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Impact of Light Limitation on Yield and Morphology in *Pleurotus ostreatus*: Optimizing Indoor Growth Conditions

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ABSTRACT

Background and Objective: *Pleurotus ostreatus* is a highly valued edible mushroom with significant nutritional, medicinal and economic benefits. Optimizing growth conditions, including light exposure, is critical to maximizing yields in commercial cultivation. This paper investigates the impact of light limitation on the growth, yield and morphology of *Pleurotus ostreatus* (oyster mushroom) in indoor cultivation. This study focuses on assessing the effects of near-dark conditions on the growth parameters and yield performance of oyster mushrooms. **Materials and Methods:** The substrate used was made up of sawdust, rice husk and calcium carbonate. Cap diameter, stipe length and stipe girth were measured using a meter rule. The number of fruiting bodies and primordia were counted. Weight of fruiting bodies w obtained using a weighing balance. The substrates were set up in an office space under medium lighting conditions. The lighting condition was 0.5 lux using the digital lux meter. **Results:** The results of the study indicate that mushrooms grown under near-dark conditions (0.5 lux) exhibited significant stipe elongation, with a maximum stipe length of 12.00 cm. Cap diameters also reached impressive sizes, with a maximum recorded diameter of 14.00 cm. Biological yield and economic yield were also significantly enhanced under near-dark conditions. The substrate with the best performance achieved a biological yield of 30.44 g and a biological efficiency of 13.15%. Results indicate that minimal light exposure can enhance certain growth characteristics, such as cap size and biological efficiency. **Conclusion:** Near-dark conditions promote larger cap sizes and higher biological efficiency, which are desirable traits for commercial production. These findings contribute to a better understanding of how light conditions can be manipulated to optimize mushroom production.

KEYWORDS

Lignocellulosic substrates, mushrooms, oysters, *Pleurotus ostreatus*, saprophytic fungus, sawdust

INTRODUCTION

Mushrooms, particularly *Pleurotus ostreatus* (oyster mushrooms), have garnered significant attention for their nutritional and medicinal properties. They contain essential vitamins, minerals, antioxidants and bioactive compounds, offering various health benefits, including anti-cancer, anti-inflammatory and

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immune-boosting properties[1,2]. As a result, there has been a growing demand for efficient mushroom production methods that can maximize yield while maintaining product quality. Indoor mushroom cultivation presents an opportunity to overcome challenges posed by environmental factors such as temperature, light and humidity. Specifically, the role of light in fungal growth is a crucial area of study. Mushrooms, being non-photosynthetic organisms, do not rely on light for food production; however, light may influence other growth aspects such as fruiting body formation, cap size and yield[3].

Pleurotus ostreatus is a saprophytic fungus widely cultivated in tropical and subtropical regions[4]. It has a distinct oyster-shaped cap and is appreciated for its rich nutritional profile, which includes proteins, vitamins and minerals[5]. Oyster mushrooms are also recognized for their medicinal properties, with studies showing their potential in treating hypercholesterolemia, hypertension, diabetes and even certain cancers[6]. Economically, *Pleurotus ostreatus* is one of the most commercially viable mushrooms due to its rapid growth and ability to thrive on a wide range of lignocellulosic substrates. This makes it a valuable crop for farmers and agribusinesses, particularly in regions where agricultural waste materials are abundant[7]. Mushroom growth is influenced by several environmental factors, including temperature, humidity, air quality and light. Temperature and humidity are the primary factors in mycelial development and fruiting body formation[8]. Light, though not essential for photosynthesis, plays a role in the photomorphogenesis of fungi. Light exposure can affect the formation and size of mushroom fruiting bodies and can influence the overall biological efficiency of the crop[9]. This study evaluates the growth and yield performance of *Pleurotus ostreatus* under near-dark conditions to explore how light limitation affects the mushroom's morphology and yield efficiency. This study focuses on assessing the effects of near-dark conditions on growth parameters and yield performance of oyster mushrooms. This paper also provides an in-depth look into how light conditions can optimize the indoor cultivation of *Pleurotus ostreatus*, offering insights that can be applied to commercial mushroom farming.

