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Preliminary evaluation of the productivity of fungi (*Agaricales* and *Gasteromycetes*) on the Kazuń meadows

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The results are reported of one-year investigations on the productivity of fungi in communities of mown and unmown grass on exploited meadows near Warsaw of the *Arrhenatheretum medioeuropaeum* (Br.-Bl. 1919) Oberd. 1952 type. The observations were made in the course of the vegetation period in 1971. Fresh and dry weight of the fruit bodies were determined as well as the weight of the ash after incineration. It was found that on the mown experimental plot the fungi produced much more organic matter than on the unmown one.

INTRODUCTION

The investigations on the productivity of fungi possessing mushroom-shaped sporophores (*Agaricales* and *Gasteromycetes*) in Kazuń near Warsaw are a part of serial studies concerning the productivity of grassland ecosystems undertaken by the Department of Ecology of the Polish Academy of Sciences within the framework of the International Biological Program and carried on at the present moment by the Group of Mycology and Algology of the Institute of Botany of the Warsaw University.

DESCRIPTION OF THE MEADOWS EXAMINED

The Kazuń meadows lie on the youngest accumulation terrace of the Vistula, running parallel to the river. This whole region is situated about 3 m lower than the dune terrace constituting the main substratum of the Kampinos Forest (Kaczorowska 1926; R. and J. Kobendza 1957).

For some time this terrace was flooded with alluvial waters which accumulated on it fertile silt soil. The thickness of the sediments exceeds sometimes 1 m. It consists of rich alluvial loam of brown type, gley soils with mechanical composition of loamy silt and silty loam. These soils deve-

loped owing to processes associated with the variation of the ground water levels which in spring reach 20-50 cm (Czerwiński 1971).

The bog alder forests which developed on these substrates, particularly patches of the *Fraxino-Ulmetum* association, the remains of which may still be found here, were out down to obtain arable soil, and almost the entire area was transformed to fields, meadows and pastures. At present the meadows are cultivated and owing to this have a high fodder value (Traczyk 1971).

In the surface layer of the soil of these meadows processes of browning and humus accumulation go on. This accumulation, in view of the rich flora, attains a thickness of 0-10 cm, and in the zone of ground water occurrence reductive processes take place. The soils here are heavy or medium heavy, therefore absorption is largely affected by the mechanical composition, beside other factors.

The porosity of the silt and loamy silt layer is high (47.0-60.2%), and lower at greater depths (31.8-45.7%), owing to the increasing sand content. The porosity of the surface layers is higher, thus water and air circulate in them freely. The water capillaries in the soil are usually filled in 32.0-58.0 per cent and the air capillaries in 0.0-9.1 per cent.

Absorption is greatly increased by the presence of mineral compounds. The Kazuń soils contain large quantities of calcium and magnesium and smaller amounts of sodium and potassium. These four elements constitute 76.0-98.0 per cent of the total soil absorption capacity (Czerwiński 1971).

The meteorological data (air temperature and precipitation) for Kazuń and its neighbourhood were obtained from the Polish Hydrometeorological Institute (PIHM) (Table 1). The highest mean temperature was noted in July and August (19.7°C). The lowest mean precipitation was recorded in July (14.0 mm), it was somewhat higher in May (24.4 mm) and November (28.1 mm). The relatively high temperatures, and at the same time small amount of rainfall did not favour profuse fructification of fungi.

The long exploited Kazuń meadows were ploughed about ten years ago and a mixture of fodder plants was sown on them. At present they are young meadows covered with vegetation of the *Arrhenatheretum medioeuropaeum* type (Br.-Bl. 1919) Oberd. 1952, of the class *Molinio-Arrhenatheretea* Tx. 1937. Beside plants typical for this association (Oberdorfer 1952), on the surface investigated the species enumerated by Traczyk (1971) were found such as *Agrostis alba*, *Phalaris arundinacea*, *Carum carvi*, *Cerastium vulgatum* and *Carex hirta*.

