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The effect of grassland utilisation on physicochemical properties of peat-muck soils and species composition of sward

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Abstract. The aim of these studies was to estimate the influence of utilisation or its lack on the changes of physicochemical properties of peat-muck soils as well as on the species composition of sward. Studies were carried out on the peatland complex located in the Pojezierze Łęczyńsko-Włodawskie (Lake District), in south-eastern Poland. This complex spreads over a wide area on both sides of the central segment of the Piwonia River. The fen was meliorated and cultivated from 1964–1966. At present, the soils of this grassland complex belong to the type of muck soils and the subtype of peat-muck soils (Mt II). Grasslands situated on the left side of the river were systematically utilised as pastures and meadows. Experiments investigating the persistency of grass-legumes swards were located in this part of the grassland and were carried out in 1995–2005. During the ten-year study controlled fertilisation (N - 40, P - 31 and K - 100 kg ha^{-1}) was employed. Pasture sward was grazed by Limousine cattle 4–5 times during the grazing season; meadows were cut three times. The meadows on the right side of the Piwonia River were mowed until 1995. Since that time, they have been used extensively (with only one or no cutting in the growing season). Important changes in the sward composition and its floristic diversity were confirmed, particularly on the meadow without utilisation. Furthermore, there were observed significant changes in physicochemical properties of peat-muck soils which were characterized by the significantly highest bulk density as well as the lowest content of organic matter in comparison to meadow and pasture utilisation. The swards of the used pasture and meadow were characterized by better species composition than the meadow without utilisation, where a high proportion of tufted hair-grass as well as herbs and weeds were noted.

Key words: peat-muck soil properties, species composition, manner of grassland utilisation

INTRODUCTION

Meadows and pastures occupy above 3 billion hectares of area of the world and make up over 60% of total agricultural land. Permanent grassland represents 40% of the total agricultural land utilised by the European Union and about 22% in Poland. Undoubtedly, such a large area of grass communities performs a significant role in the formation and diversification of the landscape, which creates living space for man. Human activity changes not only air, water or soil, but also influences natural biodiversity in ecosystems. The result is a permanent fall in the great number of fauna and flora species. Grass communities are an inseparable component of our landscape and are of crucial importance for living organisms. Permanent grasslands do not compete with field cultivations because they are usually situated in habitats with a high

level of ground water or on steep mountain slopes, as well as on soils with high organic matter content. Organic soils are characterized by an abundance of soil nitrogen, which is available for plants after the mineralisation of organic matter. In addition, they have a large field water capacity that increases soil volume in winter as a result of freezing, especially in the top stratum of soil. Because of that, organic soils need systematic rolling. Recently, many permanently unused grasslands have been studied. Most of them are located on organic soils, which should not be left uncontrolled. The aim of the study was to estimate the influence of utilisation or its lack on the changes of physicochemical properties of peat-muck soils as well as the species composition of sward.

MATERIALS AND METHODS

The studies were carried out on the peatland complex located in the Pojezierze Łęczyńsko-Włodawskie (Lake District), in south-eastern Poland. This fen was meliorated and cultivated in 1964–1966, when the Wieprz-Krzna Channel was built. After melioration, a grass-legumes mixture composed of the following were sown: *Festuca pratensis* 36%*, Festuca rubra* 17%*, Phleum pratense* 11%*, Poa pratensis* 9%*, Dactylis glomerata* 8%*, Agrostis gigantea* 3%*, Trifolium pratense* 8% and *Lotus corniculatus* 8%. At present, the soils of this grassland complex belong to the type of muck soils and the subtype of peat-muck soils (Mt II). This complex spreads over a wide area on both sides of the central area of the Piwonia River.

Grasslands on the right side of the river belong to private farmers; some are still utilised as once- or twice-cut meadows. Some sections have not been mowed for a long time. The meadow chosen for these studies has not been utilised since 1996. Grasslands on the left side of the Piwonia River belong to The Experimental Station of the Department of Grassland and Green Farming; they were systematically utilised as pastures and meadows. Pasture sward was grazed by Limousine cattle 4–5 times during the grazing season; meadows were cut three times.

