SHORT COMMUNICATION

Influence of soil temperature and precipitation depth on the biomass production of fruiting bodies of macromycetes in a submountain beech forest stand

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ABSTRACT: The paper deals with research on the biomass production of fruiting bodies of macromycetes in a submountain beech stand in dependence on selected climatic variables. The study was carried out at the Ecological Experimental Site (EES) Kremnické vrchy (Central Slovakia) in 2003 and 2004. The biomass production of sporocarps on the EES plots in the two study years was different (5.81 kg/ha of fresh biomass of sporocarps in 2003 and 39.95 kg/ha in 2004) due to better ecological and climatic conditions and higher abundance of sporocarps in 2004. It is necessary to mention that these values reflect the overall status of mycocoenoses on the plot. Unfavourable microclimate conditions and poor species composition of beech monocultures can be considered to be the main factors adversely influencing mycocoenoses in forest stands of the kind.

Keywords: *Fagus sylvatica* L.; beech; macromycetes; biomass production; climatic conditions

Macromycetes growing in beech forest stands represent an intricate ecotrophic-ecotopic system connected with beech and the associated environment. The problems of determination of abundance and production of sporocarps in macromycetes in beech stands were studied in Slovakia by Janík and Mihál (1995) and Mihál (1995), abroad by Holec (1994), Murphy and Miller (1993), Salerni and Perini (2004). Several authors also examined the species diversity, dominance and succession of macromycetes in beech stands. In Slovakia the latter issue was studied e.g. by Mihál (1998, 2002) and abroad e.g. by Adamczyk (1995).

The research into the epigeal sporocarp biomass production was carried out in beech forests at the Experimental Ecological Site (EES) Kremnické vrchy Mts. (control plot). A detailed description of the research plot is as follows: localisation: N – 48°38´, E – 19°04´, area (ha): 0.15, exposition: W, altitude (m): 470–490, age of stand (years): 100–120, stocking: 0.8–0.9, parent rock: andesite, tuffites, soil type: typical Cambisol, forest type group: *Fagetum pauper inferior*, average annual temperature (°C): 9.8, average annual precipitation (mm): 778.

The research was realised in vegetation periods 2003 and 2004, at intervals of three to five weeks (in 2003 on 28. 5., 11. 6., 15. 7., 5. 8., 10. 9., 1. 10., 11. 11.; in 2004 on 19. 5., 16. 6., 13. 7., 10. 8., 23. 9., 13. 10., 8. 11.).

In field surveys we recorded the macromycete species diversity together with the abundance of their sporocarps. The evaluation of biomass production was carried out with average samples (1–50 exemplars) of sporocarps of the relevant species. The calculated average weight of one fruiting body was multiplied by the total abundance of exemplars of the given species identified over the whole study period (in kg/ha). A more detailed description of the in-field method can be found in Mihál (1995).

It is necessary to add that in some cases we succeeded to find only a single sporocarp of certain

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Table 1. Total production of macromycetes on the EES research plot during 2003–2004 in fresh biomass of sporocarps (kg/ha)

Species of fungi	Total
Agrocybe praecox (Pers.) Fayod	0.499
Cantharellus cibarius Fr.	0.326
C. pallens Pilát	0.169
Clitocybe nebularis (Batsch.) P. Kumm.	1.020
C. odora (Bull.) P. Kumm.	0.012
Coprinus micaceus (Bull.) Fr.	0.007
Cortinarius sp.	0.130
Entoloma rhodopolium f. nidorosum (Fr.) Noordel.	0.093
Gymnopus peronatus (Bolton) Antonín et al.	0.134
Hygrophorus eburneus (Bull.) Fr.	0.865
Inocybe rimosa (Bull.) P. Kumm.	0.036
Laccaria amethystina (Huds.) Cooke	0.318
L. laccata agg.	0.064
Lactarius chrysorrheus Fr.	0.013
L. piperatus (L.) Gray	13.288
L. perlatum Pers.	0.052
L. pyriforme Schaeff.	24.425
Marasmius alliaceus (Jacq.) Fr.	0.679
Megacollybia platyphylla (Pers.) Kotl. et Pouzar	0.243
Mycena alcalina agg	0.006
M. galericulata (Scop) Gray	0.041
M. haematopus (Pers.) P. Kumm.	0.002
M. pura (Pers.) P. Kumm.	0.090
M. polygramma (Bull.) Gray	0.036
M. renati Quél.	0.005
M. rosella (Fr.) P. Kumm.	0.003
Pholiota adiposa (Batsch) P. Kumm.	0.009
Pleurotus pulmonarius (Fr.) Quél.	0.211
Pluteus cervinus (Schaeff.) P. Kumm.	0.155
P. salicinus (Pers.) P. Kumm.	0.001
Psathyrella spadiceogrisea (Schaeff.) Maire	0.079
Polyporus melanopus (Sw.) Fr.	0.002
P. varius (Pers.) Fr.	0.210
Rhodocollybia butyracea f. asema (Fr.) Antonín et al.	0.657
Russula amoenolens Romagn.	0.055
R. aurea Pers.	0.321
R. cyanoxantha (Schaeff.) Fr.	0.165
R. foetens (Pers.) Fr.	0.055
R. galochroa (Fr.) J.E. Lange	0.165
Stropharia aeruginosa (Curtis) Quél.	0.100
Tricholoma sulphureum (Bull.) P. Kumm.	0.293
Tubaria conspersa (Pers.) Fayod	0.015
Xerocomus chrysenteron (Bull.) Quél.	0.201
Xerula melanotricha Dörfelt	0.269
X. radicata (Relhan) Dörfelt	0.238
Total	45.757

