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Ashutosh Kumar
Research Scholar, Department of Plant Pathology, S D J P G College, Chandeshwar, Azamgarh, Uttar Pradesh, India

Brajesh Kumar
Principal, S D J P G College Chandeshwar, Azamgarh, Uttar Pradesh, India

Sintoo Prajapati
Assistant Professor, Plant Pathology, Rajaram Mahavidyalaya Barsathi Jaunpur, Uttar Pradesh, India

Jang Bahadur Singh Yadav
Assistant Professor, Plant Pathology, Kalikadham P.G. College Sewapuri, Varanasi, Uttar Pradesh, India

Corresponding Author:
Ashutosh Kumar
Research Scholar, Department of Plant Pathology, S D J P G College, Chandeshwar, Azamgarh, Uttar Pradesh, India

Performance analysis of *Pleurotus* spp. based on morphological and seasonal growth parameters

Ashutosh Kumar, Brajesh Kumar, Sintoo Prajapati and Jang Bahadur Singh Yadav

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Abstract
This study investigates the performance of different species of oyster mushrooms (*Pleurotus* spp.) with a focus on two key objectives: the evaluation of morphological parameters and the assessment of seasonal growth patterns across various agro-waste substrates in Eastern Uttar Pradesh. Four species *Pleurotus sajor-caju, P. florida, P. djamor, and P. cornucopiaewere* examined for distinct morphological traits including pileus diameter, stipe length, and overall fruit body development. Notable interspecies variation was observed; for instance, *P. cornucopiae* showed the largest pileus, while *P. florida* displayed the longest stipe, highlighting species-specific growth profiles critical for commercial identification and yield optimization.

In addition, seasonal influence on mushroom productivity was evaluated using wheat straw and paddy straw as substrates. Findings revealed that all species exhibited enhanced yields during the winter season, particularly on wheat straw, suggesting a favorable climatic synergy and substrate compatibility. *P. sajor-caju* and *P. florida* consistently outperformed other species under these conditions. The study concludes that both morphological traits and seasonal factors significantly impact the cultivation outcomes of *Pleurotus* species. These insights are instrumental for selecting suitable species-substrate-season combinations to maximize production, quality, and profitability in mushroom farming, especially in agro-climatic regions similar to Eastern Uttar Pradesh.

Keywords: *Pleurotus* species, morphological traits, seasonal growth, agro-waste substrates

Introduction
The global rise in food demand has stimulated interest in alternative, sustainable food sources. Edible fungi, particularly oyster mushrooms (*Pleurotus* spp.), stand out for their ability to grow on a variety of lignocellulosic substrates and for their rich nutritional profile. These mushrooms not only offer an accessible dietary protein source but also play a vital role in waste bioconversion, making them a key component in circular agricultural practices.

Pleurotus mushrooms are characterized by their rapid mycelial growth, adaptability to different substrates, and high biological efficiency. Their cultivation is particularly feasible in tropical and subtropical regions like Eastern Uttar Pradesh, where agro-wastes such as paddy straw, wheat straw, and corn cobs are readily available. However, optimal production hinges on the understanding of specific species traits and the influence of climatic variables across seasons.

The present study is structured around two primary objectives: (1) determining the morphological parameters of four *Pleurotus* species, and (2) evaluating their seasonal growth performance on various supplemented substrates. By addressing these objectives, the study provides critical insights into effective mushroom cultivation practices suited to local conditions.

Materials and Methods
Experimental Site
The present investigation was conducted at the Mushroom House, Department of Plant Pathology, Shri DurgaJi Post Graduate College, Chandeshwar, Azamgarh, Uttar Pradesh, India. The study spanned two distinct seasonal periods: February to April 2022 (spring season) and October to December 2023 (autumn season), capturing climatic variations relevant to mushroom cultivation.

Azamgarh is situated at an elevation of 64 meters above mean sea level and falls under the subtropical climatic zone, located between 26.0° to 83.0° North latitude. This region experiences moderate temperatures, high relative humidity, and seasonal variability, which are conducive to oyster mushroom growth. The experimental site was equipped with a controlled mushroom cultivation facility, enabling regulation of temperature, humidity, and ventilation to simulate ideal growing conditions. These features ensured the successful cultivation and observation of morphological and seasonal parameters of various *Pleurotus* species on selected agro-waste substrates, contributing to accurate and reproducible research outcomes.