The experiments investigating persistency of grass-legumes in swards were also located in this part of the grassland; studies were carried out in 1996–2005. Species composition of the sown pasture mixture was the following: *Lolium perenne* 35%*, Phleum pratense* 20%*, Dactylis glomerata* 10% and *Trifolium repens* 35%; the meadow mixture contained *Lolium perenne* 30%*, Festuca arundinacea* 10%, *Phleum pratense* 20%*, Dactylis glomerata* 10%, *Trifolium pratense* 20% and *Trifolium repens* 10%. During the ten years of the studies controlled fertilisation (N - 40, P - 31 and K - 100 kg ha^{-1}) was applied.

Species composition of the sward was determined by botanical-weight analyses in 1996–2005 (utilised grasslands) and in 2005 (meadow without utilisation). Physicochemical proprieties of soils were specified with the methods used in the Chemical-Agricultural Station in Lublin. Reactions were estimated for peat-muck soil, phosphorus, potassium and magnesium concentrations after extraction in 1 M HCl. In addition, the bulk density and content of organic matter were evaluated under two soil layers (5–10 cm and 15–20 cm) in 6 replications.

RESULTS AND DISCUSSION

The results of the studies indicate that the highest value of pH characterized the soil under pasture (5.21), while the lowest was in soil under the meadow without utilisation (4.55) (Fig. 1). Reaction of this last soil ranged between strongly acid and very strongly acid (Okruszko, 1991b). Independently of the manner of utilisation, the soils are characterized by very low potassium and magnesium content. A high content of phosphorus in the soil of the 3-cut meadow and average concentration of this element under pasture soil were also observed. It should be noted that there is a very high content of phosphorus in the soil of the unused meadow, probably caused by phosphorus release as a consequence of the rapidly progressing process of mineralisation (Warda et al., 1999).

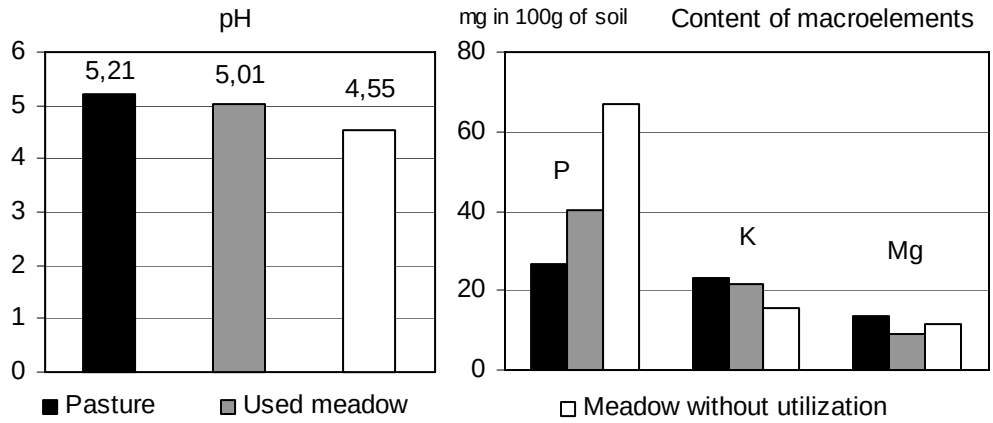

Fig. 1. Reaction of soil and content of macroelements depending on manner of utilisation.

An important feature of peat is the content of organic matter, which indicates advancement of the muck-forming process (Warda, 2004). The content of organic matter in the soil under the meadow without utilisation was significantly the lowest (50.52%) in comparison to the remaining components (Fig. 2). These studies did not prove significant differences between the soil under pasture and the 3-cut meadow. However, the higher content of some organic matter in the soil under pasture can indicate the influence of animals treading soil on the slower process of mineralisation. Grazing is one of the factors limiting the degradation of soil under postboggy habitat (Warda, 2004).

