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INFLUENCE OF THE GROUND WATER TABLE ON THE GROWTH AND HARVESTING OF GRASS

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S y n o p s i s. The aim to this paper was to estimate the influence of suction force or the level of the ground water table on the growth and distribution of roots and on yielding of grass.

It was noticed that suction force influences the growth of root mass which in turn determines yielding of grass.

The results of the crops of dry mass of hay as dependent on the depth of the ground water table show that high moisture and high level of the ground water table in early spring may in some cases limit spring and autumn crop yield.

1. INTRODUCTION

The growth and root system distribution in soil draws attention of many researches [2] because it plays an improtant role in water and nutrient uptake and their storing. It is known that in wet soils a plant shortens its root system and in dry soils the roots grow deeper [1]. Similarly, the crops of grassland decrease at the low and high ground water tables [7].

The aim of this study is to estimate the influence of suction force and the ground water table on the growth and distribution of roots and on harvesting of grassland.

2. SUBJECT AND METHODS

Among the factors determining proper growth of plants the distribution and growth of root system together with the value of evapotranspiration play an important role. The distribution of roots in the profile is accepted as an indicator of moisture uptake and the amount of active roots is a basis for establishing water amount which may be absorbed by root system. Those parameters are necessary for establishing the movement of water in the unsaturated zone of the profile, that is for calculating the value of moisture function in a given point of the profile [5].

The measurement of transpiration is carried out in lysimeters. Observation of the growth and root distribution of grass in the soil profile were carried out in the experimental station in Sosnowica. The dynamics of suction pressure was measured both in lysimeters and on the plots of the experimental station in Sosnowica.

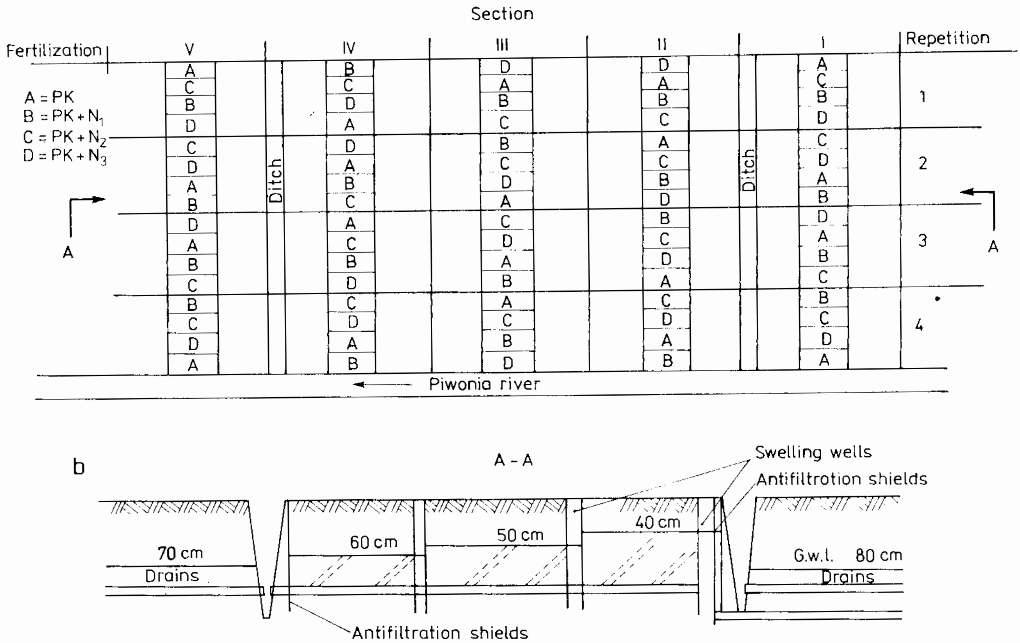

Fig. 1. Scheme of the experimental station in Sosnowica
a - plan, b - longitudinal section A-A

Fig. 1. Schéma d'une parcelle experimentele à Sosnowica
a - plan, b - section longitudinale A-A

The studies have been conducted in lysimeters of the diameter 60 cm and on 5 sections of the experimental station (Fig. 1). In the lysimeters completely covered with grass the measurement of transpiration and suction force at various depths of the ground water table was carried out. The range of studies carried in the experimental station comprised the measurement of: ground water table, growth and distribution of grass roots in 50 cm soil profile. The rainfall was also measured.

The level of ground water table approached: 50, 60, 70, 80 and 90 cm below the surface. The measurement of suction force of the soil was carried with the use of tensiometers installed at the depths 5-10, 10-15, 15-20, 25-30 and 45-50 cm. The suction pressure changed with the change of the ground water level.

