ZESZYTY PROBLEMOWE POSTĘPÓW NAUK ROLNICZYCH 1994, z. 413, 119-122

RESPONSE OF MEADOW PLANTS TO PHYSICO-CHEMICAL CHANGES OF THE SOIL AS THE RESULT OF COMPACTION DURING HARVEST TECHNOLOGY

M. Grynia, A. Kryszak

Department of Grassland Management, University of Agriculture
Wojska Polskiego 38/42, 60-637 Poznań, Poland

A b s t r a c t. Studies were conducted in years 1986-92 in RZD Brody and state farm Sobota, Poznań voivodeship, as well as on meadows of Zielona Góra voivodeship. Three different harvest technologies were applied in the investigations. Floristic composition of the meadow sward was determined with the help of the Levy and Coc's method. Moreover, sward changes as well as turf and plant damages caused by the application of different harvest technologies were ascertained. A can auger of 397.93 cm' capacity was used to determine root weight. Chemical analysis of the sward and dominants was carried out with the aim of determining the content of basic macro- (N, P, K, Ca, Na, Mg) and micronutrients (Cu, Mn, Zn, Fe) as well as organic compounds (crude protein, water soluble sugars, crude fibre, carotene, crude ash). Site investigations comprised the soil, level of ground water, climatic factors as well as the number of meadow compactions by machines.

The studies revealed significant floristic differences in the result of physico-chemical changes of the soil caused by compaction during harvest technologies. Negative differences are bigger (100 %) on organic soils than on mineral soils (50 %), and floristic changes depend, to a large extent, on the increased number of technological operations causing a higher degree of compaction and reduced soil porosity and fertility.

K e y w o r d s: meadow plants, soil compaction, physico-chemical soil properties

INTRODUCTION

Because of cosiderable diversification of meadow sites in Poland plants' response to the applied harvest technologies vary greatly. The three technologies used in the experiments were found to have a direct and indirect influence on plants and site. The strongest compaction and physico-chemical changes of the soil were observed when traditional harvesting was applied, i.e., cutting the grass for hay and leaving it to dry in swaths [4]. Plants were also found to respond negatively to physico-chemical changes of the soil by diversification of the share of individual grass species in the meadow sward and the reduction of both yield and quality of the forage. The problem is becoming increasingly important now when improvements of harvesting technologies from different types of meadows are needed urgently.

In recent years studies on the response of plants to physico-chemical changes resulting from soil compaction caused by harvesting machines were carried out on muck, peat and black soils by Grynia *et al.* [4].

One of the main reasons why the above mentioned problems have received little attention in Poland is the fact that there are still not enough modern machines and equipment used for grass harvesting. However, there is a growing need to investigate both positive and negative effects of mechanization on the site and grass ecosystems. Such studies may provide guidelines for verification of machines used for harvesting and, consequently, lead to the reduction of yield losses and improve quality.

The objective of the study was to determine

the response of meadow flora to physico-chemical changes of the soil caused by compaction during harvesting technologies.

MATERIALS

Experminents were carried out in RZD Brody and state farm Sobota in Poznań voivodeship and on meadows belonging to Nowa Wieś in Zielona Góra voivodeship.

In RZD Brody, apart from the traditional method of drying hay in swaths, two other harvesting technologies were used, namely drying with cold air and harvesting for haylage. Both in Sobota and Nowa Wieś only the traditional method of harvesting was used.

The following doses of fertilizers were used: N-240, P_2O_5-108 and K_2O-60+60 kg/ha.

Studies on physico-chemical changes of the soil were carried out by the Department of Grassland Management [4] in collaboration with the Institute of Agriculture Mechanization (Kozicz and Błaszkiewicz, 1986-92). The experiments comprised studies on: degree of soil compaction, soil drilling and pitting, soil physical properties, climatic factors, determination of soil fertility, particularly content of such nutrients as P_2O_5, Mg, Cu, Zn, and Mo according to generally accepted methods.

Analyses of plant material employed the following methods: estimation method of Braun - Blanquet, botanico-gravimetric method, Levy and Coc's method.

The studies also determined the degree of the sward damage and plant infection with the pathogens typical for meadow plants (in collaboration with Dr. Kwaśna - Department of Phytopathology).

The present paper constitutes a fragment of a larger long-term study.

