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Research Article

EFFECT OF INCREASING DOSES OF MUSHROOM SUBSTRATE ON THE ROOT MASS OF SELECTED LAWN MIXTURES

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ABSTRACT
To fertilize both grassland and turf lawns waste materials, including the substrate after mushroom cultivation have been used recently. The aim of this study was to determine the effect of the mushrooms substrate to change the amount of root mass of five turf lawns with varying precipitation of perennial ryegrass. Field experiment was established in 2004 in the agricultural station of University of Natural Science and Humanities in Siedlce. In the research, the following factors were used: 1) dose of mushroom substrate, 2) the mixtures lawns with different species composition and participation of perennial ryegrass. Within two years of research the evaluation of the amount of root mass of turf lawns were done. This assessment was made after plants' vegetation in 2005 and 2006. The roots sampling of lawns were taken. After cleaning of the root and drying at 105^0C, the mass was determined by weighing. The largest mass of roots (average from the study years and substrate doses) was observed for the two-component mixture (M1) with 80% share of perennial ryegrass, and the smallest for five-component mixture (M5), where the share of perennial ryegrass was 40%. The average for research years of and mixtures type, indicates that most of the root mass formed the turf lawns with the largest mushroom substrate doses, but at least on the control object. The majority of the tested lawn mixtures, with the exception of mixture five (M5) produced a greater mass of roots in the second year (2006) than in the first (2005) year, despite worse weather conditions.

Keywords: lawn, dry matter of roots, mixtures, mushroom's refuse.

INTRODUCTION

In Poland, especially in the central eastern part of the country, mushroom cultivation is an important and rapidly growing sector of agricultural production. The production of this mushroom in recent years reached the level of 250–300 thousand tons, which gives Poland first place in Europe and third in the world [Szudyga 2011]. We hold the same position in terms of the production of waste mushroom substrate (1.250–1.500 thousand tons).

Mushroom production provides the raw material for the processing industry and participates in the recycling of other waste organic materials such as straw and poultry manure.

In accordance with the Decree of the Minister of the Environment from 27 September 2001 substrate after mushroom production is classified as a group of waste from agriculture, horticulture, aquaculture, forestry, hunting and food processing as "other wastes not specified" [Regulation ... 2001].

This waste generates problems for mushroom producers because mushroom hall usually operate in isolation from agricultural land and do not have the capacity for utilization of the waste on their own way [Rutkowska 2009].

The studies conducted showed that spent mushroom substrate (SMS) after mushroom cultivation is a good material for fertilization [Kalembasa, Wiśniewska, 2001, Kalembasa, Wiśniewska 2004, 2006, 2008, 2009]. According to Szudyga [2005, 2009, 2011], properly prepared SMS should not contain pests, pathogenic fungi and weed seeds. But should be a good consistency and tolerated soil smell, and any residues of chemicals used prophylactic ally before mushrooms harvest do not do any threat to the later, cultivated plants due to the short waiting period.

According to Jordan et al. [2008] mushroom substrate in 65% is an organic substance which, after introduce into the soil is converted into humus. The research carried out by Kalembasa and Wiśniewska [2001] showed that the mushroom waste contains on average 25 to 35% of dry matter, has a generally neutral reaction and narrow C: N ratio (13,8:1) very favourable in terms of fertilizer value.

Maszkiewicz [2010] reports that in the spent substrate mushroom macro elements content is (kg. T^{-1}) amounted: N – 8.0, phosphorus – 2.5, potassium – 9.7, magnesium – 2, 1, sulfur – 5.0, calcium – 22; Sodium – 0.8, and micronutrients (g. t^{-1}): manganese – 118, copper – 15, zinc – 86, boron – 12. Jordan et al. [2008] as well as Salomez et al. [2009] reported that in the spent substrate mushroom, a significant part of the overall macro elements, establish their absorbed forms. Physical-chemical properties and the absence of toxic substances make the cultivation of mushroom substrate useful waste and can be effectively used.

