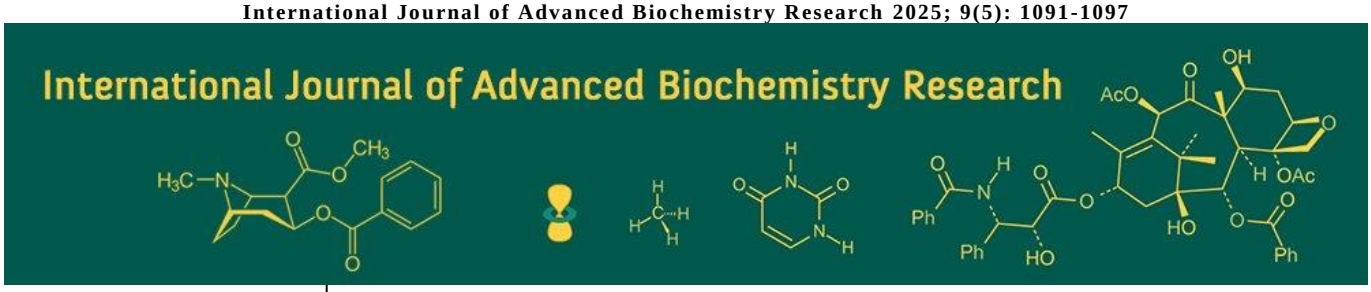

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Influence of environmental and nutritional factors on mycelial growth and spawn performance of *Pleurotus pulmonarius*

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Abstract
The present study was conducted to evaluate the growth and yield performance of *Pleurotus pulmonarius* (phoenix mushroom) under varying environmental and nutritional conditions in the plains of Chhattisgarh. Key parameters evaluated included temperature, media, pH, light wavelength, light exposure duration, carbon and nitrogen sources, and strain performance on wheat-based spawn. Among temperature treatments, 26 °C was optimal for both mycelial growth and biomass accumulation. PDA and MCM media supported the highest growth due to their rich nutrient composition. A pH of 6.0 yielded maximum growth and biomass, indicating a preference for slightly acidic conditions. Transparent and yellow light wavelengths, as well as complete darkness, favored better growth, while 12-hour light exposure significantly reduced it. Glucose was the most effective carbon source, followed by maltose and fructose, whereas lactose resulted in the least growth. Potassium nitrate and peptone proved to be the best nitrogen sources, with urea significantly inhibiting fungal development. In spawn development trials, strain PP-21-10 showed the shortest colonization time (12 days) on wheat grains, highlighting its suitability for rapid and efficient spawn production. These results demonstrate that growth and productivity of *P. pulmonarius* are highly influenced by environmental and nutritional variables. The findings provide practical insights for optimizing mushroom cultivation under controlled conditions, particularly in the subtropical climate of central India.

Keywords: Phoenix mushroom, growth, biomass production, temperature, pH, media, light wavelength, periods of light, carbon sources, nitrogen sources, spawn development

1. Introduction
Mushroom cultivation offers a sustainable solution to India's challenges of food security, malnutrition, and limited land resources amidst climate change. By converting agricultural and industrial wastes into protein-rich food, mushrooms like *Pleurotus pulmonarius* provide high nutritional value with minimal land and water use. Their medicinal properties, including antimicrobial and antioxidant effects, further enhance their value as functional foods (Kumar *et al.* 2021) [81]. This practice supports environmental sustainability and economic opportunities for India's growing population.

Pleurotus pulmonarius, known as the Phoenix mushroom, is highly adaptable, thriving in warm, subtropical climates (25-30 °C) and on substrates like wheat straw and sawdust. Its rapid growth and compatibility with diverse conditions make it ideal for cultivation in India's plains (Zhang *et al.* 2018) [31]. Oyster mushrooms, including *P. pulmonarius*, are rich in protein, fiber, vitamins, and minerals, with low calories and high polyunsaturated fatty acids, rivaling meat in protein content (Ukwuru *et al.* 2018; Al-Hussainy, 2019) [30, 19].

