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THE INFLUENCE OF THE STRAIN, FLUSH AND SIZE OF CARPOPHORES ON THE YIELD AND DRY MATTER CONTENT OF BUTTON MUSHROOM (*AGARICUS BISPORUS* (LANGE) IMBACH) CARPOPHORES

WPŁYW ODMIANY, RZUTU ORAZ WIELKOŚCI OWOCNIKÓW NA PLON I ZAWARTOŚĆ SUCHEJ MASY OWOCNIKÓW PIECZARKI DWUZARODNIKOWEJ (*AGARICUS BISPORUS* (LANGE) IMBACH)

Summary. The aim of the experiment was to obtain information about the yield quantity and quality of 16 cultivated strains of *Agaricus bisporus*. The 'Somycel 516' strain gave the highest yield, whereas the yield from the 'Sylvan 130' strain was the lowest. The 'Hauser A1.5' was characterised by the highest content of dry matter in all the three yield flushes. An equally high content of dry matter was in the first and second flush of the 'Italspawn F 50' strain and in the second flash of the strain 'Italspawn F 62'. 'Sylvan S100', 'Italspawn F 56', 'Irlandzka 501', 'Amycel 104' and 'Le Lion X13' were the strains with the lowest content of dry matter in all of the three yield flushes. The size of the carpophores had significant influence on the dry matter content. In the all three flushes, the carpophores with diameter 4.6–5.5 cm were characterized by the lowest dry matter content.

Key words: button mushroom, dry matter, flush, strain, yield

Introduction

Agaricus bisporus is characterised by attractive taste, aroma and nutritional value (Czapski, 2003). The technology of champignon cultivation was brought to Poland from France in the 19th century (Szudyga, 1984) and now Poland is a leading producer and exporter of both fresh and processed champignons in the Europe (Kubiak, 2003). For

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many years all over the world researchers have been working on the implementation of new technological solutions, which should both increase the yield and improve its quality (Beelman et al., 2000; Gapiński et al., 2010; Koc and Szarek, 2006; Sobieralski et al., 1994). The champignon cultivation has developed extensively – consequently, the production of new strains has begun (Diamantopoulou and Philippoussis, 2001).

The dry matter content is an important indicator of mushroom quality and it influences the mushroom shelf life (Beelman, 1988; Van Loon et al., 2000). The suitability of the button mushroom to processing is also dependent on the dry matter content. The percentage of dry matter of fruit bodies decreased in the course of the fruit body growth. The amount of water used for cultivation is also important. The fruit bodies ready for harvesting from watered cultures had a significantly lower dry matter content than those from unwatered cultures (Kalberer, 1990). The dry matter content is also influenced by the type of substrate (Colak et al., 2007; Gapiński et al., 2010). According to many authors (De Juan et al., 2010; Sobieralski, 1998; Sobieralski et al., 2007, 2011; Woźniak and Gapiński, 1998), the strain is the very important factor which determine the dry matter content. The aim of the study was to compare the yield and dry matter content of 16 button mushroom strains, depending on the flush of yielding and size of pileus.

Materials and methods

The experiment was conducted at the Department of Vegetable Crops, Poznań University of Life Sciences, Poland. The following strains of *Agaricus bisporus* were used: 'Somycel 516', 'Le Lion X1', 'Irlandzka 501', 'Italspawn F 62', 'Le Lion X13', 'Italspawn F 50', 'Italspawn F 56', 'Hauser A1.5', 'Amycel 2000', 'Amycel 104', 'Polmycel 22', 'Polmycel 23', 'Sylvan S100', 'Amycel 2200', 'Le Lion X25' and 'Sylvan 130'.

A phase II substrate from a composting facility was used in the experiment. The cultivation was located in an air-conditioned chamber. The experiment was carried out in plastic containers sized 38 × 30 × 18 cm. The incubation was conducted at a temperature of 25°C for 12 days, where the relative humidity was 85–90%. The substrate overgrown with mycelium was covered with a layer of peat neutralised with calcium carbonate to a pH of 7.5. The covering layer was 5 cm thick.

