ACTA MYCOLOGICA
Vol. 47 (1): 65–73
2012

Impact of light on yielding of some *Pleurotus* sp. strains

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Siwulski M., Ziombra M., Sobieralski K.*: Impact of light on yielding of some Pleurotus sp. strains.* Acta Mycol. 47 (1): 65–73, 2012.

Light is an important factor deciding about yielding and morphological characters of *Pleurotus* carpophores. The objective of the research was to ascertain the impact of period and intensity of lighting on yielding and carpophore morphological features of four strains of oyster mushroom. The following strains were investigated: *P. ostreatus*: PX, K22 and P80 strains, *P. pulmonarius*: P20 strain. Fluorescent lamps with Day-Light were used to provide light in the cultivation room. The following lighting periods were used: 6, 10 and 14 hours/day and the applied lighting intensity included: 100, 300, 500 and 700 lx. Lighting exerted a significant impact on yielding. The highest carpophore crop was recorded when the applied lighting intensity was 500 and 700 lx for the period of 14 h/d. The highest mean mass of carpophores was recorded at 14-hour light exposure and 500 and 700 lx lighting intensity. Carpophore morphological features modified by the lighting period and its intensity included the cap diameter as well as the length and thickness of the stem.

Key words: oyster mushroom, cultivation, lighting intensity, carpophore, morphological traits

INTRODUCTION

Species from the *Pleurotus* genus, including their strains, differ with regard to characters of their carpophores (Ziombra, Gembiak 2000; Siwulski et al. 2006). Yields of mushrooms from the *Pleurotus* genus depend on many factors; apart from genetic properties, also environmental factors play a significant role in this regard (Lelley 1991; Shah et al. 2004).

The mycelium of mushrooms from the *Pleurotus* genus does not require light for its growth (Sharma 2004), nevertheless, light is necessary for the proper development of carpophores (Olivier 1988; Royse, Zaki 1991). Trukhonovets (1991) maintains that during the period of carpophore development and growth, light is an important factor deciding about yielding and morphological characters of fruiting

bodies. Experiments conducted by the above-mentioned researcher showed that light quantities required for carpophore development can be regulated by shortening the exposure time and increasing the light intensity or, conversely, by lengthening the time of exposure to light and decreasing its intensity. In other words, the total quantity of light is decisive for normal development of carpophores. It should, however, be emphasised that there are significant differences between strains. Selection of profusely fruiting strains and providing optimal conditions for their cultivation are commonly considered to be among key yield-forming factors.

Due to considerable variability of the *Pleurotus* genus, both with regard to morphological as well as functional features, many forms of this mushroom have already been selected and are used in cultivation as separate strains. Strains differ among one another with regard to the weight of their carpophores, size and thickness of the pileus as well as the length and thickness of the stem. These traits alter depending on cultivation conditions, although they remain characteristic for the given strain (Curvetto et al. 2002; Siwulski et al. 2006).

The objective of the presented research project was to ascertain the impact of light on yielding and carpophore morphological features of four strains of oyster mushroom.

MATERIAL AND METHODS

The following species and strains of oyster mushroom were investigated: *Pleurotus ostreatus* Jacq.ex.(Fr.) Kumm. – PX, K22 and P80 strains, *Pleurotus pulmonarius* (Fr.) Quel. – P20 strain. The evaluation of yields depending on the duration and intensity of lighting exposure was carried out in air-conditioned chambers of the Department of Vegetable Crops, University of Life Sciences in Poznań. The experiment was set up in a random design in four replications and two cultivation cycles.

The cultivation substrate was wheat straw cut into chaff of 3-5 cm length. The substrate of approximately 70% moisture content was pasteurised at the temperature of 60°C for the period of 48 hours. After the pasteurisation process, the substrate was cooled down to the temperature of 25°C and mixed with oyster mushroom mycelium. The oyster mushroom mycelium as propagation material was produced on wheat grain. The proportion of the applied mycelium in relation to the cultivation substrate was established at 5%. The substrate, together with oyster mushroom mycelium, were placed in perforated polyethylene bags; 10 dm^3 in each bag.