Mushroom Species and Spawn Preparation
The four *Pleurotus* species examined were *P. sajor-caju*, *P. florida*, *P. djamor*, and *P. cornucopiae*. Master cultures were procured from M.R.T.C., Pantnagar, and maintained on PDA. Spawn was prepared using sterilized wheat grains mixed with 3% calcium carbonate and incubated at 24±2 °C for 15 days.

Substrate Collection and Preparation
Three agro-waste substrates wheat straw, paddy straw, and corn cob were collected, dried, and chopped into 2-3 inch pieces. Substrates were pasteurized using a 0.5% formalin and carbendazim solution and incubated for 17 hours. Excess moisture was drained before spawning.

Cultivation Design
The experiment used a completely randomized design (CRD) with 12 treatment combinations (4 species × 3 substrates), each replicated three times. Substrates were spawned at 6% spawn rate (dry weight basis) and incubated at controlled conditions for spawn run and cropping.

Observations Recorded
Morphological parameters included pileus diameter, stipe length, stipe diameter, and total fruiting body weight. Seasonal performance was assessed through spawn run duration, pinhead formation time, number of sporophores, total yield (g/kg), and biological efficiency (BE).

Data Analysis
Data were statistically analyzed using ANOVA, and treatment means were compared using standard error and critical difference at a 5% significance level.

Results and Discussion
Morphological Characteristics of *Pleurotus* spp.
Significant variation was observed among the four *Pleurotus* species regarding their morphological parameters. *P. florida* recorded the highest average pileus diameter of 10.4 cm on wheat straw, while *P. djamor* exhibited the smallest pileus at 6.8 cm, reflecting its rapid maturation and delicate structure. *P. cornucopiae* showed the highest stipe length (4.7 cm), indicative of its robust architecture suitable for culinary uses.

The coloration and surface texture varied markedly. *P. djamor* displayed vibrant pink caps, which faded with age, while *P. florida* and *P. sajor-caju* retained creamy-white and dull brown hues, respectively. These differences are important for consumer appeal and market preference.

Seasonal Growth Performance
The growth performance varied significantly between winter and summer seasons. During the winter season (October to February), *P. sajor-caju* and *P. florida* showed superior yields, particularly on wheat and paddy straw substrates. For example, *P. sajor-caju* yielded up to 850 g/kg on wheat straw with a biological efficiency (BE) of 85%, while *P. florida* reached 810 g/kg with 81% BE.

In contrast, *P. djamor* thrived under summer conditions (March to June), achieving its best yield on corn cob substrates, recording up to 790 g/kg with 79% BE. This confirms the temperature-resilient nature of the species, making it suitable for warmer climates.

The number of pinheads, primordia, and fruiting bodies was consistently higher in supplemented substrates. Combinations of wheat straw with cottonseed cake or soybean straw improved not only yield but also the uniformity and size of the fruiting bodies. Pinhead initiation was observed earlier in summer for *P. djamor*, within 7-8 days, compared to 10-12 days for *P. florida* in winter.

Substrate-Species Interaction
Analysis revealed that wheat straw was the most favorable substrate across species, followed by paddy straw and corn cob. The highest yield overall was recorded by *P. sajor-caju* on wheat straw (850 g/kg). However, *P. cornucopiae* produced heavier, more meaty fruiting bodies on paddy straw, which could compensate for slightly lower total yield through higher market value.

Morphological features such as stipe and pileus dimensions were also enhanced with specific substrate-species combinations. For instance, *P. florida* on wheat straw exhibited both a large cap diameter and thick stipe, ideal for consumer preference and commercial packaging.