So far, studies have shown that mushroom substrate is increasingly used in agriculture to fertilize of arable land and permanent grasslands, in horticulture, and for the establishment and maintenance of green areas (Kalembasa, Wiśniewska 2004, 2006, Rak et al. 2001, Jankowski et al. 2004, Jankowski et al., 2012 a, b).

The aim of this study was to determine the effect of mushroom substrate on the amount of roots matter of turf lawns established from of the five lawn mixtures with different species composition.

MATERIALS AND METHODS

The field experiment was established in 2004 in the completely randomized design object Agricultural of University of Natural Sciences and Humanities in Siedlce (coordinates: 52.169 °N, 22.280 °E). The experiment was set up in a split-plot design with three replications on plots with the area of 3 m^2, with the following research factors:

- organic manuring with mushroom substrate in different doses: D_0-0, D_1-2, D_2-4, D_3-6 ($kg \cdot m^{-2}$);
- the lawn mixture (M1, M2, M3, M4 and M5), with a varying number of components and diverse participation of perennial ryegrass (respectively: 80, 60, 40, 20 and 40%) (Table 1).

The mushroom substrate used in the experiment contained 36.0% of dry matter and 40% of organic matter, 14.0 $g \cdot kg^{-1}$ of nitrogen, 2.0 $g \cdot kg^{-1}$, of phosphorus and 5.0 $g \cdot kg^{-1}$ of potassium in according to dry matter. At all experimental objects fast-acting fertilizer Pokon was used with a con-

Table 1. Species composition of some lawn mixtures

Mixture	Grass species	Quantity of species	Share in mixture [%]
M1	Perennial reygrass	2	80
	Red fescue		20
M2	Perennial reygrass	3	60
	Red fescue		30
	Tall fescue		10
M3	Perennial reygrass	3	40
	Red fescue		30
	Tall fescue		30
M4	Perennial reygrass	4	20
	Red fescue		55
	Sheep's fescue		15
	Kontucky bluegrass		10
M5	Perennial reygrass	5	40
	Red fescue		35
	Sheep's fescue		10
	Kentucky bluegrass		10
	Common bent		5

tent N-20%, P-5%, K-7%. The dose of mineral fertilizers was applied on the basis of nitrogen, using 120 kg · ha^{-1} of this component in two equal doses in early spring and summer.

The field experiment was conducted on the soil with a particle size of clay light sand classified as anthropogenic soils of hortisole type. Its pH in 0.01 M $CaCl_2$ was 6.8, the carbon content in organic compounds 13.45 g · kg^{-1} and 1.32 g · $kg^{-1}$of total nitrogen, and C: N ratio was 10.2. The content of available phosphorus was low (P - 39.6 mg · kg^{-1} of soil), and the average abundance of potassium (K – 114.0 mg · kg^{-1} of soil), while the available magnesium in the range of very high abundance (Mg – 114.0 mg · kg^{-1} of soil).

In 2005 and 2006 (after the vegetation period) from each experiment object the samples of turf with the root system with a depth of 10 cm was taken . The samples of root mass were purified from the remaining soil and then were dried at 105^0C to a constant weight and then the dry matter of roots samples were determined.

Meteorological data from the years 2004–2006 were obtained from the Hydrological and Meteorological Station in Siedlce.

In order to determine temporal and spatial variability of meteorological elements and to assess their impact on the course of plant growth hydrothermal coefficient (K) of Sielianinow was calculated [Bac et al. 1993] dividing the sum of monthly rainfall for one-tenth of total average daily temperature for the month (Table 2).

The results of root mass of tested grass mixtures were determine by multifactor analysis of variance with using of random model (synthesis from the years). For the significant sources of variation a detailed comparison of averages by Tukey's test at the level of $p \leq 0.05$ has made [Trętowski, Wojcik 1991].