MATERIALS AND METHODS

Study area/Duration: The study was carried in at the Department of Botany, Akwa Ibom State University, Nigeria. The study was conducted for 5 weeks, 5th May- 8th June, 2024.

Source of substrate: The 6 mushroom substrates were obtained from Ime-Edem Garden, 160 Library Avenue, GRA, Ikot Ekpene.

Substrate type and composition

Substrate type: Sawdust, rice husk and calcium carbonate.

Substrate composition:

- Saw dust - 79%
- Rice husk - 20%
- Calcium carbonate - 1%

Experimental setup site: The substrates were set up in an office space under medium lighting conditions. The lighting condition was 0.5 lux using the digital lux meter.

Dry weight of substrate: The substrate bag was placed in an oven for 72 hrs at 80°C. The dry weight of the substrate was obtained.

Growth measurements: Cap diameter, stipe length and stipe girth were measured using a meter rule. The number of fruiting bodies and primordia were counted. The weight of fruiting bodies was obtained using a weighing balance (M-Metal electronic compact scale).

Colour of mushroom: The colour of caps and stems was taken after careful observation of the mushroom growth.

Biological efficiency (%):

$$\text{Biological efficiency} = \frac{(\text{Weight of harvest})}{(\text{Weight of dry substrate})} \times 100$$

Biological yield (g): Biological yield is determined by weighing the whole cluster of fruiting bodies without removing the base of stalks.

Economic yield (g): Economic yield is determined by weighing all the fruiting bodies on a substrate after removing the base of stalks.

RESULTS

Effect of near-dark conditions on mushroom growth: The results of the study indicate that mushrooms grown under near-dark conditions (0.5 lux) exhibited significant stipe elongation, with a maximum stipe length of 12.00 cm. Cap diameters also reached impressive sizes, with a maximum recorded diameter of 14.00 cm (Table 1-7) for various weeks of cultivation. Fig. 1, 2 and 3 show the fruiting bodies of *Pleurotus ostreatus;* also showing no deformities as well as the maximum cap size.

Fig. 1: *Pleurotus ostreatus* fruiting body

Fig. 2: *Pleurots ostreatus* without deformities

Fig. 3: *Pleurots ostreatus* maximum cap size

In Table 1, Mushroom growth varied across substrates, with substrate 4 showing the largest cap diameter (4.8 cm) and stipe girth (2.8 cm), though producing the fewest fruiting bodies (1). Substrates 2, 3 and 5 exhibited moderate growth with 17-23 fruiting bodies and whitish coloration, while substrates 1 and 6 showed no growth.

In Table 2, Substrate 4 showed the largest cap diameter (10.00 cm) and highest stipe girth (4.50 cm) but had the lowest number of fruiting bodies (1.00). Substrates 2 and 5 exhibited higher fruiting body counts (11.00 and 16.00, respectively), with whitish color and no deformities observed across all samples except 1 and 6, where growth parameters were zero.

In Table 3, At week 2 day 3, substrates 2, 3, 4 and 5 showed active mushroom growth with varying cap diameters (3.40-14.00 cm) and stipe lengths (6.10-12.00 cm). Substrate 4 exhibited the largest cap diameter and stipe girth, while substrates 2, 3 and 5 had higher numbers of fruiting bodies and primordia. Substrates 1 and 6 showed no growth.

In Table 4, Substrates 1 and 6 supported mushroom growth by week 2 day 4, with substrate 1 yielding larger caps (2.46 cm) and more fruiting bodies (20) compared to substrate 6. All other substrates showed no growth.

In Table 5, At week 3 day 1, substrates 1 and 6 showed successful mushroom growth with cap diameters of 5.16 cm and 5.33 cm, stipe lengths of 6.14 cm and 6.83 cm and no deformities, producing whitish mushrooms. Substrates 2-5 exhibited no growth or primordia development.