In order to follow the growth of grass roots every 10 days soil monolithes of the surface 10x20 cm from the depth of 50 cm and from each plot were collected. The monolith of the section 10x20 cm was cut into 5 cm layers. The roots were washed with the stream of water and after drying their dry matter was measured for each 5 cm layer of the profile. The measurement of transpiration was carried in lysimeters of the area of 2800 cm^2 filled with the soil natural structure. The level of the ground water table maintained at the same depth (50, 60, 70, 80 and 90 cm) was regulated by means of adding or pouring of (after rainfall) water from lysimeters. The loss and gain of water retention was estimated by means of weighing the pots every 10 days. The amount of transpiration E (in mm/day) in each decade was measured according to the following formula:

$$E = P + q - O + R,$$

where:

P - rainfall,

q - the amount of added water,

O - the amount of poured off water,

$R = Z_p - Z_n$ - the decrease or increase of water retention measured by means of weighing the lysimeters,

Z_p, Z_n - the initial and final weight of lysimeters.

On the lysimeter station the measurement of rainfall was carried by means of rain gauge which was used to estimate the transpiration E. Field experiments comprised also measurement of dry mass of grass for three swaths.

3. DISCUSSION OF THE RESULTS

The experiments were carried in vegetation period in 1977. The level of the ground water table depended on rainfalls. The change of the ground water table was followed by the change of suction pressure of the ground water. The deeper the ground water table was, the greater the fluctuation was. The greatest changes of suction pressure were observed in section I, the smallest in section II (Fig. 1).

The greatest fluctuation of pressure appeared in the layer 5-10 cm where the main bulk of roots was concentrated. The measurement of root mass in 50 cm soil profile was carried on 5 plots of experimental section. In Figure 2 the distribution of root mass in the profiles of sections I-V as averaged for the vegetational period is presented. In Figure 3 and 4 the distribution of roots (at the extre-

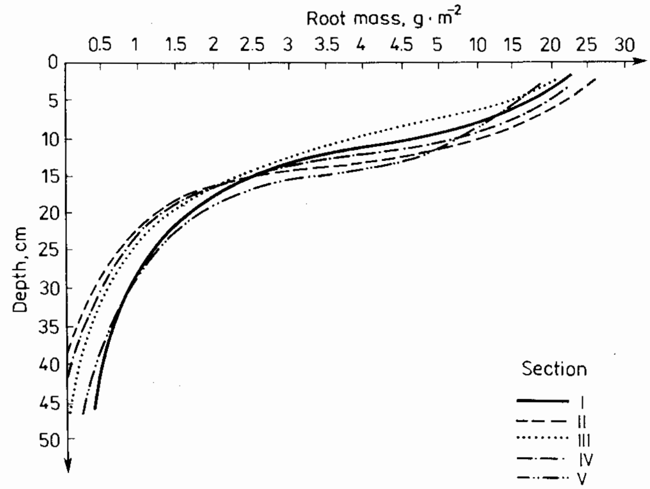

Fig. 2. Mean distribution of the root ($g \cdot m^{-2}$) in the profile in vegetational period for sections I-V

Fig. 2. Distribution moyenne des racines ($g \cdot m^{-2}$) dans le profil pendant la période végétation pour les parties I-V

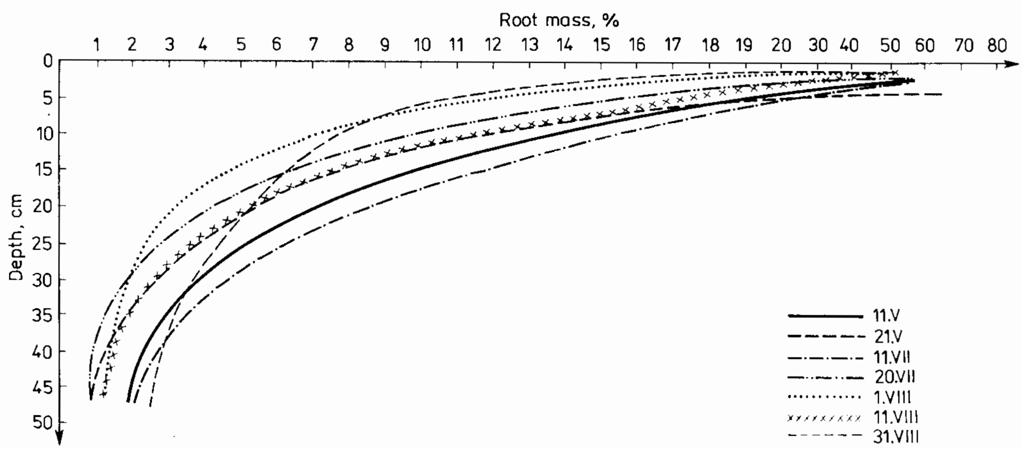

Fig. 3. Distribution of the root mass of grass (%) in vegetational period for section I

Fig. 3. Distribution de la masse des racines des herbes (%) pendant la période de végétation pour la partie I

me ground water tables) is shown. The main bulk of roots is cumulated in the upper (20 cm) layer of the profile and decreases with the depth.