The cultivation process is resource-efficient, utilizing agricultural residues and producing spent mushroom substrate as organic fertilizer, promoting circular agriculture (Adebayo *et al.* 2020) [1]. Requiring 25-27 °C and 75-90% humidity, oyster mushrooms are suited for year-round cultivation in tropical regions like India (Gupta *et al.* 2016) [12]. Their bioactive compounds offer health benefits, including anticancer and anti-diabetic properties, making them valuable for improving immunity and quality of life (Chang, 2008; Muniz & Du, 2021) [3, 22].

India, the world's second-largest mushroom producer, contributes 0.5% globally, with Bihar

leading national production at 10.82% in 2021-22. Mushroom exports surged by 173.8% in volume and 151.8% in value from 2021-22 to 2022-23, with a projected market CAGR of 7.6% from 2023-2028 (National Horticulture Board, 2023; Eximpedia, 2024) [25, 9]. This growth highlights the economic potential of mushroom cultivation as a sustainable agribusiness to address nutritional and environmental challenges.

2. Materials and Methods

The present investigation on the evaluation of growth and yield parameters of Phoenix mushroom (*Pleurotus pulmonarius*) under varying environmental and nutritional conditions was carried out in the plains of Chhattisgarh. The experiment was conducted using a completely randomized design (CRD) with multiple replications under controlled laboratory conditions. Parameters such as mycelial growth, fresh weight, and dry weight were recorded to assess the effects of different environmental variables. The treatments included different incubation temperatures (20 °C, 23 °C, 26 °C, 32 °C, and 35 °C), culture media (PDA, MCM, Richard's, MEA, GPA, etc.), pH levels (4.0 to 9.0), light wavelengths (transparent, red, yellow, green, blue), and photoperiod durations (0 h, 6 h, 12 h, 18 h, and 24 h light exposure).

In addition to physical factors, different carbon sources (glucose, fructose, lactose, maltose, sucrose, mannitol, and sorbitol) were evaluated to determine their influence on the growth and biomass of *P. pulmonarius*. All treatments were inoculated with a standardized amount of fungal culture and incubated for a fixed period, maintaining optimal humidity and aseptic conditions. Mycelial radial growth was measured in millimeters, while fresh and dry biomass weights were recorded in grams after oven drying at 65 °C until constant weight. Data were statistically analyzed using ANOVA to test the significance of treatment effects.

3. Results

The data regarding as evaluation of studies on growth and yield of phoenix mushroom (*Pleurotus pulmonarius*) in plains of Chhattisgarh has been presented in Table 1, Table 2, Table 3, Table 4, Table 5, Table 6, Table 7 and Table 8.

3.1 Effect of different temperatures on growth and biomass of *P. pulmonarius*.

From Table 1. Temperature 26 °C showed significantly higher (90.00 mm) mycelial growth of *P. pulmonarius*. followed 23 °C (83.21 mm) and temperature 32 °C (78.12 mm), However significantly less growth was noted at 35 °C (33.24 mm). The fresh weight of *P. pulmonarius* was significantly differ with respect to different temperatures. The maximum fresh weight of *P. pulmonarius* was obtained at temperature 26 °C (4.66 g) and next was 32 °C (4.03 g). but differ significantly with 26 °C, whereas it was significantly lower (1.85 g) found at temperature 35 °C followed by temperature 20 °C (2.33 g) and 23 °C (2.86 g). The dry weight of *P. pulmonarius* was also significantly influenced by different temperatures. Maximum (0.43 g) dry weight. of *P. pulmonarius* was recorded at 26 °C and minimum (0.14 g) was recorded 35 °C followed by 32 C and 23 °C (0.36 g, 0.21 g respectively). The study on the effect of different temperatures on the growth and biomass of *Pleurotus pulmonarius* revealed that temperature significantly influences its physiological and nutritional requirements. Among the treatments, 26 °C proved to be the most favorable for mycelial growth, recording the highest radial extension (90.00 mm), indicating optimal enzymatic and metabolic activity at this moderate temperature. In contrast, growth was drastically reduced at 35 °C, suggesting thermal stress that likely hindered cellular processes. Interestingly, temperature 35 °C showed the least mycelial spread, it recorded the highest fresh weight (4.85 g), which may be due to higher water retention or slower metabolism delaying desiccation. However, the maximum dry weight (0.43 g) was observed again at 26 °C, affirming that this temperature supports efficient biomass accumulation rather than just moisture content. These findings suggest that while higher temperatures may enhance water absorption, moderate temperatures around 26° Care physiologically ideal for both growth and true biomass production in *P. pulmonarius*. The results obtained in the present study are supported by the previous workers of Pant *et al.* (2020b) reported 25 °C as for growth of *P. ostreatus*. Kumar *et al.* (2018) found maximum growth of *P. florida* of 22.5-25 °C. Kaur *et al.* (2018) [14] recorded 24 an ideal temperature for the growth of *P. florida and P. eous*.