The total yield consisted of the carpophores from three yield flushes. The carpophores of four size groups, related with the diameter of the pileus (i.e. 1.5–2.5 cm, 2.6–3.5 cm, 3.6–4.5 cm and 4.6–5.5 cm) were harvested. The dry matter content in the carpophores was measured by means of the gravimetric method (by drying at the beginning of the 50°C and then to constant weight at 80°C).

Dry matter content was determined separately for stems and roots, by drying the material to constant weight at 105°C for 24 h.

The experiment was conducted in two cultivation cycles. A completely random design with four replications was used. The results obtained were analysed statistically. An analysis of variance was carried out, and the significance of differences between the investigated features were determined using LSD at a significance level of $\alpha = 0.05$.

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Results and discussion

The highest total yield was obtained from the 'Somycel 516' strain (22.1 kg·m^{-2}), whereas the yield from the 'Sylvan 130' strain (14.3 kg·m^{-2}) was the lowest (Table 1). Sobieralski et al. (2014) also confirmed large differences in the yield between the strains. According to those authors, among 16 strains compared the highest yield came from the 'Hauser A 8.8' strain (approximately 24 kg·m^{-2}), whereas the lowest yield was observed in the 'Polmycel 31' strain (approximately 17 kg·m^{-2}).

Table 1. Yielding of 16 button mushroom strains – mean of two cultivation cycles (kg·m^{-2})
Tabela 1. Plonowanie 16 odmian pieczarki – średnia z dwóch cykli uprawowych (kg·m^{-2})

Strain Odmiana	Flash – Rzut			
	I	II	III	total – razem
'Somycel 516'	11.6	7.0	3.5	22.1
'Le Lion X1'	12.3	6.8	1.8	20.9
'Irlandzka 501'	10.6	8.5	1.0	20.1
'Italspawn F 62'	10.8	6.3	2.7	19.8
'Le Lion X13'	11.0	6.6	1.7	19.3
'Italspawn F 50'	8.6	5.9	4.7	19.2
'Italspawn F 56'	8.0	6.6	4.5	19.1
'Hauser A1.5'	9.7	7.6	1.5	18.8
'Amycel 2000'	10.2	6.1	1.4	17.7
'Amycel 104'	8.1	5.2	4.4	17.7
'Polmycel 22'	9.4	5.0	2.3	16.7
'Polmycel 23'	9.3	4.6	2.8	16.7
'Sylvan S100'	7.5	5.5	3.2	16.2
'Amycel 2200'	9.5	4.1	1.9	15.5
'Le Lion X25'	7.3	4.8	3.0	15.1
'Sylvan 130'	6.9	5.0	2.4	14.3
Mean – Średnia	9.4	6.0	2.7	

$LSD_{0.05}$ for strains – 0.4, $LSD_{0.05}$ for flushes – 1.6, $LSD_{0.05}$ for interaction strain × flush – 2.5.
$NIR_{0,05}$ dla odmian – 0,4, $NIR_{0,05}$ dla rzutów – 1,6, $NIR_{0,05}$ dla interakcji odmiana × rzut – 2,5.

Our study revealed large differences in the yield between the flushes of all the strains. The yield from the third flush of the 'Italspawn F 50', 'Italspawn F 56' and 'Amycel 104' strains was only two times lower than the yield from the first flush, but the yield from the 'Irlandzka 501' strain was as much as 10 times lower. According to

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Uliński et al. (2005), the yield of strain A1.5 from the first flush was almost three times greater than the yield from the third flush. The study by Sobieralski et al. (2014) also revealed large differences in the yield between the flushes of individual strains. The yield from the third flush of the 'Hauser A 6.5' strain was almost 9 times lower than the yield from the first flush, whereas the difference between the third and first flushes of the 'Polmycel 31' strain was only 1.5 times. Philippoussis et al., (2001) arrived at different conclusions. The authors found that the yield from the third flush was only 8% smaller than the yield from the first flush, but it was nearly 14% greater than the yield from the second flush.