The process of overgrowing of the oyster mushroom mycelium through the substrate took place in darkness in a cultivation facility in which the temperature was maintained at the level of 18-20°C and air humidity – at 80-85%.

Once the substrate was overgrown by the mycelium of the examined strains, different lighting conditions were applied for the cropping period. Fluorescent lamps with light similar to natural light (Day-Light) were used to provide light in the facilities. The following lighting periods were used: 6, 10 and 14 hours/day and the applied lighting intensity included: 100, 300, 500 and 700 lx. Measurements of the

lighting intensity were performed on the substrate surface with the assistance of a luxmeter L-20.

The yield mass in relation to the substrate dry matter was determined and biometric measurements of fruiting bodies were taken. A sample for biometric measurements consisting of 40 carpophores was collected randomly from each experimental combination. The diameter and thickness of the cap and length and thickness of the stem were determined. The results comprising yields and morphological traits of carpophores were analysed for mean values from replications and cultivation cycles. The analysis of variance for three-factorial experiments was performed calculating LSD at the significance level of $\alpha=0.05$.

RESULTS

Lighting exerted a significant impact on yielding. The highest carpophore crop, irrespective of the strain, was recorded in combinations where the applied lighting intensity was 500 and 700 lx for the period of 14 h/d. The experimental strains responded differently to the applied light regimes. At lighting intensity of 500 and 700 lx, the highest and non-significantly differing crops were recorded for PX, K22 and P80 strains, whereas P20 strain exhibited the weakest response to changes in the lighting intensity, especially at 14-hour light exposure (Tab. 1).

The light exposure of 6 h/d, irrespective of the lighting intensity, resulted in a significant decline of yields in comparison with 10 and 14 h/d lighting period. The highest yields were obtained at 14-hour light exposure. Apart from the duration of the light exposure, also light intensity played a significant role. The highest crops were recorded at 500 and 700 lx lighting intensity. Yields obtained in such conditions did not differ significantly irrespective of the period of lighting.

Table 1
Pleurotus yield in relation to intensity and period of lighting (g x kg^{-1} D.M. of substrate)

Lighting		Strain			
(h)	(lx)	PX	P20	K22	B80
6	100	188	205	122	182
	300	206	275	138	235
	500	278	290	245	285
	700	346	330	282	296
Mean		256	275	196	250
10	100	228	402	232	330
	300	380	518	326	462
	500	512	622	480	634
	700	522	635	492	780
Mean		411	544	382	552
14	100	426	532	284	325
	300	595	660	398	554
	500	805	668	615	890
	700	830	672	728	912
Mean		664	633	506	670
$LSD_{0.05}$ for strain=60, for lighting intensity=86, for period of lighting=82, for interaction=115					

It was demonstrated on the basis of analyses of lighting intensity and time interrelationships that it was not possible to shorten the time of light exposure even when light intensity was increased up to 700 lx. On the other hand, it is not advisable to reduce lighting intensity below 500 lx, if we want to lengthen the duration of light exposure at the expense of lighting intensity. The examined strains responded similarly to lighting duration in the 24-hour period.

The recorded mean carpophore mass characteristic for a given strain changed following different light exposure of the cultivation. When a 14-hour lighting regime was employed, the mean weight of harvested carpophores was higher in comparison with fruiting bodies grown in 6 or 10-hour regimes. The mean carpophore weight increased together with the length of the lighting period per day. Also lighting intensity exerted influence on carpophore weight. When the applied lighting intensity was 100 or 300 lx, carpophores of significantly smaller weight were obtained than at

Table 2
Carpophore mean mass of *Pleurotus* strains in relation to intensity and period of lighting (g)

Lighting		Strain			
(h)	(lx)	PX	P20	K22	B80
6	100	22	28	20	26
	300	28	32	20	28
	500	36	32	22	40
	700	42	32	24	42
Mean		32	31	22	34
10	100	38	34	24	32
	300	42	36	36	44
	500	48	38	38	46
	700	50	38	38	48
Mean		45	37	34	43
14	100	40	24	24	36
	300	58	36	34	50
	500	66	48	48	58
	700	68	50	50	60
Mean		58	40	39	51
$LSD_{0.05}$ for strain=8, for lighting intensity=8, for period of lighting=10, for interaction=15					