In Table 6, At week 5 day 1, mushroom growth was observed only on substrates 2 and 6, with substrate 2 showing the highest cap diameter (3.23 cm), stipe length (4.83 cm) and number of fruiting bodies (13). Substrate 6 exhibited moderate growth, while no growth occurred on other substrates. Both successful substrates produced whitish mushrooms without deformities.

In Table 7, At week 5, day 2, substrate 1 showed no growth, while substrates 2-6 exhibited varying mushroom growth. Substrate 5 achieved the largest cap diameter (5.83 cm), while substrate 4 produced the longest stipe (7.83 cm). All substrates with growth yielded whitish mushrooms, with no deformities observed.

Yield performance: Biological yield and economic yield were also significantly enhanced under near-dark conditions. The substrate with the best performance achieved a biological yield of 30.44 g and a biological

Table 1: Mushroom growth parameters and morphology at week 2 day 1

Substrate	Cap diameter (cm)	Stipe length (cm)	Stipe girth (cm)	Number of fruiting bodies	Average number of primordia	Deformities	Colour
1	0.00	0.00	0.00	0.00	0.00	No	0.00
2	1.80	3.13	0.63	17.00	5.00	No	Whitish
3	2.73	3.90	0.83	23.00	25.00	No	Whitish
4	4.80	4.50	2.80	1.00	4.00	No	Whitish
5	0.50	2.16	0.33	18.00	13.00	No	Whitish
6	0.00	0.00	0.00	0.00	0.00	No	0.00

Table 2: Mushroom growth parameters and morphology at week 2 day 2

Substrate	Cap diameter (cm)	Stipe length (cm)	Stipe girth (cm)	Number of fruiting bodies	Average number of primordia	Deformities	Colour
1	0.00	0.00	0.00	0.00	0.00	No	0.00
2	5.23	4.93	3.00	11.00	8.00	No	Whitish
3	4.66	5.16	1.33	7.00	6.00	No	Whitish
4	10.00	4.00	4.50	1.00	2.00	No	Whitish
5	2.16	5.83	0.66	16.00	8.00	No	Whitish
6	0.00	0.00	0.00	0.00	0.00	No	0.00

Table 3: Mushroom growth parameters and morphology at week 2 day 3

Substrate	Cap diameter (cm)	Stipe length (cm)	Stipe girth (cm)	Number of fruiting bodies	Average number of primordia	Deformities	Colour
1	0.00	0.00	0.00	0.00	0.00	No	0.00
2	6.56	7.50	1.46	6.00	8.00	No	Whitish
3	3.40	6.10	0.93	15.00	15.00	No	Whitish
4	14.00	12.00	4.50	1.00	3.00	No	Whitish
5	5.26	8.73	1.03	15.00	7.00	No	Whitish
6	0.00	0.00	0.00	0.00	0.00	No	0.00

Table 4: Mushroom growth parameters and morphology at week 2 day 4

Substrate	Cap diameter (cm)	Stipe length (cm)	Stipe girth (cm)	Number of fruiting bodies	Average number of primordia	Deformities	Colour
1	2.46	3.40	0.90	20.00	15.00	No	Whitish
2	0.00	0.00	0.00	0.00	0.00	No	0.00
3	0.00	0.00	0.00	0.00	0.00	No	0.00
4	0.00	0.00	0.00	0.00	0.00	No	0.00
5	0.00	0.00	0.00	0.00	0.00	No	0.00
6	0.93	2.33	0.73	15.00	42.00	No	Whitish

Table 5: Mushroom growth parameters and morphology at week 3 day 1

Substrate	Cap diameter (cm)	Stipe length (cm)	Stipe girth (cm)	Number of fruiting bodies	Average number of primordia	Deformities	Colour
1	5.16	6.14	0.76	13.00	6.00	No	Whitish
2	0.00	0.00	0.00	0.00	0.00	No	0.00
3	0.00	0.00	0.00	0.00	0.00	No	0.00
4	0.00	0.00	0.00	0.00	0.00	No	0.00
5	0.00	0.00	0.00	0.00	0.00	No	0.00
6	5.33	6.83	1.10	7.00	5.00	No	Whitish

efficiency of 13.15% for various weeks of cultivation. This supports the hypothesis that limiting light exposure during vegetative growth can positively impact mushroom yield shown in Table 8.