3.2 Effect of different media on growth and biomass of *P. pulmonaius*

The mycelial growth and biomass of *P. pulmonarius* was significantly higher (90.00 mm) obtained in MCM and PDA where as it was significantly lower found in Richards (72.42 mm) and malt extract agar (78.28 g) but differ significantly with each other. In other studied growth was in between (78.32)-(83.60) mm. The fresh weight of *P. pulmonarius* was significantly higher recorded (4.40 g) on PDA. followed by Oatmeal agar (4.10 g), Glucose peptone agar (3.44 g) and Malt extract agar (3.27 g) Richards (2.02 g) Asthana & Hawker's (2.29 g) and MCM (2.56 g). The dry weight while it was Significantly differed in all studied media and it varid from 0.12-0.44 g. Significantly more (0.44 g) dry media weight was recorded in PDA. In contrast significantly less (0.12 g) was obtained in Richards's medium. The differences observed in growth and biomass of *P. pulmonarius* across various media can be attributed to the nutritional composition and availability of easily assimilable carbon and nitrogen sources in each medium. PDA (Potato Dextrose Agar) and MCM (Malt Czapek Medium) are rich in carbohydrates and other essential nutrients that promote vigorous mycelial development and biomass accumulation. PDA contains potato starch and dextrose, which are readily utilized by the fungus for energy and structural growth, explaining the highest fresh and dry weights observed. MCM supports excellent mycelial spread likely due to the presence of malt extract, which offers a rich mix of sugars, vitamins, and amino acids. On the other hand, Richards medium, which mainly contains inorganic salts and lacks complex organic nutrients, is less supportive of fungal metabolism, resulting in the lowest growth and biomass. Similarly, the moderate performance of Oatmeal Agar and Glucose Peptone Agar indicates that while they provide basic nutrition, they may lack the diversity or balance of nutrients needed for maximum fungal proliferation. Therefore, media with rich organic content and easily digestible nutrients are more conducive to the physiological and nutritional needs of *P. pulmonarius*. The finding of present studies in accordance with other workers (Krishna *et al.* 2019) [17] and Nguyen and Ranamukhaarachchi (2020))

[24] They reported potato dextrose agar medium as superior for the growth of *P. eryngii and P. ostreatus P. citrinopileatus* respectively.