species over the whole period of study (e.g. *Inocybe rimosa, Tricholoma sulphureum*). Such a fruiting body represented the average weight for the given species at the same time. Also fruticose and resupinate fruiting bodies of lignicolous species were excluded from the evaluation of the production because it was not possible to determine the number of their sporocarps precisely (e.g. *Bisporella citrina, Calocera viscosa, Hypoxylon multiforme, Trametes versicolor* and others). This influenced the abundance of the species included in the evaluation. For example, on the EES we determined 68 macromycete species; on the other hand, only 45 (66.2%) were included in the production evaluation.

The soil thermometers were placed at 5 cm below the soil surface, near the standard climate-monitoring boxes. The values were registered at regular 7-day intervals. The collected data were evaluated using the program package Statistica. The amounts of throughfall were measured with equidistantly placed passive samplers. The first were always recorded after a precipitation event and summarised to the end of the month. The impact of temperature and precipitation depth on the biomass production of macromycetes was evaluated using analysis of variance and regression analysis.

All the macromycete species included in the evaluation of biomass production in sporocarps are listed in Table 1, together with their production values. The taxonomic nomenclature of macromycetes according to Marhold and Hindák (1998) and Škubla (2003) was used. The complete list of macromycete species determined on the EES plot was presented by Mihál (2002), Mihál and Bučinová (2005).

Several species in Table 1 with the highest or relatively high biomass production of sporocarps were also reported by other authors as dominant species with frequent occurrence and reaching high values of biomass production in beech forests. For example, according to Mihál (1998) the species *Hygrophorus eburneus* is a species occurring in the conditions of the stand at the EES Kremnické vrchy Mts. with high values of biomass production (from 1991 to 1994 the values of the biomass production of fruiting bodies fluctuated in this species from 0.71 to 63.19 kg/ha). Also Adamczyk (1995) reported on this species as one of the most dominant ones in beech forest stands. Analogically to *Marasmius rotula*, Adamczyk (l.c.) assigns it to the most dominant macromycetes in beech stands. The taxonomically related species was classified by Tyler (1991) to the macromycetes with the highest biomass production of sporocarps in beech forests. The biomass amount of fruiting bodies produced by *Marasmius alliaceus* on the EES plot in 1991–1994 ranged from 0.32 to 4.97 kg/ha (Mihál 1998).

In addition to the direct evaluation of the dynamics of sporocarp biomass production, we studied the relation between the dynamics of sporocarp biomass production (kg/ha) at the EES and the dynamics of aboveground biomass production in herbs (t/ha), in dependence on the stocking on the partial research plots. We found that the dynamics of sporocarp biomass increased beginning with the clear-cut plot to the plot with a stocking of 0.9; the trend in the biomass of herbs was just opposite (Janík, Mihál 1995). According to Holec (1994), the litter layer thickness and humus form are factors controlling not only the abundance of saprophytic but also ectomycorrhizal fungi and their mutual ratio. For example, beech stands with the mull humus form support rather saprophytic than ectomycorrhizal macromycetes. Murphy and Miller (1993) found that also the saprophytic species *Collybia subnuda* was dominant in deciduous forests. Tyler (1991) examined the influence of litter removal on the production of macromycete fruiting bodies. This author observed that the production of fruiting bodies was higher on the plot with litter layer in the saprophytic species *Mycena cinerella*, *Mycena galopoda* and *Rhodocollybia butyracea f. asema*; the plots from which the litter had been removed showed the highest production of ectomycorrhizal species from the genus *Lactarius* and *Russula*. On the other hand, Salerni and Perini (2004) studying the dynamics of the fruiting bodies of the ectomycorrhizal species *Boletus edulis* found the highest amount of fruiting bodies in this species namely on plots with sufficient litter layer.

Different values on the EES plots were observed in the biomass production of sporocarps between individual years of investigation (from 5.81 kg/ha fresh biomass of sporocarps in 2003 to 39.95 kg/ha fresh biomass of sporocarps in 2004), due to better ecological and climatic conditions in 2004 and higher abundance of sporocarps in 2004. Table 2 shows the quite equilibrated dynamics of abundance and production of sporocarps during the investigated periods 2003–2004. If the microclimate conditions had been more favourable, we should have observed the higher species diversity of macromycetes and also higher values of the abundance of sporocarps. Unfavourable microclimate conditions and poor species composition of beech monocultures can be considered to be the main factors adversely influencing mycocoenoses in forest stands of the kind. For

Table 2. Abundance and production (kg/ha) of sporocarps of macromycete species, soil temperature (°C) and precipitation depth (mm) on the EES research plot during the investigated period 2003–2004