RESULTS

In RZD Brody the biggest meadow compaction (up to 50 % of the area) and most unfavourable physico-chemical soil changes were ascertained on plot I where the grass after cutting was dried in swaths. Moreover, a slight reduction in soil pH was also recorded. The following responses of meadow plants were observed:

- during the first years the share of *Dactylis glomerata* increased by about 30 % in comparison with the initial level; after 4 years of experiments its share reached 53.2 %, - the share of *Festuca pratensis* declined by 87 %,
- the share of herbs and weeds, including *Taraxacum officinale* and *Agropyron repens*, increased.

Unfavourable plant responses were not so conspicuous on plots II and III where, respectively, hay was dried with cold air or collected for haylage, because the number of mechanical operations was lower by 16-37 % and, consequently, the soil compaction was lower by 29-44 %. The meadow sward was dominated by such valuable grasses as *Dactylis glomerata, Poa pratensis, Phleum pratense, Festuca pratensis, Lolium perenne* while low value grasses such as *Bromus unioloides, Agropyron repens, Taraxacum officinale* and *Capsella bursa-pastoris* were rare.

Chemical analysis of the soil revealed considerable quantities of nitrogen (over 50 %), potassium (49 mg/100 g of soil), phosphorus (about 27 mg/100 g of soil), and magnesium (about 11 mg/100 g of soil). The soil pH ranged from 7.5 to 7.6 and, recently, it decreased slightly (7.2).

Geobotanical analyses in the state farm in Sobota revealed phytosociological diversification of meadows. Experiments comprised *Alopecuretum pratensis* and *Phalaridetum arundinaceae*. They occur on peat soils where ground water levels range from 40 to 60 cm.

Analysis of physical properties of the soil which was machine compacted during harvesting (hay dried in swaths) showed that the changes in its structure were by 100 % greater (mainly in its porosity) in comparison with soils from RZD Brody. In this variant, also the most severe damages of the meadow turf were recorded which, in some places on headlands, was completely stripped. Moreover, there were wide and deep wheel tracks from the tractor.

In *Alopecuretum pratensis* which occurs in almost optimal moisture conditions wide tractor wheel tracks are visible - they occupy

more than 60 % of the area of meadows. The share of *Alopecurus pratensis* and other valuable grass species declined. On the other hand, amounts of valuable grasses resistant to soil compaction, such as *Lolium perenne*, increased. Among less valuable grass species were: *Agropyron repens, Juncus effusus, Deschampsia caespitosa, Heleocharis palustris*. Empty areas increased from 6 to 18 %.

The reaction of the soil ranged from 7.1 to 6.8. Phosphorus concentration ranged from 96 to 136, potassium 87-128 mg/100 g of soil and magnesium 42-68 mg/100 g of soil. Concentrations of the examined microelements were as follows: copper - 6-8 mg kg^{-1}, zinc - 14-30 mg kg^{-1} and molybdenum - 7-8 mg kg^{-1}.

Despite considerable changes of the soil physical properties in this variant, plants negative response was found to be relatively small. This can be explained by the fact that during autumn singificant changes in the soil firmness occur and these meadows continue to yield well.

On meadows in Nowa Wieś *Alopecuretum pratensis* as well as *Deschampsietum caespitosae* and *Caricetum gracilis* developed on well decomposed, silted and poorly mineralized peats.

Meadows in this village were also considerably compacted by wheels of tractors and other machines. The predominant harvesting technology is drying hay in swaths. The area of meadow compaction is similar to plot I in RZD Brody and state farm Sobota. However, the soil compaction was deeper here. The depth of wheel tracks ranged from 8 to 33 cm. The damage of the turf usually ranged from 5-10 %, but along Niesulicki Canal its destruction reached 50 %.

Soil compaction caused by tractors and other machines was quite evident. This was accompanied by a drop in actual soil fertility as the applied doses of N, P, K (if any) are usually very low. The soil reaction ranged from 5.6 - 6.8. The actual productivity of these meadows was the lowest of all the examined meadows.

Studies carried out in the autumn revealed significant changes in the soil structure indicating the need to continue and even expand the scope of these investigations in future.

In the result of long-term application of traditional harvesting technologies, nearly 60 % of the meadows area is occupied by low value plant communities; they include sedge - 37 %, hairgrass - 7.4 %, swamp grasses from *Juncus effusus* - 3 % and other marshy grasses - about 4 %.

