Acta Agrophysica, 2000, 26, 7-15

PHENOMENON OF PEAT SOIL DEGRADATION IN THE LIGHT OF EXPERIMENTS

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A b s t r a c t. The trial of explanation of the phenomenon of peat soil degradation was undertaken on the basis of literature and experiments carried out in cooperation between Polish and Belarussian institutes.

K e y w o r d s: peat soils, degradation.

INTRODUCTION

The word "degradation" in the most general meaning denotes lowering of value. Hence, soil degradation is decrease in the soil production capacity. Difficulties arise when the reasons for the lowering of soil productivity are to be identified. If after application of some restorative treatments such as fertilization or irrigation, the reasons for degradation disappear, so we cannot talk about soil degradation. However, this term is justified when, despite of treatments applied to improve soil productivity, plant development and yield are worse than before the phenomenon referred to as soil degradation took place. This identification of terminology is necessary, hence the word "degradation" was understood and interpreted in various ways. In Polish literature [10] often peat soil degradation was as synonym for the process that took place in these soils after drainage and covered the whole range of phenomena that this process included. Drying of peat soils and changes in the flora related to them were also treated as degradation. Drainage peat soils on which poorly developed, weak communities of periodically drying out sod were also treated as degraded [12,17]. All these phenomena were disappearing after proper treatments, such as adjustment of moisture level and correct fertilisation, had been applied [13,14]. Hence, they do not indicate soil degradation, but can be treated as degradation of plant communities (meadows) since the change in the habitat conditions resulted in the formation of new complexes with different floristic composition that were adapted to these conditions. However, there is no return to the previous status, i.e., regeneration of these complexes.

In some cases regaining production capacity of peat soils by adjusting air-water conditions happens to be difficult due to the changes in the soil profile. Most often the changes resulting from the transformation of soil mass, consists in the generation of a layer of grainy loose moorsh with lowered water retention and water-rising properties of low efficiency. It causes limitation in supplying root zone with water from the deeper soil layers. In order to regain physical and water properties of these soils to the status typical for highly-yielding soils, it is necessary to apply agromelioration processes that transform constitution of the soil profile. It can be assumed that soil degradation took place in the sense of permanent worsening of structure of the soil profile. Only a change in this structure returns soil production capacity [16].

The phenomena presented above can be treated as more or less known in their cause and effect structure. They can be controlled and removed by proper melioration and agrotechnical practices. However, the phenomenon of failed emergencies on the peat soils still awaits explanation. Despite long-term, varied experiments and treatments it is still not known what the reason for this phenomenon is. There is a number of hypothesis that attempt to explain this phenomenon and suggest possibilities for controlling it, but they are not scientifically justified in a sufficient way.

Due to frequent appearance and difficulties that emergency failures cause in plant breeding, it is justified to call this phenomenon peat soil degradation. It is also worth serious scientific studies.

PHENOMENON OF FAILED PLANT EMERGENCE ON PEAT SOILS

Phenomenon of failed plant emergence on peat soils is well known in the agricultural practice and described in literature from the beginning of peat soils cultivation. In some cases it causes lack of sprouting and emergencies of the sown plants. It usually takes place in spring (May, June) less frequently in the second half of summer. It is usually related to surface soil drying and its strong warming up. In some cases high soil temperature causes damage to plant cells that are in contact with heated soil (the so-called ring burns). The problem is, that this phenomenon appears on some specific soils, or to be more accurate, on the soils with specific status of their organic mass. A characteristic feature of this mass is very difficult wetting, or in other words water binding. Hence, the term "irreversible soil drying" or more accurately, irreversible drying of soil colloids, was coined.

Soils showing a tendency towards irreversible drying have a specific structure of moorsh related to the character of their organic mass. Amorphic humus is predominant in this mass. It crumbles when drying, then disintegrates and falls into small grains. It should be taken into consideration that the process of turning soil mass into grains is not one-time only. It is gradual and repeated through many years of repetitive wetting (swelling) and drying (shrinking). With time, the so-called irreversible shrinking takes place. It is a permanent change in the volume of soil mass that means its condensation in grains. When this process develops, moorsh grains dry easier and quicker and it becomes more and more difficult to wet them.