	Months							Total
Years	V	VI	VII	VIII	IX	X	XI	
Abundance								
2003	0	18	0	18	10	2	172	220
2004	10	32	49	54	332	118	155	732
Production								
2003	0.00	0.93	0.00	0.76	0.08	0.01	4.03	5.81
2004	0.53	0.16	8.64	6.07	13.25	4.61	6.69	39.95
Total	0.53	1.09	8.64	6.83	13.33	4.62	10.72	45.76
Soil temperature								Average
2003	11.75	14.72	15.90	17.15	12.95	7.40	5.15	12.15
2004	10.40	–	16.40	14.20	11.30	7.80	6.20	11.05
Precipitation depth								
2003	47.9	23.7	–	36.6	–	115.2	44.2	53.52
2004	115.4	230.9	27.5	144.6	–	81.4	111.5	118.55

example, in dry years 1992 and 1993 we determined 83 macromycete species that produced 817 fruiting bodies in the stand on the beech research plot Jalná (the Štiavnické vrchy Mts.) (Mihál 1995). These values from Table 2 reflect more or less equal microclimatic, ecological and ecotrophic conditions on research plots. A similar trend like that observed in the abundance dynamics of macromycete species and abundance of their sporocarps can also be identified in the dynamics of biomass production in sporocarps. The values of biomass production followed the trend in fruiting body production.

The values of soil temperature at depths of 5 and 20 cm and the data on throughfall amounts are summarised in Table 2. It is evident that the year 2003 was drier and, at the same time, warmer, which was also reflected in the production and numbers of the individual species of macromycetes. The year 2004, on the other hand, was more abundant in precipitation, but the soil temperature in summer months was lower (1–2°C), evidently influencing the abundance and biomass production of the studied fungal species.

The results of testing differences in the abundance of individual taxa in dependence on the discussed climatic factors are represented in Table 3. The table shows the just mentioned evident dominant influence of the precipitation total in 2004 on production abilities of the studied fungal communities. The same trend was also confirmed in herbal communities in which the testing results were even more pronounced (Janík, Havranová 2004; Schieber, Janík 2004; Janík 2005). The results of correlation analysis and analysis of variance confirmed these conclusions, especially in the case of the precipitation total. In summary, we can conclude that the amount of throughfall is a stronger governing factor for production abilities of fungal communities than the soil temperature. It is however necessary to point out that, like in other plants, in the case of fungi a higher description value for the relation water-plant or water-fungus could be obtained when virtually dealing with physiologically accessible water (Pichler 1996). At present, however, we can only provide the discussed values and deal with them in this context.

Different values at the EES were observed in the biomass production of sporocarps between the individual years of investigation (from 5.81 kg/ha fresh biomass of sporocarps in 2003 to 39.95 kg/ha in 2004), due to better ecological and climatic conditions in 2004 and higher abundance of sporocarps

Table 3. The analysis of correlation and Student's t-test between climatic characteristic and biomass production of macromycetes in 2003–2004

Biomass of macromycetes	St 2003		St 2004		Pd 2003		Pd 2004	
	r_x	t	r_x	t	r_x	t	r_x	t
2003	–0.549	–5.6++	–	–	0.02	–2.5++	–	–
2004	–	–	0.03	–2.7++	–	–	–0.822	3.2++

St – soil temperature, Pd – precipitation depth, r_x – coefficient of correlation, t – characteristic, ++ – statistically significant ($\alpha = 0.05$)

in 2004. Unfavourable microclimate conditions and poor species composition of beech monocultures can be considered to be the main factors adversely influencing mycocoenoses in forest stands of the kind.

The results of research on soil temperature and precipitation depth in submountain beech forest stands are given in Table 2. The results of t-test, correlation analysis and analysis of variance show that the production of fungi was more influenced by the precipitation total than by the soil temperature (Table 3).

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Vplyv vybraných klimatických faktorov na produkciu biomasy plodníc makromycétov v submontánnych bučinách

ABSTRAKT: V práci uvádzame výsledky výskumu produkcie biomasy plodníc makromycétov v podmienkach submontánnych bučín v závislosti od vybraných klimatických faktorov. Výskum prebiehal na Experimentálnom a ekologickom stacionári (EES) Kremnické vrchy (stredné Slovensko) počas rokov 2003 a 2004. Produkcia biomasy sporokarpov makromycétov na výskumnej ploche bola počas obidvoch rokov rozdielna (5,81 kg/ha čerstvej hmotnosti sporokarpov v roku 2003 a 39,95 kg/ha v roku 2004) vďaka lepším klimaticko-ekologickým podmienkam a vyššej abundancii plodníc v roku 2004. Treba dodať, že tieto hodnoty sú výsledkom celkového stavu mykocenózy na výskumnej ploche. Nepriaznivé mikroklimatické podmienky a chudobné druhové zloženie bukových monokultúr môžeme považovať za hlavné faktory nepriaznivo ovplyvňujúce mykocenózy v takýchto lesných porastoch.

Kľúčové slová: *Fagus sylvatica* L.; buk; makromycéty; produkcia biomasy; klimatické podmienky

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