3.3 Effect of different pH on growth and biomass of *P. pulmonarius*.

Different levels of pH significantly influence the growth and biomass of *P. pulmonarius* and its value from 65.07-87.24 mm for growth 2.02-6.13 mm and 0.14 g-0.65 g fresh and dry mycelial weight respectively. Significantly more (87.24) growth was obtained at 6.0 pH however it was significantly less (65.07 mm) noticed at 9.0 pH. In other pH growth was 68.22 mm, 80.23 mm,82.30 mm and 83.10 at pH 8,4,7 and 5 respectively but all were differed significantly with each other. Significantly higher (6.13 g) fresh mycelia weight was recorded at pH 6.0 while it was lower observed at 9.0 pH (2.02 g) 8.0 pH (2.93) pH 5.0 (5.94 g), pH 4.0 (5.51 g). biomass production of *P. pulmonarius* was considerably with respect to pH, maximum dry mycelia weight of *P. pulmonarius* was observed at pH 6.0 (0.65 g), followed by pH 5.0 (0.64 g) and pH 4.0 (0.61 g), while minimum dry weight was recorded at 9.0 pH (0.14 g) and 8.0 pH (0.31 g). The variation in growth and biomass of *P. pulmonarius* under different pH levels can be attributed to the influence of pH on nutrient availability, enzyme activity, and overall metabolic efficiency. The highest fresh and dry mycelial weights, as well as mycelial growth, were observed at pH 6.0, indicating that a slightly acidic environment is optimal for fungal physiology. This pH likely enhances the solubility of essential nutrients and supports favourable conditions for enzyme function, cell membrane stability, and nutrient uptake. In contrast, growth and biomass were significantly reduced at alkaline pH levels (8.0 and 9.0), likely due to enzyme inhibition, reduced nutrient solubility, and cellular stress, making such conditions less suitable for the development of *P. pulmonarius*. Similar results were also observed by Kaur *et al.* 2018 [14] and Chowdhury *et al.* (2024) [6] recorded better that higher mycelial growth of *P florida* at pH 6.0 &7.0 similarly pH 6-6.5 was found more supportive for the growth of *P florida*. Gorai and Sharma (2018) [11] reported pH 6.5-77.5 as optimum for growth *Pleurotus ostreatus, Psajor-caju and P. florida*.

3.4 Effect of different light wavelength on growth and biomass of *P. pulmonarius*.

Different light wavelength did not show much variation in growth of *P. pulmonarius* it was significantly higher (90.00 mm) recorded under the yellow light (90.00), green light (90.00 mm) blue light (90.00mm) and transparent (90.00mm) but all were found significant at par with each other. However, it was significant least (86.13mm) recorded under red light. On average, mycelial growth and biomass of *P. pulmonarius* was considerably differ with respect to light wavelength maximum fresh weight of *P. pulmonarius* was observed at Transparent (5.11 g), which was followed by Yellow (4.48 g) and Green (4.28 g). It was significantly lower with transparent. While the minimum fresh weight was recorded at Red (3.84 g) at Blue (3.93 g). Dry mycelial weight of *P. pulmonarius* was significantly higher found at Transparent (0.61 g). whereas, it was significantly lower (0.36 g) at Red (620-750 nm), followed by Yellow (570-590 nm) (0.59 g) and Blue (450-495 nm) (0.48 g). The differences in growth and biomass of *Pleurotus pulmonarius* under various light wavelengths can be attributed to the role of light in regulating fungal metabolism and morphogenesis. The highest mycelial growth and biomass were observed under transparent light conditions, suggesting that the absence of specific wavelength interference allows the fungus to grow naturally without stress. Colored lights, particularly red light, resulted in the lowest growth and biomass, likely due to its inhibitory effect on fungal enzymatic activity and cellular development. Red and blue wavelengths are known to influence photoreceptors in fungi, which can alter gene expression related to growth. In contrast, yellow and green light had relatively moderate effects, supporting decent biomass production, though still slightly less effective than transparent conditions. This indicates that while *P. pulmonarius* can tolerate a range of wavelengths, optimal growth occurs in broad-spectrum or neutral light conditions that do not disrupt its physiological processes. The present findings are tallies with the work of Kaur *et al.* (2022) [15] They found red light more appropriate to obtain higher mycelial growth in *P. oeous* and *P florida*. De Bonis *et al.* (2024) [7] concluded that red light is more suitable for growth of *P. ostreatus*. Red light was found superior for the growth of *H. ulmarius*. Sen *et al.* (2020) [29]