Loss of emergencies can be observed on the moorshes with grainy, loose structure. It appears mainly when small seeds are sown such as: grass, rape, some vegetables (carrot, onion). It also appears when spring cereals are sown. What is characteristic of the process, is that the moorshes in which intensive humification of organic mass from after-harvest remains or green manure occurs, are less susceptible to emergency losses.

The phenomenon of emergency failures cause considerable losses in peat soil farming. It has be the subject of many different research works both on its essence and preventive measures. Attempts to counteract this process by some suitable treatments such as sprinkling, or deep ploughing, that brings to the surface soil mass resistant to this phenomenon, sanding of peat soils, liming (change of colour), and others. Research work on this phenomenon has also been carried out to understand its nature and find protective measures.

ASSUMED HYPOTHESIS ON THE REASONS OF FAILED PLANT EMERGENCIES

Studies on the recognition methods for peat soils susceptible to emergency losses were directed according to the hypothesis on the reasons for this phenomenon. There are two basic hypothesis on the reasons: the first one considers biological factors influencing plants, the second - physical factors.

The influence of biological factors on plant sprouting and development is considered to be a direct influence of microorganisms or chemical substances release by these organisms (the so-called theory of soil intoxication). Most of the attention in this respect was paid to the role of Actinomyces in the biological processes taking place in peat soils. In many research works predominance of Actinomyces was shown in the microbiological populations inhabiting peat moorshes, especially clearly transformed by this process, taking over a loose structure with poor sodding in the case of meadows. Due to the ability of Actinomyces to generate antibiotis, toxic substances in relation to other microorganisms, a hypothesis was formed on the soil environment of moorshed peats becoming toxic [11]. This hypothesis was backed up by the fact that very poor emergencies and loss of seedlings was observed on the peat soils that were previously covered by poor, degraded sod.

Comprehensive studies by the Bassalik's team [1-5] did not confirm this hypothesis, but showed relations between Actinomyces in moorsh and its trophicity. According to Fiuczek [6]. Actinomyces develop in moorsh in the conditions that are not suitable for other microorganisms, such as low moisture, periodically high temperature, no easily decomposing organic compounds. They are able to decompose humus and bituminous compounds that are not available for bacteria. Whereas in the conditions of high availability of easily decomposing organic compounds they give way to other microorganisms [20]. The above studies proved that the hypothesis of the intoxication of moorsh soils by Actinomyces should be rejected, especially since it was shown in some newer research works that generation of antibiotics by Actinomyces takes place in the extra-soil environment, and is very slight in the soil.

In order to check the hypothesis of the possible intoxication of moorsh soils, a cycle of experiments was carried out in the Experimental Station in Biebrza [9]. Emergencies and development of plants on various types of moorsh soils including also the soils on which plant decay was observed, was carried out in pot experiments. Results of these studies showed uneven emergencies and plant development on individual soils. It turned out, however, that in the conditions of very thorough control of soil moisture level, the plants sown reached a similar state of development and yield after a definite period of time, including also the soils qualified as potentially toxic on the basis of field observations.

The results obtained supported the second hypothesis and suggested that the reason for lost emergencies is shortage of water available for plants in the soils in the immediate vicinity of seeds or seedling roots. Confirmation of this hypothesis was obtained in a wide-range of experiments on monoliths and micro-plots on which emergencies and plant development was studied on various moorshes placed in the conditions that ensure equal level of ground water during emergencies and seed development [19]. Five types of soils that varied in the state of their moorsh mass, its structure and susceptibility to drying were chosen for this experiment; from moorshes originating of weakly decomposed moss peats (1), through the moorshes with the structure of humus soil (2-3), to grained (4), and coarse grained peats (5) originating from strongly decomposed oles or reed peats. The results of the above experiments showed:

- good emergencies and grass development on weakly transformed moorshes with peat or humus structure - Nos 1,2,3;

- poor emergencies or no emergencies on the moorshes with varied grain structure, and humus mass condensed in the grain, even if their structure is fine grained (powder-like) Nos 4, 5.