Moreover, the upper layer of the soil (5–10 cm) is characterized by the significantly lower content of organic matter (Fig. 2). Mineralisation of organic matter proceeds faster in the upper stratum of the soil (Okruszko, 1976; Szuniewicz, 1994).

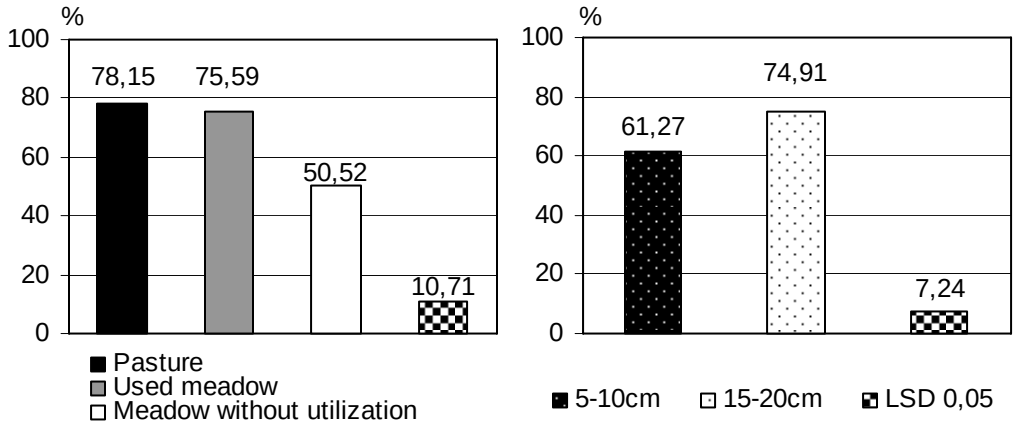

Fig. 2. Content of organic matter depending on manner of utilisation and the soil layer.

Bulk density was included among many physical properties of soil presented in this paper. Significantly, the soil under the meadow without utilisation had the highest bulk density (0.45 g cm^{-3}) in comparison to the pasture and 3-cut meadow. Values of used grasslands are characteristic for peat bulk density, while results for the unused meadow were almost twice as high (Fig. 3), indicating a rapidly progressing process of mineralisation. Obviously, the soil layer of 5–10 cm marked a significantly higher value of this feature (0.41 g cm^{-3}) than the deeper one (0.27 g cm^{-3}) (Fig. 3). The upper stratum of the soil is characterized by a higher bulk density, which is caused by a faster mineralisation process (Okruszko, 1976; Szuniewicz, 1994).

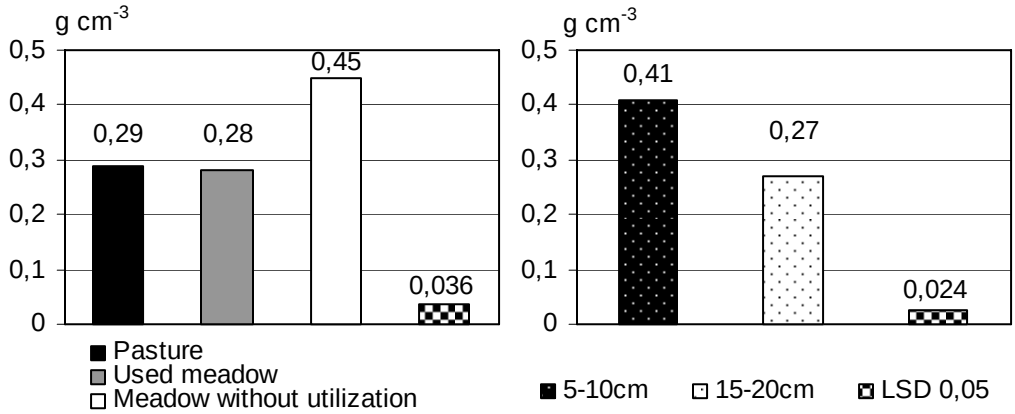

Fig. 3. Bulk density of soil depending on manner of utilisation and the soil layer.