RESULTS AND DISCUSSION

According to Harkot and Czarnecki [1999] root mass is a very important element of lawn grasses assessment and plays a very important role in the stabilization of turf areas. On the development of grass root mass can affect a variety of factors including fertilization.

The present study examined the amount of root mass from lawns which was significantly differentiated under the influence of mushroom substrate dose (Table 3).

Average from (years and doses of the mushroom substrate) the greatest mass of roots (219.9 g · m^{-2} D.M.) was observed for a quaternary mixture (M4) with 20% of perennial ryegrass, and the smallest root mass (208.5 g · m^{-2} D.M.) were obtained for the five-component mixture (M5), where the proportion of perennial ryegrass was 40%.

With increasing doses of mushroom substrate root matter of studded lawn grasses increased. The greatest root mass (245.2 g · m^{-2} D.M.) formed

Table 2. Hydrotermical Sielianinow indexes (K) in individual months of vegetation seasons in 2004–2006 (K < 0.5 high drought; 0.51 – 0.69 drought; 0.70 – 0.99 poor drought; K >1 no drought)

Year	Month						
	IV	V	VI	VII	VIII	IX	X
2004	1.58	2.29	0.96	0.99	1.20	0.44	1.05
2005	0.35	1.94	1.06	1.59	0.49	0.41	0.08
2006	1.18	0.97	0.46	0.24	4.21	0.45	0.74

Table 3. Roots dry matter depending on the kind of mixture and the dose of mushroom's refuse (mean from years 2005–2006)

Dose of mushroom substrate (A)	Kind of mixture (B)					Mean
	M_1	M_2	M_3	M_4	M_5	
D_0	201.5	194.3	200.4	198.3	192.8	197.4
D_1	205.7	201.3	208.3	206.3	212.9	206.9
D_2	224.3	224.3	217.0	230.0	213.9	221.9
D_3	227.9	238.4	227.6	245.2	214.6	230.7
Mean	214.8	214.5	213.3	219.9	208.5	
$LSD_{0,05}$ A = 15.7; B = n.s.						

quaternary compound (M4) with the lowest share of perennial ryegrass on the object fertilized with mushroom substrate at 6 kg · m^{-2} (D3), whereas the least (192.8 g · m^{-2} D.M.) pentavalent mixture (M5) on the control object, where the amount of perennial ryegrass was 40%.

The percentage of perennial in the tested ryegrass mixtures did not affect the amount of root mass produced by lawn grasses tested.

All lawn grass mixtures produced the greatest root mass on the object with the highest content of mushroom substrate (D^3 – 6 kg · m^{-2}, which is due to a large amount of nitrogen introduced together with the dose.

The size of root mass produced by each lawn mixtures, are confirmed in a study of Jankowski et al. [2011] with the using of the some lawn grass mixtures supplied with the hydrogel.

Within two study years there were no significant differences in root mass between the first and second year of research (Fig. 1a).