3.5 Effect of different periods of light on growth and biomass of *P. pulmonarius*.

The growth of *P. pulmonarius* was significantly higher (83.60 mm) was recorded at period of light 0 hrs-(24 dark) while it was lower observed at period of light 12 hrs-(12 dark) (50.13 mm), the period of light 06 hrs-(18 dark) gave (78.24 mm) 18 hrs-(6 dark) (61.23 mm), light 24 hrs-(0 dark) (72.20 mm). On an average, fresh weight (g) of *P. pulmonarius* was significantly differ with respect to period of light maximum biomass production of *P. pulmonarius* was observed at period of light 0 hrs-(24 dark) (4.24 g), followed by period of light 24 hrs-(0 dark) (4.02 g) and period of light 06 hrs-(18 dark) (3.80 g), while minimum (1.41 g) fresh weight (g) was recorded at period of light12 hrs-(12 dark) (1.41 g). The dry mycelial weight of *P. pulmonarius* was significantly higher found at a period of 06 hrs-(18 dark) (0.49 g). Whereas it was significantly lower noticed at the period of light 12 hrs-(12 dark) (0.39 g) followed by a period of light0 hrs-(24 dark) (0.46 g) and a period of light24 hrs (0 dark) (0.43 g). The variation in growth and biomass of *P. pulmonarius* under different light exposure periods is primarily influenced by how light duration affects fungal physiology, particularly its circadian rhythm, enzyme activity, and energy balance. Maximum mycelial growth and fresh weight were recorded under complete darkness (24 hours dark), indicating that light is not essential for vegetative mycelial development and that continuous darkness favors uninterrupted cellular processes and nutrient absorption. However, the highest dry weight was observed under 6 hours of light and 18 hours of darkness, suggesting that limited light exposure may stimulate certain metabolic pathways that enhance biomass accumulation without significantly hindering growth. In contrast, 12-hour light/dark cycles resulted in the lowest growth and biomass, possibly due to physiological stress or disruption in the fungus's natural rhythm. These results suggest that *P. pulmonarius* prefers minimal or no light for optimal mycelial growth, while a short period of light exposure may aid in enhancing biomass quality. The results obtained in the present study is in accordance with the Rawal and Singh 1980 they found mycelial growth of *P.*

florida, *P saju-caju*, *P. ostreatus* under total darkness. Chang and miles 2004 [3] reported that light is not essential for growth *P. pulmonarius* similarly Kumar (2011) [20] obtained maximum mycelial growth *Agrocybe aegerita* in total darkness.

3.6 Effect of different carbon sources on growth and biomass of *P. pulmonarius*

Among the different carbon sources, Glucose gave significantly higher (88.60 mm) mycelial growth *P. pulmonarius* and next were Fructose (82.31 mm) and Maltose at (80.14 mm) which were statistically differ with each other, however significantly lower with lactose at (55.23 mm) and next was Sorbitol (64.36), Sucrose (76.40 mm) mannitol at (79.12 mm). The fresh mycelial weight of *P. pulmonarius* was significantly more observed in Glucose **(**4.77 g), which was followed by Maltose (3.45 g) and Fructose (3.28 g), while minimum fresh weight was recorded Lactose (0.87 g). In other medium it varied from 1.19 g-1.33 g in similarly significantly higher (0.44 g) dry mycelial weight of *P. pulmonarius* was found in Glucose. followed by Maltose and Fructose (0.29) and (0.25 gm) respectively. However, it was significantly less (0.06 gm) obtained with lactose. The differences in growth and biomass of *P. pulmonarius* under various carbon sources are primarily due to the fungus's ability to efficiently metabolize certain sugars over others. Glucose supported the highest mycelial growth, fresh and dry weight because it is a simple, readily assimilable monosaccharide that enters directly into glycolysis, providing quick energy and biosynthetic precursors. In contrast, lactose resulted in the lowest growth and biomass, likely due to the fungus's limited ability to this polysacchride into usable sugars, as it requires specific enzymes like β-galactosidase which may be less active or absent in *P. pulmonarius*. Similarly, other sugars like maltose, fructose, and mannitol supported moderate growth, depending on their complexity and how easily the fungus could metabolize them. This indicates that the metabolic efficiency and energy yield from each carbon source significantly influence the physiological performance and biomass accumulation in *P. pulmonarius*. The above findings with the work of previous workers (Adejoye *et al.* 2006 ; Neelam *et al.* 2019; Hoa and Wang 2015) [5, 23, 13] who found glucose as the superior carbons source for the mycelial growth and biomass of *Pleurotus* spp.