At week 3 day 2, only substrates 1 and 6 supported mushroom growth, with substrate 1 yielding the highest biological (12.04 g) and economic yield (11.39 g) and an average fruiting body weight of 1.72 g. Substrate 6 showed slightly lower yields (9.31 g biological, 7.68 g economic) and an average weight of 1.41 g, while all other substrates failed to produce mushrooms shown in Table 9.

Table 6: Mushroom growth parameters and morphology at week 5 day 1

Substrate	Cap diameter (cm)	Stipe length (cm)	Stipe girth (cm)	Number of fruiting bodies	Average number of primordia	Deformities	Colour
1	0.00	0.00	0.00	0.00	0.00	No	0.00
2	3.23	4.83	1.23	13.00	4.00	No	Whitish
3	0.00	0.00	0.00	0.00	0.00	No	0.00
4	0.00	0.00	0.00	0.00	0.00	No	0.00
5	0.00	0.00	0.00	0.00	0.00	No	0.00
6	1.60	3.50	0.76	8.00	4.00	No	Whitish

Table 7: Mushroom growth parameters and morphology at week 5 day 2

Substrate	Cap diameter (cm)	Stipe length (cm)	Stipe girth (cm)	Number of fruiting bodies	Average number of primordia	Deformities	Colour
1	0.00	0.00	0.00	0.00	0.00	No	0.00
2	4.83	6.50	0.83	12.00	0.00	No	Whitish
3	2.70	4.50	1.03	8.00	0.00	No	Whitish
4	5.16	7.83	1.50	4.00	0.00	No	Whitish
5	5.83	7.33	1.20	3.00	0.00	No	Whitish
6	3.66	3.83	0.83	4.00	0.00	No	Whitish

Table 8: Mushroom yield parameters and morphology at week 2 day 5

Substrate	Average weight of individual fruiting bodies (g)	Biological yield (g)	Economic yield (g)	Biological efficiency (%)
1	0.00	0.00	0.00	0.00
2	1.18	11.61	11.50	0.53
3	3.86	15.93	20.82	1.60
4	30.44	30.44	30.36	13.15
5	5.17	17.83	18.19	2.15
6	0.00	0.00	0.00	0.00

Table 9: Mushroom yield parameters and morphology at week 3 day 2

Substrate	Average weight of individual fruiting bodies (g)	Biological yield (g)	Economic yield (g)	Biological efficiency (%)
1	1.72	12.04	11.39	0.68
2	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00
6	1.41	9.31	7.68	0.67

Table 10: Mushroom yield parameters and morphology at week 5 day 3

Substrate	Average weight of individual fruiting bodies (g)	Biological yield (g)	Economic yield (g)	Biological Efficiency (%)
1	0.00	0.00	0.00	0.00
2	2.92	16.50	13.92	1.31
3	1.73	10.92	9.55	0.72
4	4.40	15.85	11.95	1.90
5	2.87	10.20	10.15	1.19
6	2.48	9.92	7.89	1.18

Substrate 4 showed the highest average weight of fruiting bodies (4.40 g) and biological efficiency (1.90%), while Substrate 2 achieved the highest economic yield (13.92 g). Substrate 1 had no yield across all parameters shown in Table 10.

DISCUSSION

The findings of this study demonstrate that light plays a crucial role in determining the growth and morphology of *Pleurotus ostreatus*. The near-dark conditions (0.5 lux) produced larger fruiting bodies and increased biological efficiency. These results were consistent with previous studies on the effect of light on mushroom development, particularly the work of Panek *et al.*[9], who found that limited light exposure enhances cap development and yield performance. These findings aligned with previous studies that suggest light deprivation encourages the development of larger fruiting bodies, particularly cap size, which is of commercial interest[11].

