded in the 100% WS substrate (21.13), followed by the SD 75% and 25% WS mixture (17.35). The lowest NFB was observed in the 100% WC substrate (15.13).

Table 1: Effect of SD, WS and WC substrates on yield contributing characters of oyester mushroom.

Sr. No.	Treatment	Spawn run (days)	Pin head initiation (days)	Stipe length (cm)	Stipe width (cm)	Cap diameter (cm)	No. of fruiting bodies	Flush time (days)			Flush yield (g)			Average total yield (g)	Biological efficiency (%)
								1st	2nd	3rd	1st	2nd	3rd		
T_1	SD 100%	22.20^{a}	25.40^{a}	2.64^{d}	0.53^{c}	7.75^{c}	15.38^{d}	33.20^{a}	49.13^{a}	64.63^{a}	312.70^{e}	196.40^{e}	141.60^{e}	650.70^{e}	65.07^{e}
T_2	SD 75% + 25 % WS	21.68^{a}	24.88^{a}	2.83^{c}	0.71^{b}	8.10^{bc}	17.35^{b}	30.43^{b}	46.50^{b}	61.78^{b}	316.98^{b}	229.63^{b}	158.58^{b}	705.18^{b}	70.52^{b}
T_3	SD 50% + 50 % WS	20.35^{b}	23.55^{b}	3.03^{b}	0.74^{a}	8.48^{ab}	16.40^{c}	28.65^{c}	44.73^{c}	59.63^{c}	316.15^{c}	217.93^{c}	152.68^{c}	686.75^{c}	68.67^{c}
T_4	SD 25% + 75 % WS	18.35^{c}	21.55^{c}	3.15^{a}	0.75^{a}	8.53^{ab}	16.08^{cd}	25.22^{d}	41.45^{d}	56.68^{d}	313.85^{d}	201.65^{d}	147.45^{d}	662.95^{d}	66.30^{d}
T_5	WS 100%	16.88^{d}	18.98^{d}	3.18^{a}	0.17^{d}	9.03^{a}	21.13^{a}	23.78^{e}	37.95^{e}	53.40^{e}	351.57^{a}	302.68^{a}	247.85^{a}	902.10^{a}	90.21^{a}
	SE (m)±	0.18	0.17	0.04	0.009	0.20	0.24	0.19	0.20	0.20	0.22	0.37	0.42	0.89	0.08
	$CD_{p\geq0.05}$	0.54	0.54	0.12	0.02	0.60	0.74	0.57	0.61	0.61	0.67	1.12	1.27	2.68	0.26
T_1	WC 100%	25.08^{a}	28.58^{a}	2.28^{d}	0.75^{c}	6.38^{c}	15.13^{d}	36.38^{a}	53.23^{a}	66.73^{a}	305.80^{e}	194.70^{e}	129.58^{e}	630.08^{e}	63.01^{e}
T_2	WC 75% + 25 % WS	24.18^{b}	27.63^{b}	2.68^{c}	0.78^{b}	7.53^{b}	16.78^{b}	31.28^{b}	47.48^{b}	61.33^{b}	313.85^{b}	224.68^{b}	153.53^{b}	692.05^{b}	69.21^{b}
T_3	WC 50% + 50 % WS	22.33^{c}	25.83^{c}	2.83^{b}	0.83^{a}	7.78^{b}	16.20^{bc}	29.18^{c}	45.40^{c}	59.30^{c}	310.78^{c}	200.65^{c}	150.68^{c}	662.10^{c}	66.21^{c}
T_4	WC 25% + 75 % WS	19.30^{d}	22.78^{d}	3.15^{a}	0.85^{a}	8.70^{a}	15.55^{cd}	25.10^{d}	42.20^{d}	55.48^{d}	308.68^{d}	197.83^{d}	138.63^{d}	645.13^{d}	64.51^{d}
T_5	WS 100%	16.88^{e}	18.98^{e}	3.18^{a}	0.17^{d}	9.03^{a}	21.13^{a}	23.78^{e}	37.95^{e}	53.40^{e}	351.57^{a}	302.68^{a}	247.85^{a}	902.10^{a}	90.21^{a}
	SE (m)±	0.18	0.20	0.03	0.007	0.13	0.22	0.19	0.36	0.23	0.23	0.40	0.37	0.74	0.07
	$CD_{p\geq0.05}$	0.57	0.60	0.11	0.022	0.39	0.66	0.59	1.09	0.71	0.71	1.20	1.14	2.23	0.22

Note: SE ±: Standard error of mean, $CD_{0.05}$: critical difference, p = level of significance, SD: Straw dust, WS: wheat straw, WC: Wood chips.