Table 3
Cap diameter of *Pleurotus* strains in relation to intensity and period of lighting (mm)

Lighting		Strain			
(h)	(lx)	PX	P20	K22	B80
6	100	22	30	18	22
	300	30	32	20	22
	500	36	36	26	28
	700	34	38	26	32
Mean		31	34	23	26
10	100	32	42	24	28
	300	42	52	32	38
	500	50	52	37	46
	700	53	52	38	46
Mean		44	50	33	40
14	100	38	46	28	32
	300	56	48	38	46
	500	72	52	47	58
	700	74	52	52	62
Mean		60	50	41	50
$LSD_{0.05}$ for strain=6, for lighting intensity=8, for period of lighting=6, for interaction=11					

the same period to light exposure but of 500 and 700 lx. However, lighting intensity of 500 and 700 lx applied only for 6 or 10 hours exerted a negative influence on carpophore weight. The highest weight of fruiting bodies was recorded at 14-hour light exposure and 500 and 700 lx lighting intensity (Tab. 2). Strain P20 was characterised by the weakest response to changes in lighting conditions. The remaining strains were found to respond similarly to changes in both lighting intensity and duration.

Cap diameter and thickness were features characteristic for a given strain and, similarly to the carpophore mass, depended on lighting intensity and duration. Carpophores with the largest and thickest caps were observed in combinations with 14 h/d light exposure and 500 and 700 lx lighting intensity (Tabs 3 and 4).

The applied lighting intensity of cultivations affected the length and diameter of mushroom stems (Tabs 5 and 6). Fruiting bodies with the shortest stems were found in strains cultivated for the longest light exposure (14 h/d). In addition, a distinct

Table 4
Cap thickness of *Pleurotus* strains in relation to intensity and period of lighting (mm)

Lighting		Strain			
(h)	(lx)	PX	P20	K22	B80
6	100	8	6	6	8
	300	10	6	6	8
	500	12	8	6	10
	700	12	8	6	10
Mean		11	7	6	9
10	100	12	8	8	12
	300	12	9	8	12
	500	14	9	10	14
	700	14	9	10	14
Mean		13	9	9	13
14	100	12	8	10	12
	300	15	10	10	15
	500	17	10	12	16
	700	17	10	12	16
Mean		15	10	11	15
$LSD_{0.05}$ for strain=2, for lighting intensity=2, for period of lighting=2, for interaction=2					

Table 5
Stem length of *Pleurotus* strains in relation to intensity and period of lighting (mm)

Lighting		Strain			
(h)	(lx)	PX	P20	K22	B80
6	100	40	14	38	38
	300	38	14	38	36
	500	36	12	34	34
	700	36	12	34	34
Mean		38	13	36	35
10	100	40	14	36	34
	300	36	12	34	32
	500	34	12	33	28
	700	32	10	33	26
Mean		36	12	34	30
14	100	36	12	34	34
	300	32	10	26	28
	500	28	10	25	26
	700	26	10	25	26
Mean		31	11	28	28
$LSD_{0.05}$ for strain=6, for lighting intensity=8, for period of lighting=3, for interaction=10					

Table 6
Stem diameter of *Pleurotus* strains in relation to intensity and period of lighting (mm)

Lighting		Strain			
(h)	(lx)	PX	P20	K22	B80
6	100	8	8	8	9
	300	8	8	8	9
	500	8	10	9	11
	700	9	10	10	11
Mean		8	9	9	10
10	100	9	10	8	8
	300	10	10	9	8
	500	10	10	10	10
	700	12	10	10	10
Mean		10	10	9	9
14	100	10	10	8	8
	300	12	12	8	8
	500	14	12	10	10
	700	14	12	10	10
Mean		13	12	9	9
$LSD_{0.05}$ for strain=2, for lighting intensity=3, for period of lighting=2, for interaction=3					

Table 7
Proportion of stem in carpophore mass of *Pleurotus* strains in relation to intensity and period of lighting (%)

Lighting		Strain			
(h)	(lx)	PX	P20	K22	B80
6	100	42	16	36	40
	300	38	16	36	36
	500	36	14	32	34
	700	36	14	32	30
Mean		38	15	34	35
10	100	38	15	36	34
	300	35	14	36	32
	500	30	12	30	30
	700	28	12	30	30
Mean		33	13	33	32
14	100	33	13	32	28
	300	30	12	30	26
	500	27	11	27	26
	700	27	11	27	25
Mean		29	12	29	26
$LSD_{0.05}$ for strain=5, for lighting intensity=5, for period of lighting=4, for interaction=8					

tendency was found with decreasing lighting intensity for the development of carpophores with increasingly long stems. The stem thickness of carpophores declined with decreasing lighting intensity and shortening of time exposure to light.