Except for the physicochemical properties of peat-muck soils, the most important characteristic is the flora covering grasslands. The results of the studies indicate that the most persistent components of the pasture sward were *Lolium perenne* L. and *Trifolium repens* L. Persistency of these species is also confirmed by various researchers carrying out studies in the postboggy habitat (Warda, 1999; Baryła et al., 2004). They are typical pasture species with good nutritive value.

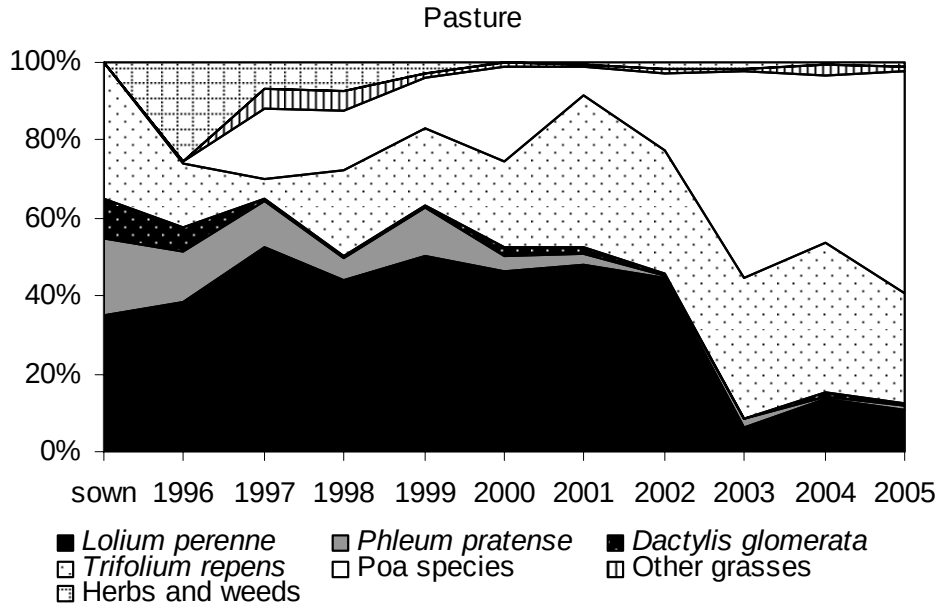

Fig. 4. Changes in species composition of pasture sward.

With the aging of the sward, grasses from *Poa* genus, especially *Poa trivialis* have appeared. In the last year of the studies, the pasture sward was characterized by a low proportion of valueless grasses as well as herbs and weeds (Fig. 4).

Lolium perenne L. and *Festuca arundinacea* Schreb. were the most persistent components of the meadow sward. Persistency of these species in the postboggy habitats is also confirmed by Baryła (2004); *Dactylis glomerata* L. had a lower share in the sward. In the next few years, grasses from *Poa* genus, especially *Poa pratensis* L. began to appear. Smooth-stalked meadow grass became a prevailing species in the sward under peat-muck soils after several years of utilisation.

Simplification of species composition of meadow sward is one of the reasons for the degradation of grass communities, especially in the postboggy habitats (Baryła, 2001). Moreover, the meadow sward was defined by a higher share of herbs and weeds in comparison to the pasture sward (Fig. 5).

Researches on the left side of the Piwonia River have been carried out since 1996; at the same time, meadow sward utilisation on the right river side was discontinued. Floristic studies on the meadow without utilisation were conducted only in 2005. Tufted hair-grass (*Deschampsia caespitosa*) characterized the highest share in this sward (38.3%). The lower share order in the sward consisted of the following: meadow foxtail (*Alopecurus pratensis*), yellow toadflax (*Linaria vulgaris*), quackgrass (*Agropyron repens*), red fescue (*Festuca rubra*), smooth-stalked meadow grass (*Poa pratensis*) and stinging nettle (*Urtica dioica*). *Linaria vulgaris* and *Urtica dioica* are the species often appearing after peatland cultivation (Okruszko, 1991a).

