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REGULATION OF WATER RELATIONS AS A FACTOR IN THE SUSTAINED DEVELOPMENT OF PEAT ECOSYSTEMS UNDER LAND RECLAMATION

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Summary. The present study determines the optimum water levels ensuring humidity levels pF 1.7 in the 2nd cut, pF 1.9 in the 1st cut, and pF at 2.1 in the 3rd cut for soils representing peat ecosystems ('MtIba' weak), ('Mt IIbb' medium) and ('MtIIcc' strong) transformed during the most intense dry periods and the highest evaporation levels. They protect the soil efficiently against unfavourable transformations after dehydration and maximise yields without excessive water usage in relation to evapotranspiration. They can be used for the control of moisture in these ecosystems in order to secure their sustained development.

Key words: sustained development, evapotranspiration, optimum water level

INTRODUCTION

Water relations in the root layer of the soil profile are an important factor determining yields and peat soil protection against the mineralisation of the organic mass. The results of lysimetric studies carried out on medium transformed peat-muck soil Mt IIbb proved [Szajda 1997, 2000, Szajda and Olszta 2002] that the factor of sustained development of the reclaimed peat ecosystems is the optimum depth of the water level ensuring a moisture level representing pF 1.7 in the 2nd, pF 1.9 in the 1st, and pF 2.1 in the 3rd cut efficiently protecting the soil against unfavourable transformations after dehydration and causing yield maximisation without excessive water usage. The optimum depth of the ground water level differs in relation to soil types and evaporation values [Viesser 1963, Feddes 1971, Olszta 1980, 1981, Brandyk 1990].

The optimum water levels ensuring moisture levels, depending on evapotranspiration equal to pF 1.7 in the 2nd, pF 1.9 in the 1st, and pF 2.1 in the 3rd cut during periods of intense drought and the highest water usage for evapo-transpiration were determined for peat-muck soils MtIba, Mt IIbb and Mt IIcc representing peat ecosystem weakly (soil MtIba), medium (soil Mt IIbb) or strongly (soil MtIIcc) transformed. The above levels can be used for the control of moisture in these ecosystems in order to ensure their sustained development.

STUDY SITE, MATERIAL AND METHODS

The basis for the present research were the results of analyses of the pF curves, measurements of the dynamics of ground water depth and moisture content in the profiles of the following soils: Mt Iba, Mt IIcc carried out in the period 1976-1981 together with lysimetric measurements of the maximum evapo-transpiration in Sosnowica, the actual evapotranspiration and Mt IIbb soil suction pressure in the period 1974-1994 [Szajda 1980, 1997].

Recognition of the soil and its characteristics was made according to Okruszko [1988]. The physical properties of the soil were determined using the generally accepted methods of the Institute of Land Reclamation and Grass Farming (IMUZ), whereas the water properties were determined by means of the pF curve method according to Zawadzki [1973]. The methodology and results of studies on the dynamics of ground water depth as well as maximum and actual evapotranspiration have been given elsewhere [Szajda 1980, 1997, Szajda and Olszta 2002, Szajda *et al.* 2003].

The basis for the selection of the empirical material collected were the values of the element of the water balance of the soil studied over individual decades. This was the basis for further analysis of decades without precipitation during which there was no ground runoff and moisture usage for evapo-transpiration was completely covered by the capillary rise from the saturated zone. In this manner, conditions for the sustained balance of soil water were taken into consideration [Kowalik and Zaradny 1978].

RESULTS AND DISCUSSION

The relation between the pF levels of the soils studied in the root zone and ground water levels at various evapotranspiration volumes