Economically valuable grasses occupy about 25 % of the area while medium-value grasses - 24.9 %.

The most extensive floristic changes were found to occur in areas deprived of turf - they are taken over by ruderal plants. However, generally speaking in meadow communities with *Alopecuretum pratensis* floristic changes are relatively smaller even when the traditional harvesting technology is used. Apparently, these changes depend on the sward floristic composition, turf density, humidity and soil structure.

DISCUSSION

The obtained results confirm reports from earlier studies conducted by Honczarenko [6], Denisiuk and Grynia [1], Grynia [3] and Grynia *et al.* [5]. All of these studies discuss the response of plants to changes occurring in the natural-agricultural environment [2], primarily to humidity and soil properties.

Generally speaking, the biggest floristic changes were observed on muck soils of RZD Brody when traditional harvesting technology was applied (hay dried in swaths). According to Kozicz [7], this is connected with the highest degree of soil compaction and changes of its physical properties. Experiments showed that these have a negative influence on the share of valuable meadow grasses leading to reductions of not only yields but also their quality. Limiting the number of technological operations carried out on meadows and, consequently, the degree of soil compaction is usually reflected in an improvement in floristic composition of meadows, by increased yields and enhanced sward density (technology II and III) as well by fewer empty areas. These observations are

in agreement with both domestic and foreign findings [7].

Relatively little is known about the response of meadow plants on organic soils to compaction during mechanical harvesting technologies. Some available data refer to compaction by a roller applied as a management treatment. These results stress a limited negative response of plants growing on peats. This may be due to higher elasticity of the upper layer of these soils in conditions of good moisture content and high soil fertility.

CONCLUSIONS

1. The strongest response of plants to soil compaction accompanied by unfavourable changes in physico-chemical properties of muck and black soils was observed in RZD Brody when traditional harvesting technology was applied. The response was smaller when the applied harvesting technology was either drying grass with cold air or haylage production, i.e., when the applied technology did not require so many technological operations.

2. The degree of soil compaction, i.e., changes in total porosity, is different for mineral and organic soils. Generally speaking, organic soils undergo stronger physical changes in the result of compaction than mineral soils. After the first cutting, the total porosity of organic soils was reduced by 11.75 %, and of mineral soils by 5.26 %.

3. On organic soils (peats) of the state farm Sobota and Nowa Wieś more serious damage of the turf and deeper uneven compactions resulting from a high ground water level was observed.

4. In the sward of *Phalaris* and *Alopecurus* meadows, no significant negative changes were observed except for those caused by stripping of the turf by tyres of tractors and other machines. Such areas are slowly taken over by ruderal and swamp plants.

Smaller negative changes of the sward of these meadows may be due to a good moisture content, high site fertility and deformation of the upper soil layer.

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REAKCJA ROŚLIN ŁĄKOWYCH NA ZMIANY FIZYKO-CHEMICZNE GLEBY W WYNIKU UGNIATANIA W CZASIE TECHNOLOGII ZBIORU

Badania wykonano w latach 1986-92 w woj. poznańskim w RZD Brody i PGR Sobota jak również na łąkach woj. zielonogórskiego. W badaniach stosowano 3 różne technologie zbioru. W runi łąkowej wykonano badania florystyczne metodą botaniczno-wagową, Levy'ego i Coc, zmian runi w wyniku różnych technologii zbioru, uszkodzeń darni i roślin, jak również określono masę korzeniową świdrem puszkowym o objętości 397.93 cm^3. Wykonano także badania chemiczne runi i dominantów na zawartość podstawowych makro- (N, P, K, Ca, Na, Mg) i mikroskładników (Cu, Mn, Zn, Fe) oraz związków organicznych (białko ogólne, cukry wodno-rozpuszczalne, włókno surowe, karoten, popiół surowy).

W badaniach siedliska uwzględniono glebę, poziom wody gruntowej, czynniki klimatyczne, a ponadto - wielokrotność ugniecenia łąki mechanizmami jezdnymi i określono właściwości fizyko-chemiczne gleby.

Badania wykazały duże różnice florystyczne w wyniku zmian fizyko-chemicznych gleby wywołanych ugniataniem w czasie technologii zbioru.

S ł o w a k l u c z o w e: rośliny łąkowe, zagęszczenie gleby, właściwości fizyko-chemiczne gleby.