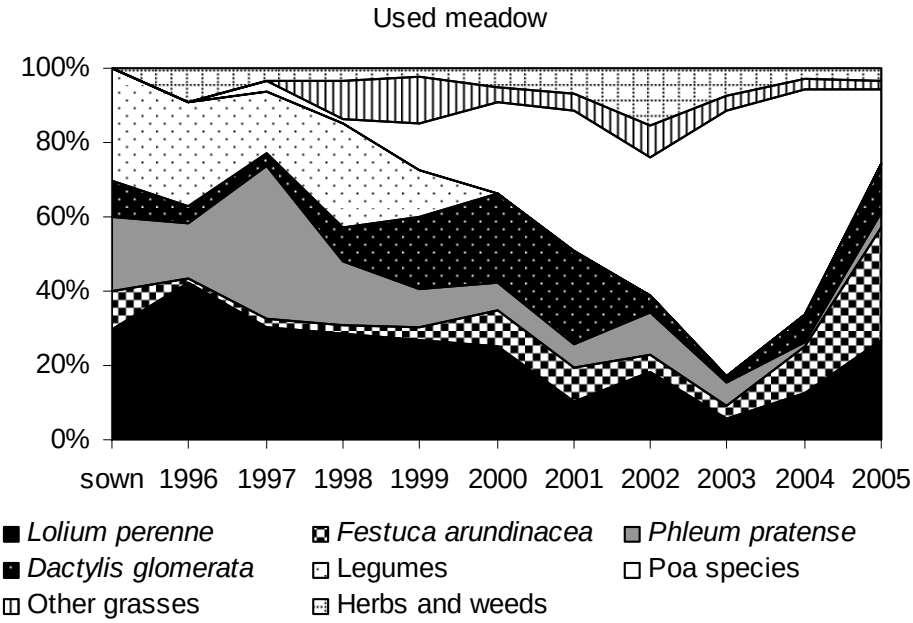

Fig. 5. Changes of species composition of used meadow sward.

The remaining species had an unimportant share in the sward (Fig. 6). The grass *Deschampsia caespitosa* is one of the dangerous weeds found in permanent grasslands. This species is characterized by rough and sharp blades and is highly resistant to cold and long periods of snow. It is mainly distributed on peat soils but is also widespread on clay soils. From an agricultural point of view, *Deschampsia caespitosa* is a valueless species. Therefore, a large proprotion of tufted hair-grass in the meadow sward indicates its degradation (Ilnicki, 2002).

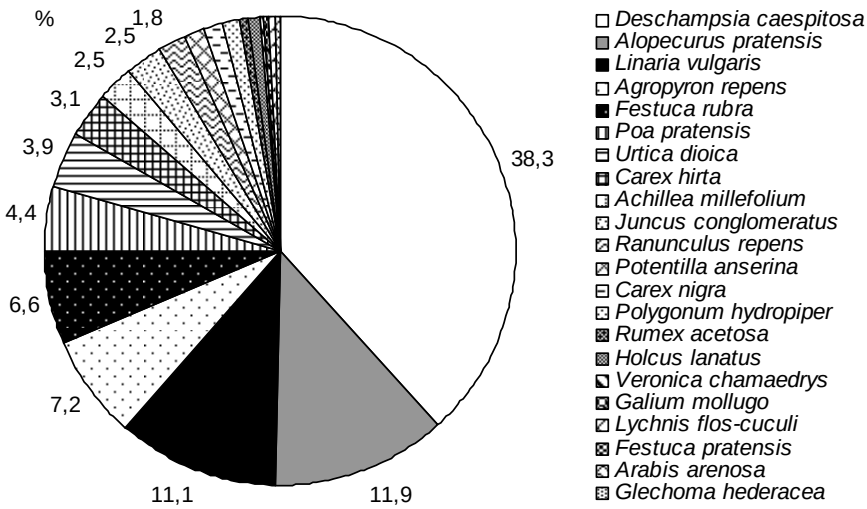

Fig. 6. Species composition of meadow sward without utilisation.