The proportion of stems in the weight of carpophores ranged from 11 to 42% depending on strain, lighting intensity and light exposure time. P20 strain was characterised by the smallest proportion (11-16%) of stems in carpophores; short stems are typical for this strain and in comparison with other strains, the length of their stems is least dependent on variations in lighting. In the case of the remaining strains, the percentage proportion of the stem weight in the carpophore weight was considerably higher ranging from 25 to 42%, depending on the lighting regime. In general, it can be said that the better the lighting conditions, the smaller was the proportion of the stem weight in the carpophore weight. It is true that when lighting conditions

deteriorated, the stem also became thinner but it also became longer and this caused that the stem weight increased affecting its percentage proportion in the carpophore weight (Tab. 7).

DISCUSSION

Light, along with other external factors, exerts a significant impact on the growth and development processes of carpophores of mushrooms from the *Pleurotus* genus. It acts as a signal triggering off various biophysical and biochemical processes ultimately leading to morphological and phototrophic reactions (Trukhonovets 1991).

In the performed investigations, the size and thickness of the cap and length and thickness of the carpophore stem characteristic for the strain altered under the influence of the applied various lighting regimes. The mean carpophore weight was a trait characteristic for a given strain but dependent on time and intensity of lighting of cultivations.

Also Trukhonovets (1991) reported a dependence of the size of the cap and stem length on lighting intensity. Among important characters affecting salability of fruiting bodies is the ratio of the cap size to the stem size. Stems of carpophores of the majority of oyster mushroom species, with the exception of *Pleurotus eryngii*, are inedible and should be as small as possible. In our investigations, irrespective of the applied lighting regime, the shortest stems were determined in the case of carpophores of the P20 strain, whereas in the remaining examined strains stems were longer and changed depending on lighting intensity.

However, according to literature data, there is no agreement as to the optimal range of lighting intensity recommended in the mushroom cultivation of *Pleurotus* genus and, depending on individual researchers, this range fluctuates from 300 to 1500 lx (Lelley 1991; Stamets 2000; Oei 2003; Ziombra et al. 2008).

In the presented experiments, the optimal lighting intensity to obtain high crops of advantageous carpophore morphological features ranged from 500 to 700 lx for PX, K22 and B80 strains. The examined P20 strain was characterized by the lowest requirements regarding the applied lighting regimes and gave similarly high yields both at 300 and 700 lx lighting intensity. Carpophore morphological traits of the P20 strain remained unchanged throughout the examined range of lighting intensity.

The appropriate growth of fruiting bodies is also affected by the length of the lighting period in the 24 h rhythm (Trukhonovets 1991). The research results obtained in this study indicate that the applied 14 h lighting regime turned out to be the most favourable for carpophore development. Crops harvested following the 8 h light regime were lower than in the case of 10 h and 14 h light exposure despite the application of higher lighting intensity of 500 and 700 lx.

Recapitulating, it was concluded on the basis of the performed experiments that cultivations of the examined species of mushrooms from the *Pleurotus* genus should receive, during the period of the development and growth of fruiting bodies not less than 10 hours of light per 24 h. In order to obtain carpophores of large caps and short stems, the lighting intensity should not be lower than 500 lx. In addition, the

obtained research results showed that a longer lighting period within the 24 h period failed to compensate insufficient lighting intensity and, conversely, despite high intensity of lighting, shortening of the lighting exposure time below 10 hours/day is not recommendable.