Our study revealed that among the 16 strains compared 'Hauser A1.5' was the strain with the highest content of dry matter in all of the three yield flushes (Tables 2–4). Apart from that, there was an equally high content of dry matter in the first and second flush of the 'Italspawn F 50' strain and in the second flash the strain 'Italspawn F 62'. 'Sylvan S100', 'Italspawn F 56', 'Irlandzka 501', 'Amycel 104' and 'Le Lion X13' were the strains with the lowest content of dry matter in all of the three yield flushes. Apart from that, 'Le Lion X1' and 'Polmycel 22' were the strains with a low content of dry matter in the first flush, while 'Somycel 516' and 'Sylvan 130' in the third flush. Sobieralski et al. (2014) also observed large differences in the dry matter content in button mushroom carpophores. As their study revealed, the dry matter content ranged from 7.1% in the 'Italspawn F 59' strain to 9.6% in the 'Somycel 11' strain.

Uliński and Szudyga (2004) also found differences in the dry matter content among strains. They found that the fruit bodies of large-fruiting strains had significantly higher dry matter content. The analysis of the findings of our study enabled us to conclude that the diameter of the pileus and in consequence, the size of the carpophores had influence on the dry matter content. The carpophores with the diameters of 1.5–2.5 cm and 2.6–3.5 cm from the first yield flush proved to have similar dry matter content, i.e. 7.7%, whereas the larger carpophores with the diameters of 3.5–4.5 and 4.6–5.5 cm were also found to have similar content of dry matter, i.e. 7.4% (Table 2). The analysis of the dry

Table 2. Dry matter content in carpophores of button mushroom strains of different pileus diameter in the first flush of yielding – mean of two cultivation cycles (%)
Tabela 2. Zawartość suchej masy w owocnikach odmian pieczarki o różnej średnicy kapelusza w pierwszym rzucie plonowania – średnia z dwóch cykli uprawowych (%)

Strain Odmiana	Pileus diameter – Średnica kapelusza				
	1.5–2.5 cm	2.6–3.5 cm	3.6–4.5 cm	4.6–5.5 cm	mean średnia
1	2	3	4	5	6
'Somycel 516'	7.5	7.7	7.3	7.0	7.4
'Le Lion X1'	7.4	6.9	7.2	7.0	7.1
'Irlandzka 501'	6.9	6.8	7.0	6.8	6.9
'Italspawn F 62'	8.4	8.6	8.0	7.6	8.2
'Le Lion X13'	6.9	7.1	7.0	6.8	7.0

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Table 2 – cont. / Tabela 2 – cd.

1	2	3	4	5	6
'Italspawn F 50'	9.0	8.7	8.4	8.6	8.7
'Italspawn F 56'	7.1	7.2	6.8	6.9	7.0
'Hauser A1.5'	8.8	8.9	8.3	8.7	8.7
'Amycel 2000'	7.3	7.3	7.5	7.6	7.4
'Amycel 104'	7.5	7.4	7.0	7.1	7.3
'Polmycel 22'	7.3	7.2	7.0	7.1	7.2
'Polmycel 23'	7.9	8.2	7.4	7.5	7.8
'Sylvan S100'	7.0	7.1	7.3	6.9	7.1
'Amycel 2200'	7.6	7.8	7.4	7.3	7.5
'Le Lion X25'	8.4	8.0	7.9	8.1	8.1
'Sylvan 130'	7.9	7.8	7.5	7.3	7.6
Mean – Średnia	7.7	7.7	7.4	7.4	

$LSD_{0.05}$ for strains – 0.4, $LSD_{0.05}$ for carpophore sizes – 0.3, $LSD_{0.05}$ for interaction strain × carpophores size – 0.8.