Systematically used perennial grasslands are characterized by a higher proportion of valuable grasses, e.g. from 69.4% for pasture utilisation to 94.3% for meadow use. However, a low share of these grasses (23.1%) was observed on the unused meadow. The opposite was true with valueless grasses. Sward of used grasslands marked an insignificant share of this plant group, while the amount of valueless grasses on the meadow without utilisation totalled 50.6%. Moreover, sward of this meadow is characterized by a high proportion of herbs and weeds (26.3%) (Fig. 7). The results concerning species composition of the sward indicate degradation of the meadow without utilisation.

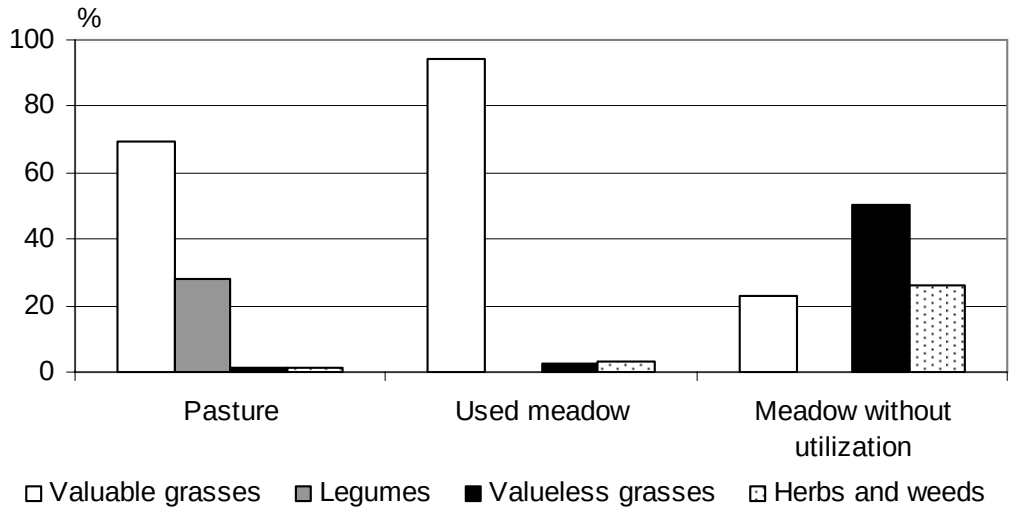

Fig. 7. Share of particular plant groups in the swards in the last year of studies.

The results of the studies indicate unfavourable changes in peat-muck soils that are not properly utilised.

There are significant consequences to human interference in the natural environment. Following dewatering and peatland cultivation, these areas should have proper control to avoid potential degradation. If rewetting or return to the natural conditions is impossible, we should do our best to protect it.

CONCLUSIONS

1. Grassland utilisation affected physicochemical soil properties and the floristic composition of plant communities.
2. The soil under the meadow without utilisation exhibited the lowest pH value as well as the high content of phosphorus.
3. The soil under the meadow without utilisation was characterized by the significantly highest bulk density and the lowest content of organic matter.
4. The soil of the 5–10 cm layer exhibited significantly higher bulk density as well as the lowest content of organic matter in comparison to soil from the deeper stratum.

5. Mineralisation of organic matter proceeds more rapidly on the soil under the meadow without utilisation as well as in upper layers of soil.
6. The swards of the used pasture and meadow were characterized by better species composition than the meadow without utilisation, where a high proportion of tufted hair-grass, herbs and weeds were noted.
7. Lack of utilisation of permanent grasslands leads to irreparable changes in organic soils, consequently, protection of peatland or its restoration to agricultural use is necessary.

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