CONCLUSIONS

1. The highest yields of PX, K22 and B80 strains of oyster mushroom were obtained from cultivations exposed to 10 and 14 hours of light per 24 h applying 500 and 700 lx lighting intensity.
2. The P20 strain of oyster mushroom gave similar yields at lighting intensity ranging from 300 through 500 up to 700 lx.
3. The examined oyster mushroom strains developed carpophores with largest caps within the range of lighting considered as optimal to obtain abundant crops.
4. Carpophore morphological features modified by the length of the lighting period and its intensity included the cap diameter as well as the length and thickness of the stem.

REFERENCES

Curvetto N. R., Figlas D., Devalis R., Delmastro S. 2002. Growth and productivity of different *Pleurotus ostreatus* strains on sunflower seed hulls supplemented with N-NH_4 + and/or Mn (II). Bioresource Technology 84(2): 171–176.

Lelley J. 1991. Pilzanbau. Biotechnologie der Kulturspeisepilze. Ulmer, Stuttgart, 404 pp.

Oei P. 2003. Mushroom cultivation. Backhuys Publishers Leiden, Netherlands, 429 pp.

Olivier J. M. 1988. Les besoins en lumiere dans la culture des Pleurotes. Bull. Fed. Nat. Syndicate Agricol. Cult. Champignons 40: 1433–1439.

Royse D. I., Zaki S. A. 1991. Yield stimulation of *Pleurotus* sp. by dual nutrient supplementation of pasteurized wheat straw. (In:) M.J. Maher (ed.). Science and cultivation of edible fungi. Balkema, Rotterdam: 545–547.

Shah Z. A., Ashraf M., Ishtiag M. 2004. Comparative study on cultivatin and yield performance of oyster mushroom (*Pleurotus ostreatus*) on different substrates. Pakistan J. Nutrition 3 (3): 158–160.

Sharma B. B. 2004. Effect of duration of light on radial growth of pink oyster mushroom. Indian Pathology 57 (2): 234.

Siwulski M., Sobieralski K., Ławicka K. 2006. Porównanie plonowania wybranych odmian i krzyżówek boczniaka *Pleurotus* sp. Folia Horticulturae, Supl. 2: 130–133.

Stamets P. 2000. Growing Gourmet and Medicinal Mushrooms. Ten Speed Press, Berkeley, pp.574.

Tan Q., Wang ZQ., Cheng JH., Guo Q., Guo L. 2005. Cultivation of *Pleurotus* spp. in China. Acta Edulis Fungi 12: 338–342.

Trukhonovets V. V. 1991. Effect of illumination intensity on the formation of fruiting bodies in *Pleurotus ostreatus* (Jacq. Fr.) Kumm. Ukr. Bot. Zh. 48 (2): 67–72.

Ziombra M., Gembiak R. 2000. Cechy morfologiczne owocników grzybów z rodzaju *Pleurotus* sp. Rocz. AR Pozn. 31: 573–577.

Ziombra M., Czerwińska-Nowak A., Ławicka K. 2008. Wpływ natężenia światła i czasu oświetlenia na plon i cechy morfologiczne owocników kilku odmian boczniaka. Zeszyty Problemowe Postępów Nauk Rolniczych 527: 335–341.

Wpływ światła na plonowanie kilku ras *Pleurotus* sp.

Streszczenie

Światło jest ważnym czynnikiem decydującym o plonowaniu i cechach morfologicznych owocników boczniaka. Celem badań było określenie wpływu czasu i natężenia oświetlenia na wielkość plonu oraz cechy morfologiczne owocników czterech ras boczniaka. Przedmiotem badań były rasy *Pleurotus ostreatus*: PX, K22 i P80 oraz rasa *Pleurotus pulmonarius:*P20. Do oświetlenia pomieszczeń uprawowych użyto lamp fluoroscencyjnych o świetle zbliżonym do naturalnego. Okres oświetlenia wynosił 6, 10 i 14 godzin na dobę. Zastosowano oświetlenie o natężeniu 100, 300, 500 i 700 lx. Stwierdzono, że światło wywierało znaczący wpływ na plonowanie. Największe plony owocników uzyskano stosując oświetlenie o natężeniu 500 i 700 lx przez 14 godzin na dobę. Cechami morfologicznymi owocników modyfikowanymi przez długość okresu oświetlenia i jego intensywność były średnica kapelusza oraz długość i grubość trzonu.