METHODS

For preliminary investigations a part of the exploited meadows in Kazuń (near Ordona district) was chosen, on which a surface area (100 m²)

was delimited for the studies in the shape of two parallelly situated experimental plots (50×1 m), 10 m distant from one another. One was used during the investigations as a community of mown grass (*k*), the other remained unmown (*nk*). The narrow strip (1 m) of experimental plots made possible observation in detail without the necessity of treading on the plants of the experimental area.

The investigations were started in May and ended in November 1971. The plots were inspected at two-week intervals so that the plots were examined in all 14 times. The fruit bodies were removed by twisting. Further analysis was performed in the laboratory.

The fungi were identified only in fresh material. The diameter of the pilei of all the fruiting bodies of the given species was measured and the particular fresh fruiting bodies were weighed on an analytical and a torsion balance (with accuracy up to 0.1-0.01). They were then dried in a thermostat at 105°C (3 times for 3 h) and weighed all together in dry state. The difference between dry weight and that of the ash obtained indicates the amount of organic matter produced. The last step in the analysis was the conversion of the productivity of the fungi to g/m².

PRODUCTION

In the period May-November 1971, 695 fruit bodies were found on the experimental area. They were most numerous (266) in July (256 among them belonged to *Marasmius oreades*) in September they were also numerous (205). In this period the weather was rather warm (July 19,7°, September 11.0°) and precipitation scarse (July 14.0, September 38.9 mm). The soil moisture, however, was good since in the preceding months there had been high precipitation (June 57.4, August 42.9 mm) so that the conditions for the fructification of the fungi were rather favourable (Table 1).

Table 1
Mean monthly air temperature and sum of precipitation in 1971

Months	V	VI	VII	VIII	IX	X	XI
Temperature °C	15.9	16.4	19.7	19.7	11.0	8.3	2.3
Precipitation mm	24.4	57.4	14.0	42.9	38.9	56.1	28.1

The above given results are counted jointly for both plots. If we compare the harvest from each of them, there are wide differences. Many more fruit bodies were found on the *k* plot (683) than on the *nk* one (12) and on the latter they were collected mainly in the autumn. The grass community on the plot *k* thus gave favourable conditions for the development of the flora of pileate fungi, although hey mowing and raking distur-

bed the balance of the h bitat, and could also damage the forming fruit bodies.

The grass on the unmown plot reached a height up to 1.5 m, and although in the ground layer moisture was high, the fungi hardly produced any fruit bodies. The strong weft of grasses made the growth of fruiting bodies difficult, did not give access to sunlight, and the high grass haulms swinging in the wind injured mechanically the fruit bodies. The soil surface layer compact and without moss had a low humus content, in spite that the amont of moulding plant remnants was relatively high. It is probable that not only the lack of moisture, but also the slowed down processes of rotting and humus accumulation, were factors which impeded a profuse fructification of the pileate fungi.

The profusion of fruiting bodies must have also been influenced by the over-all surface area of the pilei. This not only contributes to an increased mosaic-like covering of the soil, (although only periodically for a period of about 2 weeks), but it gives a correspondingly larger sporulating surface.

In order to establish in how much the fungi investigated periodically increase the soil covering, the over-all surface of their pilei was calculated. It amounted to 0.53 m² of this 0.52 m² on the *k* plot (1.05% of covering). This was due to the large number of fruit bodies found there, although the diameter of their pilei was small. The highest covering on this plot occurred in July (0,28 m²) and September (10-19 m²), that is in the months when the greatest number of fruit bodies was recorded (July 266, Sept. 205). In this period air temperature was high and the mean precipitation level low (Table 1). In spite of the dry weather the harvest in July was good, owing to the warm weather lasting for two months with high precipitation which favoured the development of the summer flora of meadow fungi.