One may state that the root mass depends on the depth of the ground water table in certain layers. In the lower layers of the profile the root mass (in %)

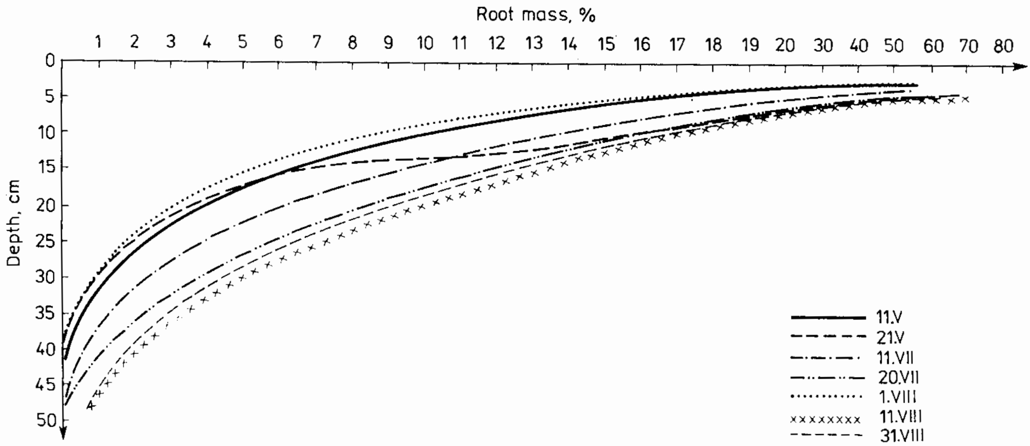

Fig. 4. Distribution of the roots of grass (%) in vegetational period for section II

Fig. 4. Distribution de la masse des racines des herbes (%) pendant la période de végétation pour la partie II

is several times lower in the sections of low dehydration as compared to sections of the deeper ground water.

One may conclude that at the high level of the ground water the depth of root penetration decreases which in certain periods may be unfavourable for the crops. Similar effect of moisture on the distribution and growth of root mass was found by Janus [3].

3.1. The dependency between the water pressure and root mass

The acquired results of root mass and distribution (in %) of roots is combined together in Figure 5 and 6 as a function of suction pressure of soil water. Figure 5 shows the influence characterizing (for 5 sections) the root mass acquired from messurement at the depth of 5-15 cm. Those dependencies are different in quantity for each section. For example, in section II (strongly saturated) at the pressure of 45 cm of H_2O column the mass was 15 $g \cdot cm^{-2}$. On the other hand in section I (strongly dehydrated) this quantity was reached at the suction 120 cm. This is probably due to the differentiation of moisture in the above sections. Figure 5 shows the dependency between root mass (expressed in percentage of the total root mass in the profile) and the suction of the ground water table. Similarly to the previous dependencies this dependency has curvilinear character. The percentage of roots in the analyzed layer grows with the increase of suction force.

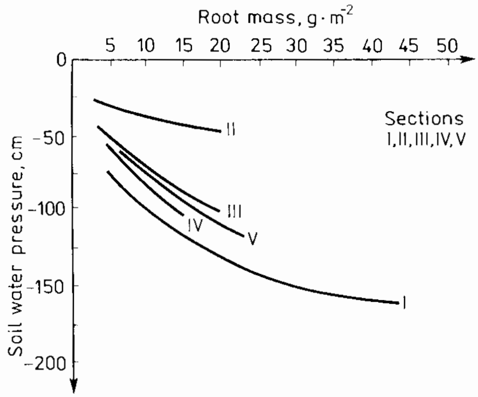

Fig. 5. Relation be:ween suction force of soil water and the root in g·m^{-2} at the depth 5-15 cm

Fig. 5. Relation entre la suction de l'eau du sol et la masse de racines en g·m^{-2} à 5-15 cm de profondeur