The experiment was repeated many times in different weather conditions with or without precipitation (micro-plots under roof), which enabled to formulate conclusions showing that:

- in the strongly transformed moorshes (degraded) drying of soil mass till the point of plant wilting during the periods of warm, dry weather, takes place in the surface soil layer in a few days' time and makes sprouting and development of seedling impossible;
- in the above moorshes soil moisture ensuring good emergencies is preserved in the second part of summer when the ground water level is raised to the contact point with moorsh layer (the depth of 30 cm);
- in the same weather conditions and at the same depth of ground water level at which plant emergencies are lost on the degraded moorshes, good emergencies and following plant development takes place on weakly transformed and humus moorshes that ensures full sodding of a newly founded meadow.

Data in Table 1 are an illustration of the above conclusions. These data characterise physical and water properties of the soil used for the experiment. These studies were confirmed by the results of experiments carried out in the period 1986-1989 and led to the conclusion that the decisive factor for successful or lost emergencies are not biological and chemical moorsh properties but the physical condition of its mass and character of soil moisture pattern in the layer with direct contact with the seed or plant roots.

FORECASTING POSSIBILITIES FOR PLANT EMERGENCIES ON THE BASIS OF CONDITION OF MOORSH MASS

Study results presented above allow us to assume the hypothesis that loss of emergencies is caused by the susceptibility of moorsh mass to quick drying. If we assume this hypothesis, the next question is on the character of transformation that make moorsh mass transform and change into a new quality with lowered water retention and susceptibility to drying as a characteristic feature. The next question is whether and how it is possible to determine the state of moorsh mass in order to forecast its susceptibility to drying, and hence forecasting danger for the emergencies of the plants sown. This question is of special significance if we consider the scope of losses caused by the failure of emergencies. Numerous research works in many different countries were undertaken. Literature on the subject of changes taking place in

Table 1. Differentiation of physical-water properties in moorshes at various stages of transformations

Type of moorsh	Full water capacity in % vol.	Wilting moisture in % vol.	Potential useful retention in % vol.	Soil moisture level in % volume in the conditions of plant sprouting at the depth of ground water level - 50 cm in the layer cm			
				5-10	15-20	25-30	35-40
Weakly transformed							
No. 1	84.4	19.4	45.6	55.0	51.7	72.9	82.1
2	84.5	21.4	41.8	53.2	60.2	65.8	84.9
good emergencies and development of seedling							
Strongly transformed							
No. 4	79.4	26.8	31.3	23.5	37.0	57.7	83.8
5	75.5	32.0	25.0	26.2	36.1	47.3	80.0
no emergencies							

the peat mass under the influence of drying manifested by the decrease of water capacity. Attempts to explain the nature of these changes have been undertaken.

Leaving the subject of results on the essence of changes for another review, we propose to concentrate on these studies that aimed at searching for the possibilities of recognising and determining the state of transformation of soil mass.

A comprehensive cycle of research in this respect was carried out in Holland under Hooghoudt's leadership [8]. The aim of these experiments was to find a method for the evaluation of the degree of soil susceptibility to the so-called "irreversible drying". Such soils which water binding abilities in the field conditions and after drying at 105 °C were identical. This state was reached by the peat soils in the field conditions when they were subjected to intense, repeated drying, that usually occur in intensely dried (degraded) habitats. The soils that were not transformed by the process of long-term drying, have a considerably higher adsorptivity in the natural (field) state than after drying of their mass to the absolutely dry state (in 105 °C). Basing on the assumption, the Hooghoudt's team worked out a methods for determining a degree of soil transformation toward the state of irreversible drying. This state is characterised by a 10-degree scale and illustrates soil differentiation in respect to water binding abilities assuming that the more peat mass is transformed due to drying and wetting, with an increase in the value of this index, the soil shows smaller difference in the ability to bind water in the natural (field) state as compared to the state after complete drying. It can be interpreted as a loss of water binding abilities due to the process that take place in the soil in natural conditions similar to those at which total drying of soil mass takes place in the temperature of

105 °C. It is assumed that total drying causes changes in the colloidal properties of the peat mass which result in a decrease of the soil abilities to bind water.