The second period of maximum covering of the *k* plot with fungi fell to September, but fructification was less profuse than in July. The precipitation was sufficient but air temperature began to fall (Table 1). It is wort noting that in the preceding months the weather was also warm and moist. The covering of plot nk was also highest in September. In June and August no fruit bodies were found on it, although they developed on the *k* plot.

In the period of observation 576.17 g of fresh fruiting bodies (without any worms) were collected, thus an average of 5.76 g/m² (Table 2). The fresh weight of the fruit bodies collected on plot *k* was 551.73 g, and on the *nk* plot 24.44 g. As seen the productivity of fresh fungi on the mown plot is twenty five times higher (11.05 g/m²) as compared with that on the nk plot (0.45 g/m).

The fresh material collected on both plots gave after drying 73.25 g

(0.73 g/m²) of dry matter. The dry weight of the fungi from plot *k* (69.52 g) is almost eight times lower than the fresh weight of the fruit bodies collected on the same area. A similar ratio was found for the material from the *nk* plot. The productivity of the fungi as regards dry matter per 1 m² was higher on the mown plot (1.39 g/m²) that on the unmown one (0.07 g/m²).

After incineration of the material 27.51 g of ash was obtained, 27.21 g and 0.30 g, respectively from the *k* and *nk* plots. These values indicate that the ash from the *k* plot amounts to almost one half of the dry weight, and on plot *nk* to as little as one tenth. On the mown plot there grew more numerous species with a dry and tougher consistency which gave more dry matter, and it is this that probably affected the result (Table 2). In conversion to 1 m the ash content from plot *k* was higher than from plot nk (0.54 and 0.01 g/m², respectively).

Table 2

Productivity of fungi on plots *k* and *nk* on the managed meadows in Kazuń

Surface	Number of carpophores	Number of species	Fresh weight		Dry weight		Ash	
			g	g/m²	g	g/m²	g	g/m²
50 m² (*k*)	633	18	551.73	11.05	69.52	1.39	27.21	0.54
50 m² (*nk*)	12	6	24.44	0.45	3.73	0.07	0.30	< 0.01
100 m²	695	22	576.17	5.76	73.25	0.73	27.51	0.27

k — mown plot; nk — unmown plot

Thus the productivity of the fungi both as regards fresh and dry weight was higher on the mown area.

If we consider the productivity of the fungi on both plots in particular months in reference to fresh and dry weight, it appears that is was highest in September (Table 3). In spite of this, from plot *k* less ash (0.15 g/m²) was obtained in this month than in July (0.26 g/m²). These data are only apparently contradictory: in July temperature was rather high with low precipitation, and this probably affected the consistency of the forming fruit bodies of the meadow fungi such as *Marasmius oreades*. In September, on the other hand, this species was absent, and other more fleshy species dominated such as *Armillariella mellea*, and *Pholiotina togularis*.

A total of 22 species of pileate fungi were collected on both plots including 21 species of *Agaricales* and one of *Gasteromycetes* (Table 4). The most important role in the productivity of the fungi on the meadows was played by the species dominating as regards the number of fruit bodies and fresh and dry weight, such as *Armillariella mellea*, *Marasmius oreades*, *Agaricus campester* and *Galerina sideroides*.

The first species is found in forests in connection with the large quan-

Table 3

Productivity of fungi on plots *k* and *nk* in the particular months on the managed meadows in Kazuń

Months	Number of carpophores	Production					
		fresh weight		dry weight		ash	
		g/m²		g/m²		g/m²	
		k	nk	k	nk	k	nk
V	—	—	—	—	—	—	—
VI	26	0.08	—	0.04	—	< 0.01	—
VII	266	1.20	0.03	0.45	0.02	0.26	< 0.01
VIII	65	3.06	—	0.29	—	0.13	—
IX	205	4.93	0.42	0.55	0.05	0.15	< 0.01
X	40	0.03	< 0.01	0.02	< 0.01	< 0.01	< 0.01
XI	93	1.75	< 0.01	0.04	< 0.01	< 0.01	< 0.01
Total	695	11.05	0.45	1.39	0.07	0.54	< 0.01