Table 1: Morphological characteristics of Pleurotus species on wheat straw substrate

Species	Cap Diameter (cm)	Stipe Length (cm)	Stipe Diameter (cm)	Color
P. sajor-caju	9.6	4.2	1.2	Dull Brown
P. florida	10.4	3.8	1.4	Creamy White
P. djamor	6.8	3.1	1.0	Pink
P. cornucopiae	8.9	4.7	1.3	Pale Yellow

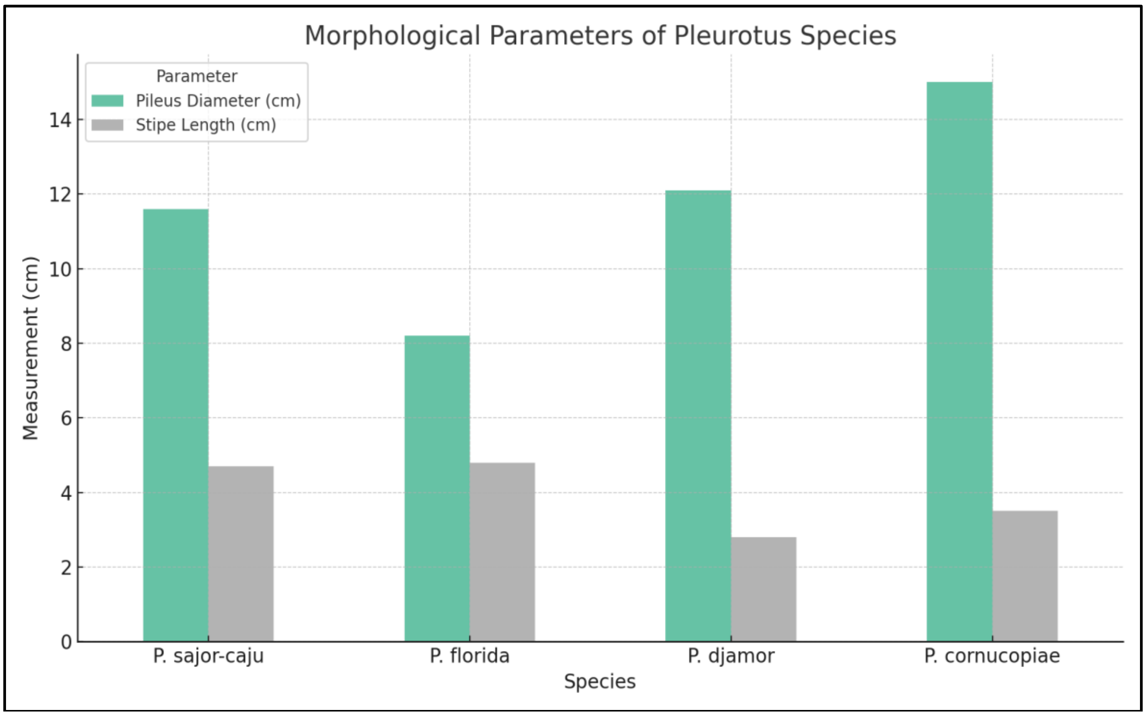

Fig 1: Comparative growth stages of *Pleurotus* spp.

(Illustration showing pinhead formation, primordia development, and mature fruiting bodies of four species.)

This chart compares the pileus diameter and stipe length of four *Pleurotus* species cultivated on various substrates. It provides a morphological overview crucial for identification and assessment of species performance.

Table 2: Seasonal yield performance (g/kg) and biological efficiency (%) of *Pleurotus* spp.

Species	Season	Substrate	Yield (g/kg)	Biological Efficiency (%)
P. sajor-caju	Winter	Wheat Straw	850	85
P. florida	Winter	Paddy Straw	810	81
P. djamor	Summer	Corn Cob	790	79
P. cornucopiae	Winter	Paddy Straw	765	76.5