In this study fastest mycelial growth and the shortest spawn running period were observed on 100% WS than on other substrates such as SD, WC and their combination with WS. The observed differences in mushroom growth and yield across these substrate ratios can be attributed to variations in the chemical composition and physical characteristics of the substrates used. This finding is favour with previous research that have identified WS as an excellent substrate for oyster mushroom cultivation due to its high content of cellulose, hemicellulose, and lignin (Jafarpour and Eghbalsaeed, 7). These lignocellulosic components are easily degraded by *P. membranaceus*, providing a rich source of nutrients necessary for both spawn growth and fructification. In comparison, the substrates containing combinations of WS and agro-wastes, such as SD and wood chips, showed slower mycelial growth and longer spawn running periods. This can be explained by differences in the chemical properties of these materials, particularly their carbon-to-nitrogen (C/N) ratios. Substrates with higher C/N ratios have been shown to support faster fungal colonization, as the optimal balance of carbon (for energy) and nitrogen (for protein synthesis) is critical for fungal metabolism and mycelial expansion (Maheswari *et al.,* 10; Orngu *et al.,* 13). In this study, WS, with its favourable C/N ratio, facilitated more rapid mycelial growth, cap diameter, stipe length, stipe width and the number of mushroom fruiting bodies compared to the other mixed substrates (Fanadzo *et al*., 4 and Han *et al*., 5). This highlights the potential of WS as an effective substrate for optimizing both growth rate and mushroom quality.

The time to harvest the 1st flush ranged from 23.78 to 36.38 days, with the shortest duration recorded in the 100% WS substrate (23.78 days) and the longest in the 100% WC substrate (36.38 days). Similar results were observed for the 2nd and 3rd flushes with the minimum time taken by WS 100% and the maximum time by WC 100%. The flush yield during the 1st flush ranged from 305.80 g to 351.57 g per bag. The highest yield in the 1st flush was achieved with the 100% WS substrate (351.57 g), while the lowest yield was obtained from the 100% WC substrate (305.80 g). In the 2nd and 3rd flushes, the highest yields per bag were also recorded in the 100% WS substrate, with 302.68 g and 247.85 g, respectively. Similar results were observed for the 2nd and 3rd flushes with the lowest yield was obtained from the 100% WC substrate (194.70 g and 129.58 g). Overall, the highest average total yield (902.10 g per bag) and biological efficiency (90.21%) were obtained from the 100% WS substrate. This was followed by the 75% SD + 25% WS mixture, which

Fig. 1. Effect of different substrates on yield contributing characters of oyester mushroom.

yielded 705.18 g per bag with 70.52% biological efficiency. The lowest yield (630.08 g per bag) and biological efficiency (63.01%) were recorded in the 100% WC substrate.

The study demonstrated that oyster mushrooms cultivated on 100% WS substrate achieved the highest flush yield and biological efficiency, reinforcing the suitability of WS as an optimal substrate for mushroom production. This result is consistent with several previous studies that have also highlighted WS as a superior substrate for oyster mushrooms, owing to its high content of cellulose, hemicellulose, and lignin, which provide a rich source of carbon necessary for fungal growth (Onyeka *et al*., 13; Patel *et al*., 14; Elattar *et al*., 3; Muswati *et al*., 11). In addition, the substrate combination of 75% SD and 25% WS also showed promising results, suggesting that incorporating SD can still yield productive results, albeit slightly lower than pure WS (Sofi *et al*., 18). SD while a commonly used lignocellulosic substrate in mushroom cultivation, contains a more complex composition of fibres that can slow down initial mycelial colonization. However, when combined with WS, it likely benefits from the more readily available carbohydrates and nutrients in the straw, boosting the biological efficiency.

Higher fiber content substrates, such as those predominantly consisting of WS, were found to reduce the total growth period, decrease the time for pinhead initiation, and ultimately lead to increased yield and biological efficiency. This accelerated growth is likely due to the balanced availability of carbon-rich compounds in WS that are easier for *P. membranaceus* to break down and utilize for fruiting body development. These findings align with prior studies that suggest lignocellulosic materials, particularly those with high cellulose and hemicellulose content like WS, provide an ideal substrate for fungal growth and fruiting (Fanadzo *et al*., 4). Furthermore, the positive results achieved with WS are significant in the context of agro-waste utilization. WS, as an abundant agricultural by-product, represents a cost-effective and sustainable option for mushroom farmers. The findings of this study, in line with previous research (Elattar *et al*., 3; Muswati *et al*., 11), confirm that WS not only enhances yield but also promotes efficient use of agricultural residues, which contributes to reducing environmental waste and promoting circular agriculture.

This study highlights the superior performance of WS as a substrate for the cultivation of *Pleurotus membranaceus*, demonstrating the highest flush yield and biological efficiency compared to other substrate combinations. The fast mycelial growth and rapid pinhead initiation observed on 100% WS can be attributed to its high cellulose, hemicellulose, and lignin content, which provide readily accessible nutrients for mushroom growth. The positive results achieved with a mix of 75% SD and 25% WS also suggest that combining substrates can be a viable alternative, though pure WS remains the most effective option. Additionally, the inclusion of nitrogen-rich agro-wastes, such as soybean and chickpea straw, contributed to enhanced yield and biological efficiency, emphasizing the importance of nitrogen in mushroom metabolism (Han *et al*., 5). These findings are consistent with existing literature, confirming that WS is a highly suitable substrate for mushroom production due to its optimal carbon-to-nitrogen ratio and its abundance as an agricultural by-product. Overall, this research supports the use of WS not only for its high productivity but also for its role in promoting sustainable and cost-effective agricultural practices by utilizing agro-wastes. Future studies should explore further optimization of substrate mixtures to enhance production efficiency while maintaining environmental sustainability.