k — mown plot; *nk* — unmown plot

tities of decomposing wood, the second one is typical for open spaces covered with grass. The presence of *Armillariella mellea* on the meadows is probably accidental, perhaps due to the remains of wood found at a depth of 10-20 cm the only time the fruit bodies were collected. *Marasmius oreades* is ecologically adapted to life on exposed strongly insolated areas. It is rather resistant to drying and has small fruit bodies of high vitality. Although it fructified profusely during the whole period of observation (327) fruit bodies, it gave less fresh matter than *Armillarella mellea*. *Marasmius oreades* proved to be most productive of all the fungi collected giving 46.57 per cent of dry matter, whereas *Armillariella mellea* gave only 35.62 per cent (Table 4).

The contribution of the next two species *Agaricus campester* and *Galerina sideroides* was much lower. The fresh and dry weight of the fruit bodies of the 18 other species did not exceed 1 g/m², therefore their productivity in the period May-November 1971 was negligible.

The dry weight of the bodies of the dominating species was largely decisive for the over-all productivity of fungi in the particular months (Fig. 1). On the *k* plot in June, July and August it consisted mainly of the fruit bodies of *Marasmius oreades* (0.03, 0.42 and 0.23 g/m², respectively). In August the productivity of this fungus was much higher than that of *Agaricus campester* which fruited at the same time (0.05 g/m²). The highest productivity on this plot was noted in September with the mass contribution of *Armillariella mellea* (0.45 g/m²). In the autumn months *Galerina sideroides* dominated on plot *k*, the productivity of

Table 4

Productivity of fungi on the managed meadows in Kazuń

Species	Number of carpophores	Fresh weight		Dry weight		Ash	
		g/m²	%	g/m²	%	g/m²	%
Armillariella mellea (Vahl. in Fl. Dan. ex Fr.) Karst.	80	2,23	37,00	0,23	35,62	0,05	18,52
Marasmius oreades (Bolt. ex Fr.) Fr.	327	1,30	22,57	0,34	46,57	0,15	55,55
Agaricus campester (L.) Fr.	9	1,02	17,70	0,05	6,87	0,01	3,70
Galerina sideroides (Fr.) Kühn.	131	0,89	1,56	0,04	5,47	0,01	3,70
Pholiotina togularis (Bull. ex Fr.) Fay.	61	0,17	1,21	0,05	6,87	0,01	3,70
Hypholoma subericaeum (Fr.) Kühn.	9	0,03	0,52	0,01	—	0,01	—
Psathyrella gyroflexa (Fr.)	11	0,03	0,52	0,01	—	0,01	—
Agrocybe semiorbicularis (Bull. ex Fr.) Fay.	22	0,03	0,52	0,01	—	0,01	—
Panaeolus sphinctrinus (Fr.) Quél.	2	0,02	0,34	0,01	—	0,01	—
Bovista pila Berk. et Curt.	1	0,02	0,34	0,01	—	0,01	—
Mycena avenacea (Fr.) Quél.	20	0,01	0,17	0,01	—	0,01	—
Stropharia albonitens (Fr.) Karst.	7	0,01	—	0,01	—	0,01	—
Psathyrella subnuda (Karst.) A. H. Smith.	1	0,01	—	0,01	—	0,01	—
Coprinus subimpatiens M. Lge. et A. H. Smith.	1	0,01	—	0,01	—	0,01	—
Hygrocybe citrina (Rea) Lge. (ss. Lge. vix Rea)	1	0,01	—	0,01	—	0,01	—
Mycena aetites (Fr.) Quél.	1	0,01	—	0,01	—	0,01	—
Pholiota conissans (Fr.) Mos.	1	0,01	—	0,01	—	0,01	—
Coprinus ephemerus (Bull. ex Fr.) Fr.	1	0,01	—	0,01	—	0,01	—
Conocybe tenera (Schaeff. ex Fr.) Kühn.	2	0,01	—	0,01	—	0,01	—
Mycena sanguinolenta (Alb. et Schw. ex Fr.) Kummer	1	0,01	—	0,01	—	0,01	—
Mycena stylobates (Pers. ex Fr.) Kummer	5	0,01	—	0,01	—	0,01	—
Lepiota setulosa Lge.	1	0,01	—	0,01	—	0,01	—
Total	695	5,76	100,00	0,73	100,00	0,27	100,00

Numbers in brackets indicate values smaller than 0.01.