$NIR_{0,05}$ dla odmian – 0,4, $NIR_{0,05}$ dla wielkości owocników – 0,3, $NIR_{0,05}$ dla interakcji odmiana × wielkość owocników – 0,8.

matter content in the champignon carpophores of the second yield flush of the strains under investigation (Table 3) revealed that there were smaller differences in the average dry matter content depending on the pileus diameter. Only the differences between the carpophores of the pileus diameter ranging from 1.5 to 2.5 cm and from 2.6 to 3.5 cm (7.9%) and in the group of champignons with the largest pileus diameter ranging from

Table 3. Dry matter content in carpophores of button mushroom strains of different pileus diameter in the second flush of yielding – mean of two cultivation cycles (%)
Tabela 3. Zawartość suchej masy w owocnikach odmian pieczarki o różnej średnicy kapelusza w drugim rzucie plonowania – średnia z dwóch cykli uprawowych (%)

Strain Odmiana	Pileus diameter – Średnica kapelusza				
	1.5–2.5 cm	2.6–3.5 cm	3.6–4.5 cm	4.6–5.5 cm	mean średnia
1	2	3	4	5	6
'Somycel 516'	7.6	7.9	7.5	7.3	7.6
'Le Lion X1'	7.6	7.8	7.4	7.0	7.5
'Irlandzka 501'	7.1	6.9	7.0	6.8	7.0
'Italspawn F 62'	8.8	8.9	8.2	7.7	8.4

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Table 3 – cont. / Tabela 3 – cd.

1	2	3	4	5	6
'Le Lion X13'	7.1	7.4	6.9	6.9	7.1
'Italspawn F 50'	8.8	9.2	8.3	8.1	8.6
'Italspawn F 56'	7.3	7.2	7.2	7.0	7.2
'Hauser A1.5'	9.1	8.8	8.6	8.7	8.8
'Amycel 2000'	7.4	7.6	7.7	7.6	7.6
'Amycel 104'	7.4	7.6	7.3	7.0	7.3
'Polmycel 22'	8.1	8.0	7.6	7.2	7.7
'Polmycel 23'	8.1	8.4	7.8	7.3	7.9
'Sylvan S100'	7.4	7.3	7.1	6.9	7.2
'Amycel 2200'	8.1	8.0	7.0	7.1	7.6
'Le Lion X25'	8.0	7.9	7.8	7.6	7.8
'Sylvan 130'	8.1	7.6	7.5	7.6	7.7
Mean – Średnia	7.9	7.9	7.6	7.4	

$LSD_{0.05}$ for strains – 0.4, $LSD_{0.05}$ for carpophore sizes – 0.4, $LSD_{0.05}$ for interaction strain × carpophores size – 1.0.

$NIR_{0,05}$ dla odmian – 0,4, $NIR_{0,05}$ dla wielkości owocników – 0,4, $NIR_{0,05}$ dla interakcji odmiana × wielkość owocników – 1,0.

4.6 to 5.5 cm were found to be significant. To sum up, we can say that the dry matter content in the carpophores with the largest pileus diameter, i.e. from 4.6 to 5.5 cm, was significantly lower than in the carpophores with smaller pileus diameters, i.e. from 1.5 to 2.5 cm and from 2.6 to 3.5 cm.

The analysis of the dependence between the dry matter content in the champignon carpophores of the third yield flush of different strains and the size of the carpophores revealed that this value was the most diversified (Table 4). The carpophores belonging to the groups with the smallest pileus diameters, i.e. from 1.5 to 2.5 cm and from 2.6 to 3.5 cm, were found to have a significantly higher content of dry matter than the carpophores with the diameters of 3.6–4.5 cm and 4.6–5.5 cm. We observed that the dry matter content in the carpophores of the third flush decreased in the groups of the carpophores with larger diameters, i.e. 3.6–4.5 cm and 4.6–5.5 cm.