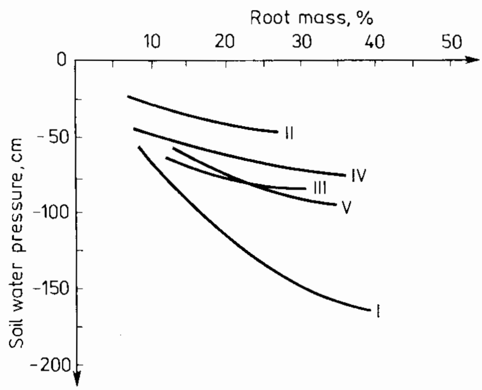

Fig. 6. Relation between succion force of soil water and the root mass (%) at the depth 5-15 cm

Fig. 6. Relation entre la succion de l'eau du sol et la masse de racines (%) à 5-15 cm de profondeur

We may infer that at the decrease of moisture (suction force increase) the depth of root penetration increases, therefore the product of photosynthesis is directed more on the creation of root system. On the other hand at extensive moisture in the soil the root system is shallow and the plant develops the stem and leaves.

3.2. The harvesting of grass as dependent on the ground water table

The crops of the dry mass of hay in the experimental station of IRGF in Sosnowica are shown in Figure 7 where the depth of the ground water table and the level of nitrogen fertilization (A-D) are shown.

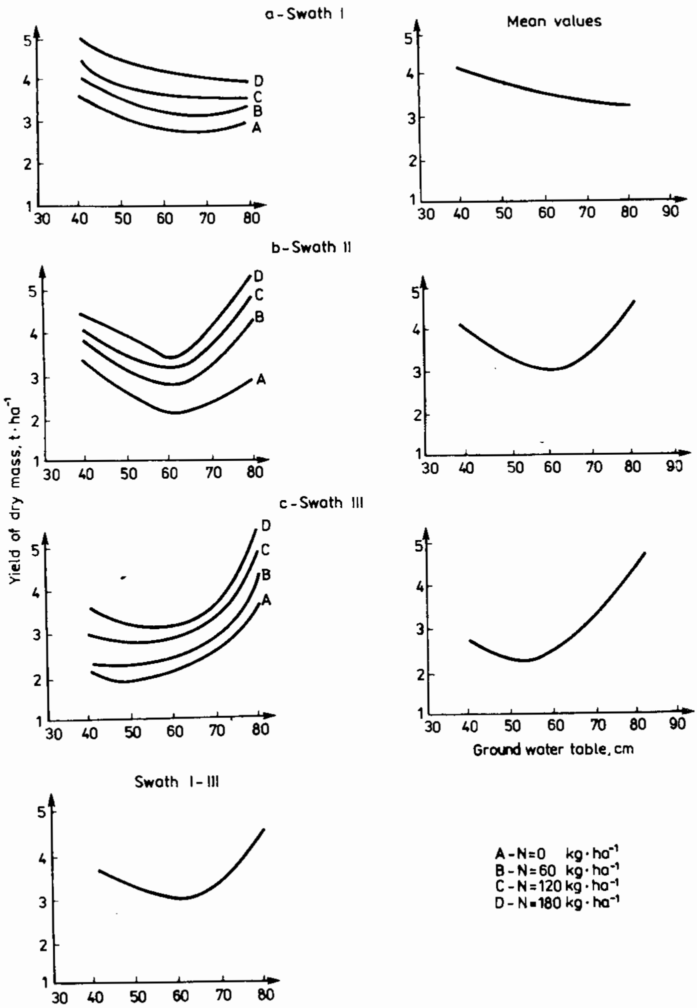

Fig. 7. Interrelation between the dry mass of hay (t) and the depth of the ground water table and the level of nitrogen (N) fertilization according to the data obtained on the experimental section in 1973

Fig. 7. Interaction entre la matière sèche de foin (t) et la profondeur de la nappe d'eau souterraine et le niveau de la fertilisation azetée (N) d'après les données obtenues dans la parcelle expérimentale en 1973

The depth of the ground water table presented on the abscissa was as follows: section II - 40 cm, section III - 50 cm, section IV - 60 cm, section V - 70 cm, section V - 70 cm, section I - 80 cm below the surface. The decrease of grass crop is parallel to the decrease of the level of the ground water table (Fig. 7a).

During the outgrowth after the first cut when there was considerable water reserve and relatively small loss of water for transpiration the moisture in the root zone is the function of the depth of the ground water table. In section I and V, of lowest levels of the ground water table, the moisture of the root zone lower in comparison to moisture of other sections. During the second outgrowth the loss of water for transpiration was larger and there was a visible decrease of crops in sections II, III and IV but in section I a considerable increase of crop was observed. The observations of other studies which claim that the decrease of crop is due to the deepening of the ground water table are not supported.