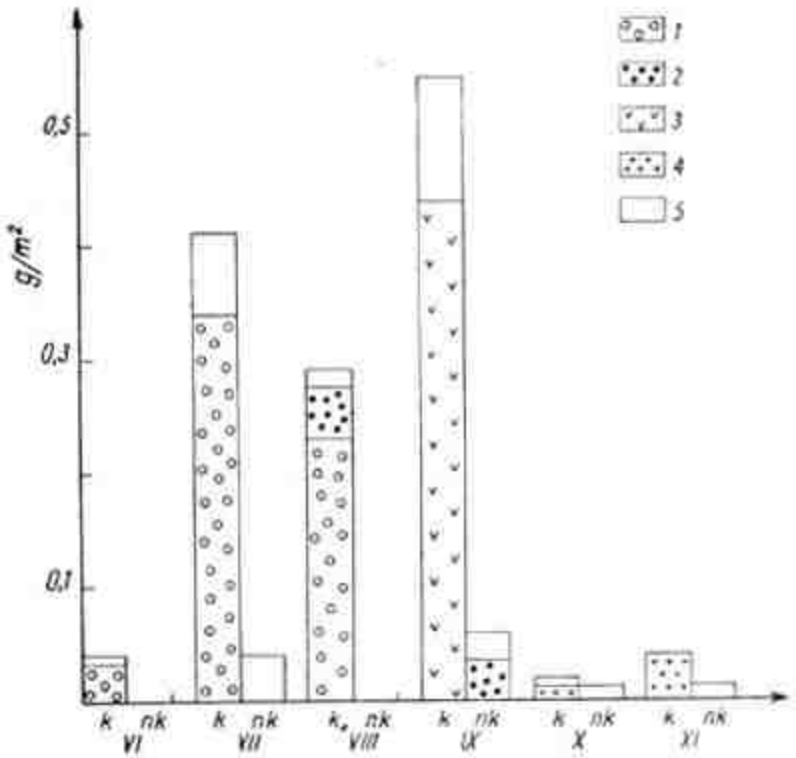

Fig. 1. Production of dry matter by the dominating species on both plots in the particular months of the vegetation period

1 — *Marasmius oreades*; 2 — *Agaricus campester*; 3 — *Armillariella mellea*; 4 — *Galerina sideroides*; 5 — Another fungi; *k* — mown plot; *nk* — unmown plot

this fungus in November corresponded almost to the over-all productivity of fungi in this month (Table 3). The highest productivity on the *nk* plot was recorded in September when *Agaricus campester* prevailed (0.3 g/m²).

Comparison of the two plots as regards the occurrence of various species of fungi showed that only two species were common to both plots: *Agaricus campester* and *Agrocybe semiorbicularis* (Table 5). The fungi had more fruit bodies on the *k* plot than on the nk where *Agaricus campester* dominated, also productivity was higher on plot *k*. From both species more dry matter and ash was obtained from the fruit bodies on plot *k* than on plot *nk* (Table 5). Fungi of these species can grow both in a mown and unmown grass habitat, their fruiting, however, was more profuse on the *k* plot than on the other.

