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ФИЗИОЛОГИЧНА РЕАКЦИЯ НА *SALIX VIMINALIS* В УСЛОВИЯТА НА АНТРОПОГЕНЕН СТРЕС
PHYSIOLOGICAL REACTION OF *SALIX VIMINALIS* TO STRESS OF ANTHROPOGENIC ORIGIN

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Резюме

Целта на проучването беше да се сравнят растежът и някои физиологични параметри на *Salix viminalis* (клон Bjor) при отглеждане върху антропогенно променени почвени легла. Чувствителността на *Salix viminalis* към деградацията на почвените легла беше оценена на базата на растежни (растеж на стъблата и техния диаметър и структура на добива) и физиологични (интензивност на CO_2 асимилация и транспирация, водно съдържание, съдържание на хлорофил, съдържание на пролин) показатели. В резултат на изследването беше установено, че почвените легла намаляват съществено растежа, продуктивността и физиологическия статус на клон Bjor. Засоляването беше факторът с най-силен редуциращ ефект върху измерваните показатели. Върбата от вида *Salix viminalis* беше най-чувствителна към киселинността на почвеното легло.

Засоляването индуцира натрупване на най-високата концентрация на пролин в листата (осмопротектор, ангажиран в защитата на растенията от стресови фактори).

Abstract

The aim of the study was to compare the growth and some physiological parameters of *Salix viminalis* of Bjor clone growing on anthropologically changed soil beds. Sensitivity of *Salix viminalis* to soil bed degradation was evaluated based on measurement of its biometric (intensity of shoots growth and their diameter, yield structure), physiological (assimilation and transpiration intensity, water content in shoots and a+b chlorophyll concentration and proline content) features. As a result of the studies, a significant influence of the examined, degraded soil beds was reported on a decrease in growth, productivity and physiological status of the basket willow of Bjorn clone. Salinity was the factor most reducing the above mentioned features. Among the examined stress factors, the basket willow was the most sensitive to soil bed acidity.

Salinity was the reason for the highest proline concentration in the leaves – an osmoprotectant engaged in protecting the plant from the stress results.

Ключови думи: *Salix vimnalis,* увредени почви, асимилация, транспирация, пролин.
Key words: *Salix vimnalis,* degraded soil bed, assimilation, transpiration, proline.

INTRODUCTION

Biodegradation of the natural environment is, above all, connected with human activity. The area of anthropogenically altered land is still increasing. Within the territory of Poland there are over 70 thousand hectares of land which requires recultivation, including over 64 thousand hectares of devastated land and ca. 6 thousand hectares of degraded land (the Central Statistical Office, 2004). Salix (Dubas, 2008) may be used for biological recultivation especially in its bush forms *Salix americana, Salix amygdalina* and its hybrid form *Salix viminalis* (Szczukowski et al., 2002). These forms are characterised by wide range of ecological tolerance. They can grow in conditions of high abiotic stress intensity, in which many other plants would not have any chance of survival. They

are able to adapt morphologically, biochemically and physiologically to changing environmental conditions.

The aim of the study was to compare the growth and physical activity intensity of *Salix viminalis* of Bjor clone growing on anthropologically changed soil beds.

MATERIAL AND METHODS

The biological material consisted of the basket willow Bjor clone seedlings produced in Sweden and propagated on the Hvidsted Energy Forest nursery plantation in Denmark.

In the years 2002-2008, 2 series of vase experiments were conducted, each repeated three times with four degraded soil beds and a control soil bed. The vases (of 20 kg capacity) were filled with the following soil bed layers (0-45 cm): former arable soil – valuation class 6 (light loamy sand) with low pH of 4.0; sand silt from Szczecin-Ньwinoujьcie water lane dredging (sand) with low water capacity and nutrients content; oiled soil (silt loam) contaminated with petroleum derivative compounds, taken from former Soviet airport near Szczecin; saline soil taken from a road side of strong salinity (ca. 16g NaCl per dm^{-3}) and control soil bed – valuation class 4 (loamy fen soil). The following measurements were made during vegetation of the willow growing on the above mentioned soil beds: height and diameter of the willow shoots, growth kinetics of the shoots with the use of the exponential logistic function according to Richard, dry mass yield and water content in shoots determined with the gravimetric method, net assimilation and transpiration intensity with the use of LCA-4 gas analyser (ADC Bioscentific Ltd. Hoddeson, UK) working in an open system with PLC-4 type chamber with lighting of about 1000 $\mu mol \cdot m^{-2} \cdot s^{-1}$. Also, the effectiveness of water use during assimilation was calculated. a+b chlorophyll content was determined with Lichtenthaler and Welburn method (1983), while free proline content – with Bates method (1973).

The significance of differences for the interactions was determined based on the variance analysis with significance level α =0.05.

RESULTS AND DISCUSSION

The results of the examined parameters are presented in table 1 and figures 1-2. The willow shoots in the control soil reached the greatest final height of ca. 2.6 m and diameter of ca. 10 mm. Whereas, the growth dynamics on degraded soils was much lower. The lowest shoots were recorded on saline soil, slightly higher ones on the sand silt and oiled soil (ca. 150 cm), while their diameter did not usually exceed 6-8 mm. A slight decrease in shoot height and diameter was recorded for the soil bed with low pH.