3.7 Effect of different nitrogen sources on growth and biomass of *P. pulmonarius*.

From the table it is clear that nitrogen ammended medium significantly reduced the growth *P. pulmonarius* except potassium nitrate and peptone as compared to control and it varied from 68.32 mm-90.00 mm. significantly higher (90.00 mm) mycelial growth was recorded and in Potassium Nitrate (90.00 mm), Petone (90.00 mm) and Control at (90.00 mm) and did not show significantly difference each other. However, it was significantly lower found in Urea (68.32 mm), which was followed by L-Arginine at (68.41 mm), Barium Nitrate (73.42 mm), Glycine (77.30 mm) and Magnesium Nitrate (78.29 mm). The growth was found at par in medium *L. Arginine*, barium nitrate and urea mixed medium but inferior with glycine and ammonium nitrate supplemented medium. In liquid medium, significantly higher (4.48 g) fresh mycelial weight of *P. pulmonarius* was found in potato dextrose agar (Control) Potassium Nitrate (4.44 g) L-arginine incorporated nitrogen sources which were significantly on par with each other. However significantly lower (2.04 g) fresh weight was obtained with Urea, followed by glycine (2.29 g), Ammonium Nitrate (2.39 g) Barium nitrate (2.52 g) and Magesium Nitrate (2.62 g). Similarlily follow by significantly higher (0.39 g) dry mycelial weight of *P. pulmonarius* was recorded in control and (0.37 g) (0.31 g) (0.28 g) respectively Potassium Nitrate, L-Arginine and Petone were significantly lower (0.16 g) noticed in Urea, and Ammonium Nitrate (0.17 g) and Glycine (0.18 g) and which were statistically at par with another one. The variations in growth and biomass of *p. pulmonarius* under different nitrogen sources can be attributed to the availability of nitrogen in forms that the fungus can most effectively assimilate and incorporate into cellular structures. The highest mycelial growth, fresh weight, and dry weight were observed in potato dextrose agar (PDA, control), likely because it provides an optimal balance of nitrogen and carbon that supports robust fungal growth. Nitrogen sources like potassium nitrate and petone also support good growth, as these forms are easily assimilable by the fungus for protein synthesis and cellular functions. On the other hand, urea resulted in the lowest growth and biomass, likely due to its slow release of nitrogen or the need for the fungus to first hydrolyze it into usable forms. The lower biomass observed with ammonium sulfate and glycine can be explained by either slower nitrogen uptake or toxicity at higher concentrations. Overall, the nitrogen form, along with its bioavailability, plays a crucial role in determining the growth and biomass of *P. pulmonarius*, with easily assimilable nitrogen sources leading to better performance. These outcomes are consistent with the findings of Debnath *et al.* (2021) [8] found that peptone as amended medium enhance the growth of *P. flabellatus*. Chauhan (2013) [5] reported potassium nitrate amended medium gave the highest mycelial growth of *P. djamor*.

3.8 Effect of different strains of *P. pulmonarius* on spawn development in wheat grains

Ten strains of *P.pulmonarius* evaluated for spawn development on wheat grain, among the different strains there were significant differences in spawn development period and shortest period required (12.0 days) by strain PP-21-10 which significant more time taken by PP-21-02 and PP-21-07 (15.0 day). Other strain required 13-15 days to complete colonization of wheat grains. The differences in spawn development among various strains of *P. pulmonarius* on wheat grains can be attributed to the genetic variability and physiological characteristics of each strain. Strains like PP-21-02 and PP-21-07 showed the lower spawn development (15 days), likely to possess more efficient growth characteristics, enabling them to colonize the substrate at a faster rate. This could be due to optimal metabolic pathways, enzymatic efficiency, or better adaptation to the growth medium. In contrast, strains like PP-21-10 that exhibited faster spawn development (12 days) may have inherent factors that quikest mycelial colonization, such as faster metabolic activity and enhanced efficiency in utilizing available nutrients. Overall, the differences highlight how strain-specific traits can significantly influence the efficiency of spawn production, with some strains more suited for quicker colonization than others. Similar studies were also observed by. Rathod *et al.*