Light intensity also influenced the morphology of *Pleurots ostreatus* fruiting bodies. In this study, mushrooms grown under limited light developed longer stems and smaller caps, a characteristic response to low light conditions that have been previously documented in mushroom cultivation research[9]. These morphological changes may be explained by the mushrooms' response to phototropic cues, which encourage stem elongation as the organism seeks optimal light sources for growth[2]. Such changes, while adaptive, can reduce the commercial appeal of the mushrooms, as consumers and culinary professionals typically prefer larger caps and shorter stems for culinary uses.

Stipe elongation in this study under low light conditions is consistent with earlier studies, which suggest that mushrooms tend to grow longer stems in low-light environments as a phototropic response, seeking light for further development[12]. Similar trends were observed in other studies involving *Pleurotus* species where reduced light intensity prompted increased elongation and cap expansion[11]. The absence of deformities in the fruiting bodies, coupled with the significant cap size observed in this study, suggests that near-dark conditions can promote healthy growth, further supporting findings by Al Mamun *et al.*[11].

Biological efficiency, which measures the ratio of mushroom yield to substrate weight, was also improved in near-dark conditions. This outcome corresponds with the results of studies by Shah *et al.*[7], which found that mushrooms grown under restricted light conditions exhibited higher biological efficiency compared to those exposed to moderate light. Furthermore, the enhanced biological yield observed in this study corroborates research showing that mushrooms grown with limited light can achieve superior yields due to optimized substrate utilization[9,10].

In addition to yield, the quality of mushrooms grown in near-dark conditions is of significant importance for commercial production. Mushrooms with larger caps and longer stems are often preferred in culinary applications, adding to their marketability[12]. Thus, cultivating *Pleurots ostreatus* under near-dark conditions could offer both yield and quality advantages, making it a favorable strategy for commercial growers.

The findings of this study have important implications for mushroom cultivation practices, particularly in indoor farming systems where light control is more manageable. By carefully controlling light exposure, growers can enhance both the yield and morphology of *Pleurots ostreatus*, making it a viable option for large-scale production. Oyster mushroom species and varieties require light of specific intensity to produce properly formed fruiting bodies. Light is not essential in the mycelial growth period. However, in the period of initiation and growth of fruiting bodies, it is a decisive factor in obtaining a high yield of good quality. The growth of fruiting bodies depends not only on the light intensity but also on the length of the light period in a diurnal rhythm. The amount of light needed to develop fruiting bodies can be adjusted by decreasing the lighting duration while increasing light intensity at the same time. It is also possible to increase the lighting duration while decreasing light intensity[13]. Most importantly, however, light intensity was found to affect the morphological characteristics of the oyster mushroom, including cap size and stem length in this study which is a similar observation reported by Zawadzka *et al.*[14].

Furthermore, the economic viability of growing *Pleurotus ostreatus* under near-dark conditions is promising, as it reduces the need for artificial lighting, thereby lowering production costs. This method is particularly suitable for small-scale growers or urban farmers looking to minimize energy consumption.

CONCLUSION

This study highlights the importance of optimizing light conditions in the indoor cultivation of *Pleurotus ostreatus*. Near-dark conditions promote larger cap sizes and higher biological efficiency, which are desirable traits for commercial production. Further research should explore the interaction between light and other environmental factors such as temperature and humidity to optimize indoor mushroom production further. Additionally, studies on other light qualities, such as wavelength and photoperiod, could reveal further nuances in how light affects mushroom morphology and yield.

SIGNIFICANCE STATEMENT

Pleurotus ostreatus, commonly known as the oyster mushroom, is an economically important edible fungus, valued for its nutritional content and environmental benefits. Optimizing indoor cultivation conditions for this species is critical to improving yield and morphological quality, especially as indoor farming expands to meet sustainable food production needs. This study explores the role of light as a limiting factor in indoor growth, aiming to enhance both productivity and quality. By understanding the impact of light limitation, this research provides insights into more efficient resource use, potentially reducing energy costs and increasing feasibility for indoor mushroom cultivation on a larger scale.

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