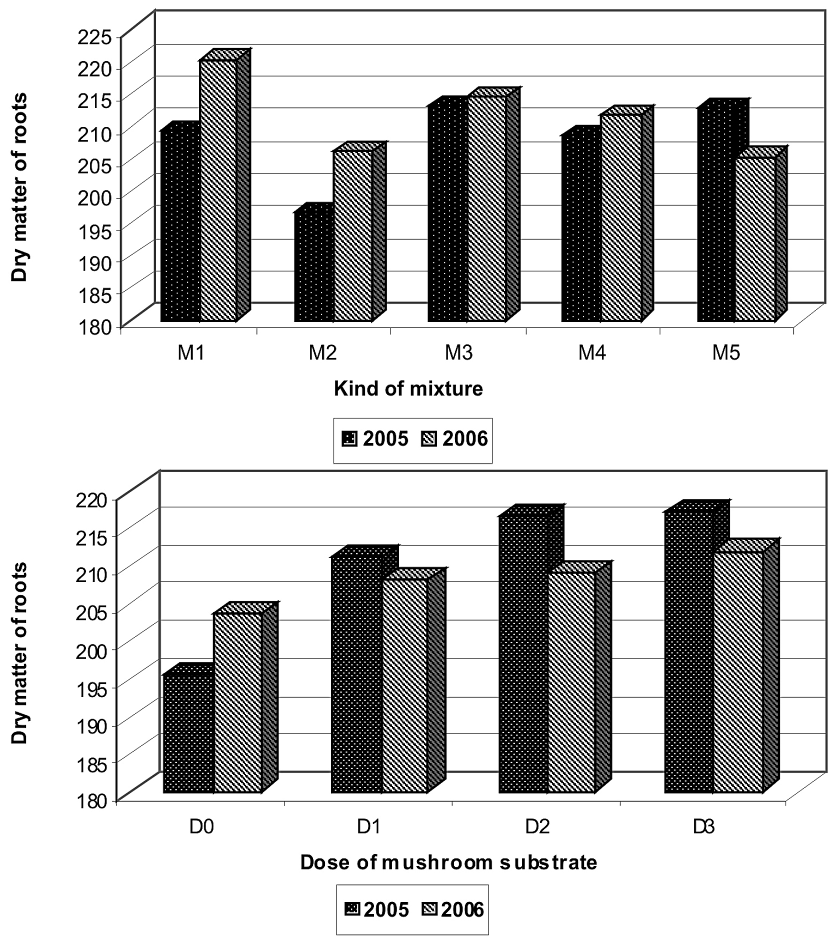
In the first study year (2005), the greatest mass root (average for dose) was recorded for the ternary mixture (M3) with perennial ryegrass in the amount of 40%, and the lowest also for the ternary mixture (M2), but with a larger share of perennial ryegrass (60 %). The greatest root mass in the second year (2006) was recorded for the two-component mixture with perennial ryegrass constituating 80% (M1), but the smallest one was for the component mixture (M5) with 40% share of ryegrass.

The majority of the tested mixtures lawn, except the five-component mixture (M5), produced greater root mass in the second than in the first study year despite worse weather conditions (table 2), because in five months (May, June, July, September, October) drought was recorded.

Böhm [1985] and Falkowski et al. [1994] suggested that the root system has a decisive impact on the plant survival under water deficit conditions. Roots played great role in the adaptation

a)

B)



A – study years A = n.s.
B – kind of mixture B = n.s.

A – study years A = n.s.
B – doses B = n.s.

Fig. 1. Roots dry matter of turf lawns in depends of kind of mixture (a) and doses of mushrooms substrate (b) in the study years.

of plants to changing habitat and weather conditions. It has connected with differing resistance to stress conditions which expose individual plants and the unequal ability to run and nutrient uptake from the soil.

According to Fiala [1997] drought periods activate the root system to the intensity of the development, especially in depth of the soil profile, which helps plants maintain the physiological condition.

Increasing doses of the mushroom substrate had a positive effect on root mass of the tested lawns, as evidenced by the tendency to increase the root mass with increasing dose of used waste, but this difference is not statistically significant (Fig. 1b).

Similar results for the root mass of turf lawn mixtures obtained in studies of Grabowski et al. [2008] with the fact that these lawns were fed with different doses of sewage sludge.

CONCLUSIONS

1. Roots mass of lawn grasses showed significant differences depending on the dose of mushroom substrate.
2. The highest roots mass (average from the years and doses) was observed for the four component mixture (M4) with 20% share of perennial ryegrass, but the smallest one was the five component mixture (M5), where the proportion of perennial ryegrass was 40%.
3. The average from the study years and the types of mixtures, indicate that the highest roots was mass produced by lawn turf grown on the highest doses of mushroom substrate and at least on the control object, where no fertilizers were used.
4. Most of the tested lawn mixtures, except of the five component mixture (M5), produced greater root mass in the second than in the first study year, which demonstrates the viability of the lawns maintaining in good shape, even in bad weather conditions.

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