This preliminary analysis of the productivity of fungi possessing mushroom-shaped sporophores on managed meadows gives only some orientational data on the relations prevailing in 1971 in the mycoflora. The established fact of profuse fruiting of the fungi on the mown plot may have various causes which cannot be explained at present. In the first place we do not know exactly the meadow mycoflora. Physiographic

Table 5

Species common to plots *k* and *nk* and their contribution to the productivity of fungi on the managed meadows in Kazuń

Species	Plot	Number of carpophores	Fresh weight g/m²	Dry weight g/m²	Ash g/m²
Agaricus campester	*k*	6	1.59	0.05	0.02
	nk	3	0.40	0.03	0.01
Agrocybe semiorbicularis	*k*	21	0.04	0.02	< 0.01
	nk	1	< 0.01	< 0.01	< 0.01

k — mown plot; *nk* — unmown plot

notes do not give much information on this subject. The year 1971 owing to the high air temperature and small amount of precipitation, was exceptionally disfavourable for the development of fungi with mushroom-shaped sporophores. Nevertheless on the mown plot more species and fruit bodies (yielding also a larger fresh and dry weight) were collected than on the unmown plot. It is obvious that mowing of the grass disturbs the growth of these plants and causes their tillering, on the other hand it favourably affects fruiting of the fungi. Moreover, it is not known which of the fungal species found is a symbiont of definite grass species on the meadows investigated. The chemical composition of the soil and its pH should also be taken into account, and the germination ability of the spores tested. In order to obtain at least fairly representative results, and to clear the doubts and obtain further information, the investigations should be repeated on various types of meadows.

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Wstępna analiza produktywności grzybów (*Agaricales* i *Gasteromycetes*) na łąkach w Kazuniu

Streszczenie

Do badań wytypowano powierzchnię podzieloną na dwa równoległe położone poletka po 50 m², koszone i niekoszone (*k*, *nk*). Owocniki zbierano co dwa tygodnie, ważono w stanie świeżym i suchym, spalano i wyprażano na popiół do stałej wagi. Z całej powierzchni zebrano 695 owocników, w tym 266 w lipcu (256 z nich reprezentował *Marasmius oreades*). Znacznie więcej ich znaleziono na poletku *k* (683) niż na poletku *nk* (12). Wykonano również obliczenie powierzchni kapeluszy, która wyniosła 0,53 m², z tego na poletko *k* przypadło 0,52 m². Największe pokrycie, a jednocześnie największą liczbę owocników stwierdzono tam w lipcu i we wrześniu. Drugie maksimum dla poletka *k* wystąpiło we wrześniu, lecz było ono niższe od lipcowego. W tym czasie stwierdzono największe pokrycie dla poletka *nk*.

Z całej powierzchni zebrano 576,17 g świeżej masy owocników, z której otrzymano 73,25 g masy suchej (0,73 g/m²). Produktywność grzybów na poletku *k* pod względem masy świeżej i suchej była większa niż na poletku *nk*. Popiół otrzymany z owocników z poletka *k* stanowił prawie połowę masy suchej, a z poletka *nk* — dziesiątą część. Produktywność grzybów na obu poletkach była największa we wrześniu, mimo to z poletka *k* w tym miesiącu uzyskano mniej popiołu niż w lipcu.

Największy udział w produktywności odegrały: *Armillariella mellea*, *Marasmius oreades*, *Agricus campester* i *Galerina sideroides*. Obecność opieńki była prawdopodobnie przypadkowe. Z zebranych w roku 1971 gatunków najbardziej produktywny (46,57% masy suchej) okazał się *Marasmius oreades*, chociaż dał mniejszą masę świeżą (22,57%).

Stwierdzono tylko dwa gatunki wspólne dla obu poletek: *Agaricus campester* i *Agrocybe semiorbicularis*. Na poletku *k* grzyby te występowały w większej liczbie owocników i odznaczały się wyższą produktywnością niż na poletku *nk*.

Uzyskane wyniki wykazały, że na poletku koszonym znaleziono więcej gatunków i owocników grzybów (o 671) i że produktywność była tam wyższa niż na poletku niekoszonym. Stwarza to konieczność powtórzenia obserwacji w latach następnych na różnych typach łąk.