(2002) [27] obtain wheat grains as a better substrate for commercial spawn production of *P. florida*. Wheat grains were found to be suitable spawning substrate for *Pleurotus spp*. (Mathew *et al.* 1996; Khatri and Agrawal, 2002) [21, 16].

Table 1: Effect of different temperatures on growth and biomass of *P. pulmonarius*.

Sr. No.	Temperature (°C)	Mycelial growth (mm)	Fresh weight (g)	Dry weight (g)
1	20	76.12	2.33	0.18
2	23	83.21	2.86	0.21
3	26	90.00	4.66	0.43
4	32	78.12	4.03	0.36
5	35	33.24	1.85	0.14
	Sem (±)	0.96	0.06	0.01
	CD (1%)	3.85	0.24	0.02

*Average of 5 replications

Table 2: Effect of different media on growth and biomass of *P. pulmonarius.*

Sr. No.	Media	Mycelial growth (mm)	Fresh weight (g)	Dry weight (g)
1	PDA	90.00	4.40	0.44
2	MCM	90.00	2.56	0.35
3	Asthana & Hawker's	78.32	2.29	0.17
4	Richards	72.42	2.02	0.12
5	Oatmeal agar	83.60	4.10	0.30
6	Malt extract agar	76.28	3.27	0.26
7	Glucose peptone agar	82.20	3.44	0.26
	Sem (±)	0.92	0.04	0.01
	CD (1%)	3.60	0.14	0.02

*Average of 5 replications

Table 3: Effect of different pH on growth and biomass of *P. pulmonarius*

Sr. No.	pH	Mycelial growth (mm)	Fresh weight (g)	Dry weight (g)
1	4.0	80.23	5.51	0.61
2	5.0	83.10	5.94	0.64
3	6.0	87.24	6.13	0.65
4	7.0	82.30	4.80	0.48
5	8.0	68.22	2.93	0.31
6	9.0	65.07	2.02	0.14
	Sem (±)	0.91	0.03	0.01
	CD (1%)	3.60	0.11	0.03

*Average of 5 replications

Table 4: Effect of different light wavelength on growth and biomass of *P. pulmonarius.*

Sr. No.	Light wavelength	Mycelial growth (mm)	Fresh weight (g)	Dry weight (g)
1	Red (620-750 nm)	86.13	3.84	0.36
2	Yellow (570-580 nm)	90.00	4.48	0.57
3	Green (550 nm)	90.00	4.28	0.48
4	Blue (450-495 nm)	90.00	3.93	0.48
5	Transparent	90.00	5.11	0.61
	Sem (±)	0.85	0.06	0.01
	CD (1%)	3.42	0.25	0.04

*Average of 5 replications

Table 5: Effect of different periods of light on growth and biomass of *P. pulmonarius.*

Sr. No.	Period of light	Mycelial growth (mm)	Fresh weight (g)	Dry weight (g)
1	0 hrs-(24 dark)	83.60	4.24	0.49
2	06 hrs-(18 dark)	78.24	3.80	0.46
3	12 hrs-(12 dark)	50.13	1.41	0.39
4	18 hrs-(06 dark)	61.23	2.87	0.41
5	24 hrs-(0 dark)	72.20	4.02	0.43
	Sem (±)	0.94	0.01	0.01
	CD (1%)	3.78	0.04	0.03

*Average of 5 replications

Table 6: Effect of different carbon sources on growth and biomass of *P. pulmonarius.*