Basing on similar assumptions, Schmidt [18] tried to establish state of moorsh transformation on the basis of the amount of water bound at the suction power of 100 kP determined by edometer. He used an idea of unit water capacity of peat (Einheitswasserzahl), calculated on the basis of quotient of water mass in a saturated sample to the mass of dried soil. He gave these values in decimal numbers proposing division of moorshes into three groups characterised by respective values of the unit water capacity:

- weakly transformed 2.7 - 2.2.
- optimum transformed 2.2 - 1.8
- degraded 1.8 - 1.2

Gawlik [7] developed and modified the Hooghoudt's method for determination of the state of transformation of moorshes and assumed index of water adsorptivity (W_1) expressing the relation between water capacity of the sample that had been previously dried in the temperature of 105 °C (c) to water capacity of the sample in the natural state (a). Adsorptive abilities (water capacity) of moorshes was then determined by the centrifugal method with the rate of centrifugation equal to the acceleration of 1000 g. Differentiation in the water adsorptivity was calculated from the equation: $W_1 = c / a$ and is given as a decimal fraction. The value of 0.36 distinguishes non-transformed peat formations from the transformed or moorshed ones. Moorshes with the index of above 0.61 are strongly transformed, and above 0.80 - degraded.

Usefulness of the indices of moorsh transformations determined by the methods of Gawlik and Schmidt for forecasting phenomena of emergency losses, was tested in a field experiment on the micro-plots with eight different moorshes that were placed in identical conditions of soil moisture [15]. Emergencies and plant development was determined as a percentage of seedlings calculated in rows in which 200 seeds were placed on the 1 m of length. The results obtained (Table 2) did not give any basis to claim that the indices of the state of moorsh transformation allow for forecasting conditions for plant emergencies and development. According to the index of unit water capacity by Schmidt, all the studied moorshes were degraded and emergencies on these moorshes are strongly endangered. In the experiment, emergencies were very varied, from 10 to 60% of the seeds sown, without any visible correlation with the value of index. Similar conclusions can be drawn when comparing emergencies with the index of water adsorptivity by Gawlik. On the soils with similar values of this index (0.51-0.57) emergencies were from 10 to 60%.

Table 2. Relation between plant emergencies and index of moorsh transformation

Soil No.	Emergencies in % of seeds sown	Index according to		Useful retention in % of volume	
		Schmidt	Gawlik	potenatial	effective
1	10	1.09	0.51	25.0	8.0
2	25	1.34	0.64	33.0	15.5
3	30	1.03	0.63	43.0	13.0
4	32	1.23	0.57	26.0	10.5
5	40	1.46	0.46	23.0	8.5
6	46	1.41	0.55	52.0	22.0
7	48	1.36	0.54	43.5	13.5
8	60	0.81	0.57	30.5	10.5

This preliminary study on the possibility of forecasting dangers for emergencies by studying the condition of moorsh mass in respect of its water adsorptivity lead to the conclusion that this phenomenon is very complex and cannot be characterised only by the differences in the water binding abilities of moorsh mass. It requires detailed studies that would penetrate deeply into the very essence of the processes that take place in the organic mass of these soils under the influence of drying. Hence, an initiative to organise co-operation in working on this subject basing on the specialists from Belarussia where this phenomenon is also present and causes considerable economic damage. The basis for this co-operation are the samples of moorshes in different stages of transformations subjected to various experiments in co-operating research centres. Analysis of results of these studies were the aim of bilateral seminars.

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