AUTHORS' CONTRIBUTION

All the authors involved in this study contributed to the study design, fieldwork, and cartography works. Data analysis and interpretation of the data (AK, GK, and ARW); Writing manuscript (AK).

DECLARATION

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

ACKNOWLEDGEMENTS

This research paper was supported by all the researchers from the Department of Plant Pathology, College of Agriculture, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur.

REFERENCES

1. Chang, S.T. and Miles, P.G. 1981. Edible mushroom and their cultivation *CRC Press*. Boca Raton, Florida. **6**: 555-565.

2. Davari, M., Sharma, S.N. and Mirzakhani, M. 2012. Residual influence of organic materials, crop residues, and biofertilizers on performance of succeeding mung bean in an organic rice-based cropping system. *Int. J. Recycl. Org. Waste Agric.* **1**: 1-9.

3. Elattar, A.M., Hassan, S. and Awd-Allah, S.F. 2019. Evaluation of oyster mushroom (*Pleurotus ostreatus*) cultivation using different organic substrates. *Alex. Sci. Exch. J.* **40**: 427-440.

4. Fanadzo, M., Zireve, D.T., Dube, E. and Mashingaidze, A.B. 2010. Evaluation of various substrates and supplements for biological efficiency of *Pleurotus sajor-caju* and *Pleurotus ostreatus*. *Afr. J. Biotechnol*. **9**: 2756-2761.

5. Han, J., Sun, R., Huang, C., Xie, H., Gao, X., Yao, Q. and Gong, Z. 2024. Effects of different carbon and nitrogen ratios on yield, nutritional value, and amino acid contents of *Flammulina velutipes*. *Life*, **14**(5): 598.

6. Hussain, T. 2001. Growing mushroom: a new horizon in agriculture. *Mushroom J*. **21**: 23–26.

7. Jafarpour, M. and Eghbalsaeed, S. 2012. High protein complementation with high fiber substrates for oyster mushroom cultures. *Afr. J. Biotechnol.* **11**: 3284-3289.

8. Jafarpour, M., Jalali, Z.A., Dehdashtizadeh, B. and Eghbalsaied, S.H. 2010. Evaluation of agricultural wastes and food complements usage

on growth characteristics of *Pleurotus ostreatus*. *Afr. J. Agric. Res.* **5**: 3291-3296.

9. Kumawat, A., Wasnikar, A. R. and Kumawat, G. 2024. Impact of crop straw on the nutritional quality of oyster mushroom (*Pleurotus membranaceus*). *Forage Res*. **50**: 64-67.

10. Maheswari, S., Rajarajan, P., Pandian, P. M. and Krishnan, B. B. 2021. Yield performance of mushroom (*Pleurotus ostreatus*) on different treatment of sugarcane bagasse and SD and its nutrient analysis. *Plant Cell Biotechnol. Mol. Biol.* **22**: 7-13.

11. Muswati, C., Simango, K., Tapfumaneyi, L., Mutetwa, M. and Ngezimana, W. 2021. The effects of different substrate combinations on growth and yield of oyster mushroom (*Pleurotus ostreatus*). *Int. J. Agron.* **10**: https://doi.org/10.1155/2021/9962285.

12. Ola, F.L.and Oboh, G. 2001. Nutrient distribution and zinc bioavailability. Estimation in some tropical edible mushrooms. *Nahrung*. **45**: 67-68.

13. Orngu, O. A., Mbaeyi-Nwaoha, I. E., Unagwu, B. O. and Etim, V. E. 2021. Oyster mushroom (*Pleurotus ostreatus*) cultivation using SD and different organic manures. *Asian Food Sci. J.* **20**: 67-74.

14. Patel, S.K., Chandra, R. and Dhakad, P.K. 2019. Comparative study on growth parameters and yield potential of five species of oyster mushroom. *J. Pharmacogn. Phytochem*. **8**: 152-156.

15. Peng, J.T. 1996. The cultivation of *Pleurotus eryngii* on rice straw substrate. *J. Agric. Res. China.* **45**: 382–387.

16. Roksana, K. M., Ahmed, K. U. and Uddin, M. N. 2018. Effect of Chemically Disinfected Wheat Straw on the Growth and Yield of *Pleurotus ostreatus* Mushroom. *J. Agric. Stud.* **6**(1): 189-202.

17. Saber, W.L., El-Naggar, N.E. and Abdal-Aziz, S.A. 2010. Bioconversion of lignocellulosic wastes into organic acids by cellulolytic rock phosphate solubilizing fungal isolates grown under solid-state fermentation conditions. *Res. J. Microbiol.* **5**: 1–20

18. Sofi, B., Ahmad, M. and Khan, M. 2014. Effect of different grains and alternate substrates on oyster mushroom (*Pleurotus ostreatus*) production. *Afr. J. Microbiol. Res.* **8**: 1474-1479.

(Received : December, 2024; Revised : July, 2025; Accepted : September, 2025)