The relation between the pF level in the root zone of the soils studied and the ground water depth at various evapotranspiration volumes, determined over decades without precipitation (in which there was no surface run-off), and moisture usage for evapotranspiration was balanced by the capillary rise [Szajda and Olszta 2002, Szajda *et al.* 2003], has been presented in Figure 1. This proves that the values of the capillary rise ensuring preservation of the moisture level in the root zone of soil Mt Iba (Fig. 1a) equal to pF of 1.7 in the case of ET = 1.7 mm $\cdot$ d^{-1} was 47 cm; in the case of ET = 3.4 mm $\cdot$ d^{-1} – 36 cm; and ET = 5.2 mm $\cdot$ d^{-1}- 29 cm. The height of the capillary rise ensuring preservation of moisture in the root zone of soil Mt IIbb (Fig. 1b) equal to pF of 1.7 was 38 cm in the case of ET = 1.9 mm$\cdot d^{-1}$; 34 cm in the case of ET = 4.0 mm $\cdot$ d^{-1}; and 30 cm at ET = 5.5 mm $\cdot$ d^{-1}. The height of the capillary rise ensuring moisture level in the root zone of soil Mt IIcc (Fig. 1c) equal to pF of 1.7 in the case of ET = 1.9 mm $\cdot$ d^{-1} was 51 cm; 43 cm in the case of ET = 3.2 mm $\cdot$ d^{-1} ; and 36 cm at ET = 6.8 mm $\cdot$ d^{-1}, whereas the volume of the capillary rise ensuring preservation of moisture in the root zone of the soils studied equal to pF of 2.1 was, respectively: 130, 79, 54 cm for soil Mt Iba: 85, 74, 65 cm for soil Mt IIbb and 78, 62, 51 cm for soil Mt IIcc. Hence, it can be concluded that the moisture level of the root zone is a function of ground water depth, water usage for evapo-transpiration and soil type, which confirms the results obtained in model studies [Viesser 1963, Feddes 1971, Olszta 1980, 1981, Brandyk 1990] and field studies [Szajda and Olszta 2002]. The use of ground water surface depth as an indicator of the condition of soil moisture during periods of drought is very general and can be related to the depth at which the capillary rise from the ground water level completely compensates water usage for evapotranspiration. However, from the practical point of view, the physical measurement of this depth is easy and simple.

The relation between the optimum ground water level of the soils studied and evapotranspiration

The basis for the estimation of the optimum ground water level ensuring moisture level equal to pF 1.7 in the 2nd, pF 1.9 in the 1st, and pF 2.1 in the 3rd cut, which effectively protects the soil against unfavourable transformations following dehydration and maximalising yields without excessive water consumption as related to evapotranspira-

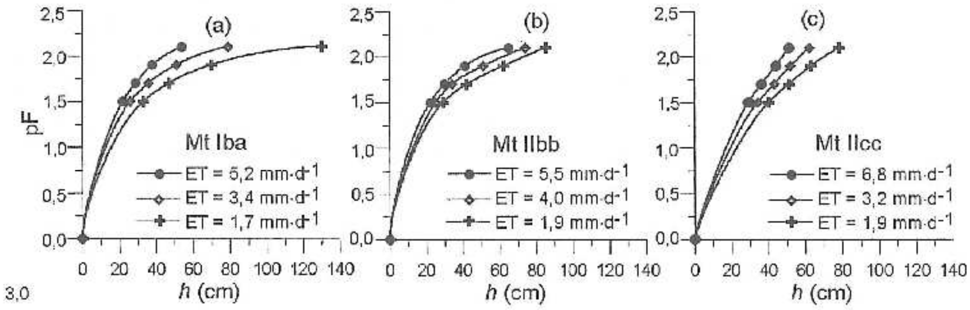

Fig. 1. Dependence of suction head (pF) of Mt Iba (a), Mt IIbb (b), Mt IIcc (c) soil in root layer from groundwater level (h) with various real evapotranspiration ET

Rys. 1. Zależność pF warstwy korzeniowej gleb Mt Iba (a), Mt IIbb (b), Mt IIcc (c) od poziomu wody gruntowej h (cm) przy różnej wielkości ewapotranspiracji rzeczywistej ET (mm · d^{-1})

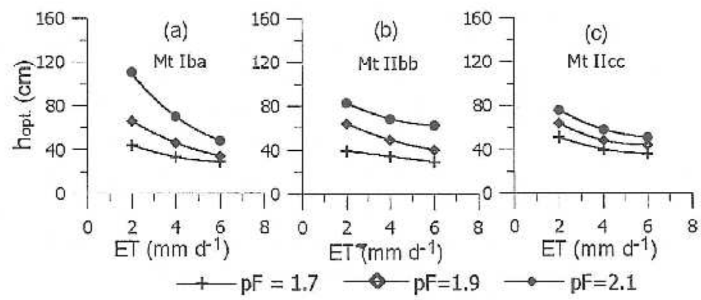

Fig. 2. Dependence of optimal groundwater level ($h_{opt.}$) of soil in the first (pF = 1.9), the second (pF = 1.7) and the third (pF = 2.1) harvesting, from real evepotranspiration (ET)