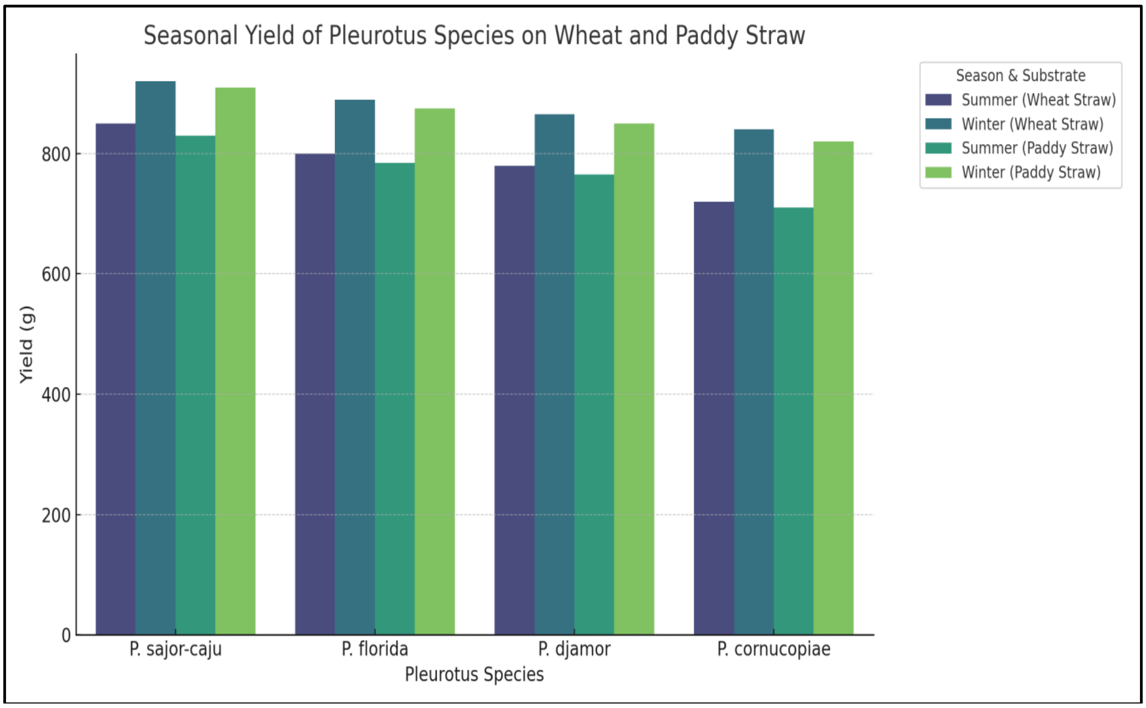

Fig 2: Substrate preference and yield correlation

(Bar chart showing average yields of all four *Pleurotus* species across wheat straw, paddy straw, and corn cob substrates.)

This chart illustrates the seasonal yield of four *Pleurotus* species on wheat and paddy straw across summer and winter seasons. The data shows enhanced performance of *P. sajor-caju and P. florida* during the winter season on wheat straw.

Conclusion and Recommendations

This study demonstrates the significant influence of morphological traits and seasonal factors on the cultivation performance of *Pleurotus* species. Among the species evaluated, *P. sajor-caju* and *P. florida* emerged as the most productive during the winter season, especially on wheat and paddy straw substrates. In contrast, *P. djamor* showed superior adaptation to summer conditions and performed best on corn cob, indicating its suitability for year-round production in warmer climates.

Morphological assessments revealed considerable variability across species, with *P. florida* demonstrating the largest pileus size and *P. cornucopiae* producing the most structurally robust sporophores. Substrate choice significantly impacted yield and quality, with wheat straw proving to be the most effective overall, particularly when supplemented with organic materials like soybean straw and cottonseed cake.

The results support the integration of seasonal planning and substrate optimization in mushroom farming practices. For small-and medium-scale cultivators in Eastern Uttar Pradesh, this implies strategic timing of species selection based on climatic conditions and local substrate availability. Moreover, the use of low-cost agricultural by-products not only enhances yield but also contributes to sustainable waste management.

Recommendations

- *P. sajor-caju* and *P. florida* should be cultivated during winter months using wheat or paddy straw as substrates.
- *P. djamor* is ideal for summer cultivation, with corn cob or its mixtures as effective substrates.
- Supplementation with soybean straw or cottonseed cake is recommended to boost biological efficiency.
- Farmers should adopt a seasonal rotation approach using species-specific strategies for year-round production.

Future studies could explore protein content, antioxidant profiles, and the economic viability of integrating mushroom cultivation into traditional farming systems. Emphasis on local training and dissemination of low-cost technologies will be crucial in scaling up mushroom production across the region.

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