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Table 4. Dry matter content in carpophores of button mushroom strains of different pileus diameter in the third flush of yielding – mean of two cultivation cycles (%)
Tabela 4. Zawartość suchej masy w owocnikach odmian pieczarki o różnej średnicy kapelusza w trzecim rzucie plonowania – średnia z dwóch cykli uprawowych (%)

Strain Odmiana	Pileus diameter – Średnica kapelusza				
	1.5–2.5 cm	2.6–3.5 cm	3.6–4.5 cm	4.6–5.5 cm	mean średnia
'Somycel 516'	7.4	7.5	7.3	7.6	7.5
'Le Lion X1'	7.9	7.8	7.4	7.4	7.6
'Irlandzka 501'	7.5	7.4	7.5	7.2	7.4
'Italspawn F 62'	8.9	8.8	8.4	8.0	8.5
'Le Lion X13'	7.6	7.8	7.3	7.4	7.5
'Italspawn F 50'	8.7	8.9	8.4	8.2	8.6
'Italspawn F 56'	7.5	7.6	7.5	7.3	7.5
'Hauser A1.5'	9.3	9.5	9.4	9.4	9.4
'Amycel 2000'	7.9	8.1	7.6	7.5	7.8
'Amycel 104'	7.6	7.8	7.5	7.2	7.5
'Polmycel 22'	8.4	8.5	7.9	7.4	8.1
'Polmycel 23'	8.4	8.0	7.5	7.7	7.9
'Sylvan S100'	7.6	7.8	7.3	7.0	7.4
'Amycel 2200'	7.9	8.4	8.2	8.0	8.1
'Le Lion X25'	8.4	8.6	8.4	8.3	8.4
'Sylvan 130'	8.1	8.0	7.5	7.5	7.8
Mean – Średnia	8.1	8.2	7.8	7.7	

$LSD_{0.05}$ for strains – 0.4, $LSD_{0.05}$ for carpophore sizes – 0.3, $LSD_{0.05}$ for interaction strain × carpophores size – 0.8.

$NIR_{0,05}$ dla odmian – 0,4, $NIR_{0,05}$ dla wielkości owocników – 0,3, $NIR_{0,05}$ dla interakcji odmiana × wielkość owocników – 0,8.

Conclusions

1. The 'Somycel 516' strain was characterised by the highest yield, whereas the yield of the 'Sylvan 130' strain was the lowest.

2. The 'Hauser A1.5' strain was characterised by the highest content of dry matter in all the three yield flushes. Apart from that, in the first and third flushes the dry matter content in the 'Italspawn F 50' strain was also found to be high.

3. The lowest dry matter content in all the three yield flushes was observed in the following strains: 'Sylvan S100', 'Italspawn F 56', 'Irlandzka 501', 'Amycel 104', 'Le Lion X13' and 'Somycel 516'.

4. The dry matter content depended on the size of the carpophores.

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WPŁYW ODMIANY, RZUTU ORAZ WIELKOŚCI OWOCNIKÓW NA PLON I ZAWARTOŚĆ SUCHEJ MASY OWOCNIKÓW PIECZARKI DWUZARODNIKOWEJ (*AGARICUS BISPORUS* (LANGE) IMBACH)

Streszczenie. Celem doświadczenia było uzyskanie informacji co do wielkości plonowania i jakości 16 odmian uprawowych pieczarki dwuzarodnikowej. Największy plon dała odmiana ‘Somycel 516’, a najmniejszy – odmiana ‘Sylvan 130’. Odmiana ‘Hauser A1.5’ we wszystkich trzech rzutach plonowania charakteryzowała się największą zawartością suchej masy. Równie dużą zawartość suchej masy w pierwszym i drugim rzucie plonowania stwierdzono u odmiany ‘Italspawn F 50’ i w drugim rzucie u odmiany ‘Italspawn F 62’. Odmiany ‘Sylvan S100’, ‘Italspawn F 56’, ‘Irlandzka 501’, ‘Amycel 104’ i ‘Le Lion X13’ charakteryzowały się najmniejszą zawartością suchej masy we wszystkich trzech rzutach. Wielkość owocników miała istotny wpływ na zawartość suchej masy. We wszystkich trzech rzutach owocniki o średnicy od 4,6 do 5,5 cm charakteryzowały się najmniejszą zawartością suchej masy.

Słowa kluczowe: pieczarka, sucha masa, rzut, odmiana, plon

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