Rys. 2. Zależność optymalnego poziomu wody gruntowej $h_{opt.}$ (cm) od ewapotranspiracji rzeczywistej; ET (mm · d^{-1}) dla gleb Mt Iba (a), Mt IIbb (b), Mt IIcc (c) przy wilgotności warstwy korzeniowej odpowiadającej pF 1,7 w drugim, pF 1,9 w pierwszym i pF 2,1 w trzecim pokosie tion volumes, are the relations presented in Figure 1. The optimum depths of such levels for the soils studied are presented in Figure 2. These show that the optimum water level depth ensuring moisture in the root zone (0-30 cm) representing pF 1.7 in the 2nd, pF 1.9 in the 1st and pF 2.1 in the 3rd cut differs with respect to evapotranspiration and soil type. At average evapotranspiration of 2 mm·d^{1}, the ground water surface depth ensuring moisture level in the root zone of pF = 1.7, pF = 1.9 and pF = 2.1, was, respectively: 44, 66, 110 cm for soil Mt Iba (Fig. 2a); 39, 64, 83 cm for soil Mt IIbb (Fig. 2b); 51, 64, 76 cm for soil Mt IIcc (Fig. 2c), below the terrain's surface. At average evapotranspiration of 6 mm·d^{1}, the ground water depth ensuring the above moisture levels in the root zone were, respectively: 29, 34, 48 cm for soil Mt Iba; 29, 40, 62 cm for soil Mt IIbb; 36, 44, 51 cm for soil Mt IIcc. The optimum ground water level differs therefore with respect to the soil type and evapotranspiration volume, which confirmed the results obtained in model studies [Olszta 1980, 1981, Brandyk 1990].

CONCLUSIONS

On the basis of the studies carried out on the reclaimed peat-muck soils representing peat ecosystems weakly (soil MtIba), medium (soil Mt IIbb) or strongly (soil MtIIcc) transformed, and used as highly fertilised meadows, it has been found that the optimum ground water level ensuring humidity at pF equal to 1.7 in the 2nd cut, pF equal to 1,9 in the 1st cut and pF 2,1 in the 3rd cut, which effectively protects the soil against unfavourable transformations following dehydration and ensures maximum yields without excessive water consumption.

1. At the average level of evapotranspiration of 2 mm · d^{1} and these levels were, respectively: 44, 66, 100 cm on soil Mt Iba; 39, 64, 83 cm on soil Mt IIbb; 51, 64, 76 cm on soil Mt IIcc, below the terrain's surface. At the average evapo-transpiration level of 6 mm·d^{1}, the ground water surface depth ensuring moisture level of the root zone given above was, respectively: 29, 34, 48 cm for soil Mt Iba; 29, 40, 62 cm for soil Mt IIbb; 36, 44, 51 cm for soil Mt IIcc.

2. The relations presented in this study can be used to control hydration in dehydrated peat ecosystems which are weakly or strongly transformed in order to ensure conditions for their sustained development.

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REGULACJA STOSUNKÓW WODNYCH JAKO CZYNNIK ZRÓWNOWAŻONEGO ROZWOJU ZMELIOROWANYCH EKOSYSTEMÓW TORFOWISKOWYCH

Streszczenie. Na podstawie badań przeprowadzonych na zmeliorowanych glebach torfowo-murszowych, reprezentujących ekosystemy torfowiskowe słabo (gleba Mt Iba), średnio (gleba Mt IIbb) i silnie (gleba Mt IIcc) przeobrażone, użytkowane jako łąki wysoko nawożone, stwierdzono, że optymalny poziom wody gruntowej, zapewniający wilgotność odpowiadającą pF 1,7 w drugim, pF 1,9 w pierwszym, pF 2,1 w trzecim pokosie, skutecznie chroniącą gleby przed niekorzystnymi przemianami po odwodnieniu, oraz powodującą uzyskanie maksymalnych plonów bez luksusowego zużycia wody, różnicuje się w zależności od rodzaju gleby i wielkości ewapotranspiracji. Poziom ten przy średniej ewapotranspiracji 2 mm · d[1] wynosi odpowiednio: 44, 66, 100 cm na glebie Mt Iba; 39, 64, 83 cm na glebie Mt IIbb; 51, 64, 76 cm na glebie Mt IIcc, poniżej powierzchni terenu. Przy średniej ewapotranspiracji 6 mm · d[1], głębokość zwierciadła wody gruntowej zapewniająca w warstwie korzeniowej podaną wyżej wilgotność wynosi odpowiednio: 29, 34, 48 cm na glebie Mt Iba; 29, 40, 62 cm na glebie Mt IIbb; 36, 44, 51 cm na glebie Mt IIcc. Głębokość ta maleje, gdy wzrasta wilgotność (maleje pF) oraz wielkość ewapotranspiracji.
Przedstawione w pracy zależności mogą być wykorzystane do sterowania nawadnianiem odwodnionych ekosystemów torfowiskowych słabo i silnie przeobrażonych w celu zapewnienia warunków zrównoważonego rozwoju.

Słowa kluczowe: zrównoważony rozwój, ewapotranspiracja, optymalny poziom wody