On the experimental plots in Sosnowica the ground table levels were maintained at a stable level with accuracy ±10 cm. In spring period in sections I and V, as mentioned above, the moisture of the root zone was lower in comparison to the moisture in sections II, III and IV; the products of photosynthesis (as the above results showed) were used more for the development of root system which caused the decrease of the aerial parts of the plants. In the second outgrowth the decrease of moisture in the root zone in all sections appeared due to increasing loss of water for transpiration. Nevertheless, the crop in sections I and V was considerably larger as compared to the crops of section IV. The root zone of plants in the intensively unsaturated sections reached deeper layers of the profile. The layers which were easily provided with water from the saturated zone. This process was more clearly visible in the third outgrowth when only small rainfalls appeared.

We may infer that high moisture and high level of fertilization of the soil in spring period may in certain unfavourably influence summer and autumn crops of plants. This is due to the fact that at the beginning of vegetational period plants are in close vicinity of water and nutrients and they do not extend their root systems.

3. RESULTS AND CONCLUSIONS

After analysing the growth and developement of plants it was stated that the main bulk of roots is concentrated in the upper 20 cm layer of the profile and decreases with the depth. On the plots of high level of the ground water table the root system is more developed in the upper layer of the profile. On the other hand on the plots of deeper dehydration greater bulk of roots is visible in the lower layers of the profile which in some cases (great losses of water for transpiration) makes it possible for the plants to survive during the critical periods. It was clearly seen in the crop of grass. On the plots of the depth of dehydration (80 cm - section I) the greatest crops were gathered especially in the third cut.

The above suggest the following conclusions:

1. The influence of suction force on the growth of root mass was noticed. This dependency is different for each sections. Nevertheless, the root mass grows proportionally to the increase of suction force.

2. The results of the crops of the dry mass as dependent on the depth of the ground water table are related to the root system. They also show that high moisture and high level of fertilization in early spring period may in some cases influence unfavorably summer and autumn harvesting.

3. The results of the function dependencies of the root systems are not precise because of the short period of measurement but they show the tendency of the investigated phenomena.

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EFFET DE LA NAPPE PHRÉATIQUE SUR LA CROISSANCE DES RACINES ET LE RENDEMENT DE L'HERBE

R é s u m é

La formation des conditions optimales d'humidité dans le sol a une importance essentielle pour la production végétale. Ceci concerne surtout les sols de prairie dont les réserves hydriques influencent d'une façon importante le rendement de l'herbe. En général le rendement des cultures herbagées diminue quand le niveau de la nappe phréatique est trop bas ou trop élevé.

L'objectif de ce travail est un essai de déterminer l'effet de la succion ou du niveau de la nappe phréatique sur la croissance et la distribution des racines et sur la production de l'herbe. On a constaté l'influence de la succion sur l'augmentation de la densité racinaire qui, en grande partie, décide de la production de la végétation herbacée.

Les résultats des récoltes de la matière sèche de foin restant en relation avec la profondeur de la nappe phréatique font voir qu'une grande humidité et la fertilisation abondante au début du printemps peuvent, en certains cas, limiter la production des plantes en été et en automne. Vu la période d'études assez courte, les résultats des essais, surtout s'il s'agit de la croissance des racines, ne sont que préliminaires et exigent de continuer les measures.

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WPŁYW ZWIERCIADŁA WODY GRUNTOWEJ NA WZROST KORZENI ORAZ PLONOWANIE TRAW

S t r e s z c z e n i e

Kształtowanie się w glebie optymalnych stosunków wilgotnościowych ma istotne znaczenie dla produkcji roślinnej. Dotyczy to szczególnie gleb łąkowych, których zasoby wody glebowej wpływają w dużym stopniu na plonowanie traw. Plonowanie użytków zielonych maleje zwykle przy zbyt niskich lub wysokich poziomach wody gruntowej.

Celem tego opracowania była próba określenia wpływu, jaki wywiera ciśnienie ssące bądź poziom wody gruntowej na wzrost i rozmieszczenie korzeni oraz na plonowanie traw. Stwierdzono wpływ ciśnienia ssącego na wielkość przyrostu masy korzeniowej, która w dużym stopniu determinuje plonowanie roślinności trawiastej.

Wyniki plonów suchej masy siana w zależności od głębokości lustra wody gruntowej, wskazują, że wysokie uwilgotnienie i wysoki poziom nawożenia gleby w okresie wczesnowiosennym może w pewnych przypadkach ograniczyć letnie i jesienne plonowania roślin. Uzyskane wyniki badań szczególnie w odniesieniu do przyrostu masy korzeniowej z uwagi na krótki okres badań należy traktować jako wstępne - wymagające kontynuacji pomiarów.