Sr. No.	Carbon sources	Mycelial growth (mm)	Fresh weight (g)	Dry weight (g)
1	Fructose	82.31	3.28	0.25
2	Glucose	88.60	4.77	0.44
3	Maltose	80.14	3.45	0.29
4	Sorbitol	64.36	1.19	0.11
5	Sucrose	76.40	2.45	0.18
6	Lactose	55.23	0.87	0.06
7	Mannitol	79.12	1.33	0.20
	Sem (±)	0.89	0.01	0.01
	CD (1%)	3.50	0.05	0.02

*Average of 5 replications

Table 7: Effect of different nitrogen sources on growth and biomass of *P. pulmonarius*.

Sr. No.	Nitrogen sources	Mycelial growth (mm)	Fresh weight (g)	Dry weight (g)
1	Glycine	77.30	2.29	0.18
2	L-Arginine	68.41	4.30	0.31
3	Potassium Nitrate	90.00	4.44	0.37
4	Barium Nitrate	73.42	2.52	0.19
5	Urea	68.32	2.04	0.16
6	Petone	90.00	3.06	0.28
7	Magnesium Nitrate	78.29	2.62	0.20
8	Ammonium Nitrate	82.25	2.39	0.17
9	PDA (Control)	90.00	4.48	0.39
	Sem (±)	1.44	0.06	0.005
	CD (1%)	5.55	0.23	0.02

*Average of 5 replications

Table 8: Effect of different strains of *P. pulmonarius* on spawn development in wheat grains.

S. No	Strains	Spawn development (days)
		Wheat
1	PP-21-01	13
2	PP-21-02	15
3	PP-21-03	13
4	PP-21-04	14
5	PP-21-05	13
6	PP-21-06	14
7	PP-21-07	15
8	PP-21-08	13
9	PP-21-09	14
10	PP-21-10	12
Sem (±)	-	0.24
CD (5%)	-	0.70

4. Conclusion

The present study demonstrated that environmental and nutritional factors significantly influence the growth and biomass of *Pleurotus pulmonarius*. Among temperatures tested, 26 °C proved optimal, supporting the highest mycelial growth and biomass. PDA medium, pH 6.0, and transparent light conditions were most favorable for development. Darkness (24 hours) enhanced fresh weight, while 6 hours of light promoted dry biomass accumulation. Glucose emerged as the best carbon source, and potassium nitrate and peptone were the most effective nitrogen sources. Genetic variability among strains also influenced spawn development, with strain PP-21-10 showing the fastest colonization. These findings highlight that optimal conditions vary by factor, and a combination of moderate temperature, slightly acidic pH, appropriate nutrients, and minimal light promotes optimal fungal growth and biomass yield in *P. pulmonarius*.

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6. Future of Study

The findings of this study provide a foundation for optimizing the cultivation of *Pleurotus pulmonarius* under controlled environmental and nutritional conditions, particularly in subtropical regions like central India. Future research could focus on the following areas:

1. **Field Trials and Scaling:** Conducting large-scale field trials to validate laboratory results under real-world conditions and assess the feasibility of commercial production using optimized parameters.
2. **Substrate Diversity:** Exploring alternative, locally available agricultural residues as substrates to reduce cultivation costs and enhance sustainability.
3. **Genetic Improvement:** Investigating genetic modifications or selective breeding of *P. pulmonarius* strains, such as PP-21-10, to further enhance growth rates, yield, and adaptability to varying environmental conditions.
4. **Bioactive Compounds:** Analyzing the impact of optimized growth conditions on the production of bioactive compounds with medicinal properties, such as antioxidants and antimicrobials, to add value to the crop.
5. **Climate Resilience:** Studying the effects of climate variability, such as temperature fluctuations and humidity changes, on *P. pulmonarius* cultivation to develop resilient cultivation practices in the face of climate change.
6. **Automation and Technology:** Integrating sensor-based technologies and automation for precise control of environmental factors to improve efficiency and reduce labor costs in mushroom farming.

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