The maximum daily height gain appeared to be the parameter which differentiated the shoot elongation growth most (fig. 1). In the control conditions, it was definitely the highest with the value of ca. 3 cm. This occurred on the 70th vegetation day. Whereas, maximum height gains on degraded soils occurred several days earlier with the values from 1 cm on saline soil to 1.8 cm on acid soil. On most soil beds the willow shoot elongation growth had a characteristic sigmoid shape – fig. 1. The duration of fast growth phase was most significantly reduced by soil bed salinity. This was reflected in a flattened shape of the growth curves. On the other hand, Gregorczyk et al. (2004) in their studies used a polynomial of the second degree to describe the growth kinetics of three basket willow clones growing in saline soil stress conditions. The growth curves were parabolic and not sigmoid.

The unit yield was differentiated by the type of soil bed. The biomass growth was most reduced by the sodium chloride and petroleum derivative compounds. The quantity of accumulated dry mass was twice lower than in the control. Relatively high shoot yield was obtained by willows on the acid soil – ca. 83% of the control. According to many authors, it is not acidity but alkaline soil reaction (pH above 8.0) that significantly reduces the growth and yielding of the basket willow.

The share of the individual organs in the yield varied depending on the type of soil bed. The roots share was dominant on the sand silt and the oiled soil (47-48%), while the shoots share was relatively small – almost 40%. Large shoots share was recorded in the optimal and ca. 70% salinity conditions – fig. 2.

The results concerning the shoot water content in various soil beds indicate that shoot hydration was the highest on saline soils (over 60%), while on other soil beds it was from 46 to 51%. Greszta and Gruszka (2002) demonstrated a significant influence of NaCl on higher wood hydration of urban plants. Retaining the highest possible photosynthetic activity of leaves is a decisive factor especially for the yielding of cultivable plants grown in less favourable habitat conditions.

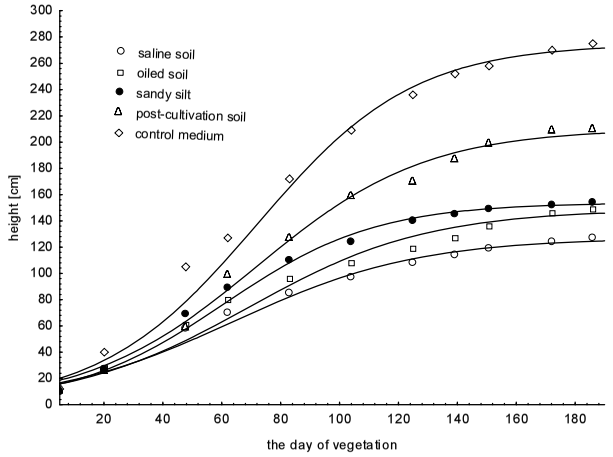
Assimilation is a complex process subject to strong internal and environmental regulations. Soil bed salinity again appeared to be the factor most reducing the assimilation and transpiration intensity caused by limited access to water in the soil resulting from reduced chemical potential of water. Furthermore, increased resistance of diffusive stomata is worth noticing in soil bed salinity conditions, which is caused by extensive accumulation of Na and Cl ions in leaves (Johnson et al., 2002; Sperry et al., 2002). Petroleum derivative compounds also strongly reduced both assimilation and transpiration. On the other hand, soil bed acidity did not significantly influence the reduction of gas exchange in willow leaves.

Photosynthetic effectiveness of water usage is an important parameter decisive for plant productivity, especially in stress conditions. In the conditions of strong

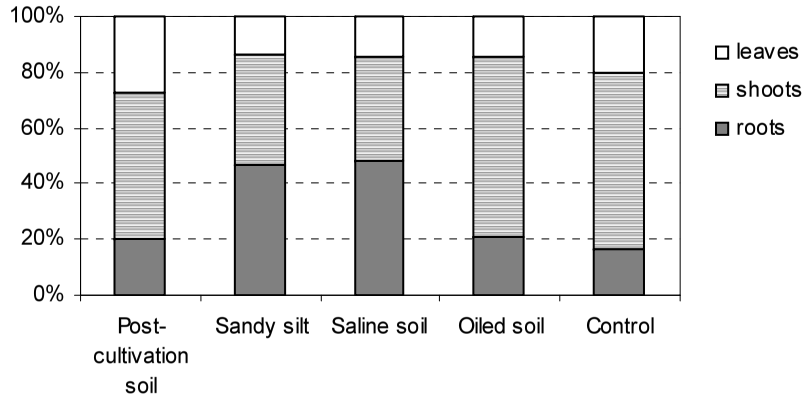
Таблица 1. Биометрични, физиологични и биохимични характеристики на *Salix viminalis* клонинг Bjor в различни почвени субстрати
Table 1. Biometrical, physiological and biochemical features of *Salix viminalis* clone Bjor in different soil substratum

Type soil substratum	Analysed parameters								
	Height [cm]	Diameter [mm]	Dray mater shoots [g per plant]	Water content in shoots [%]	Assimilation [$\mu molCO_2 \cdot m^{-2} \cdot s^{-1}$]	Transpiration [$mmolCO_2 \cdot m^{-2} \cdot s^{-1}$]	Effectiveness of water use in assimilation [$mmol \cdot mol^{-1}$]	Chlorophyll a+b [$mg \cdot g^{-1}$ f.m.]	Proline content [$mg \cdot g^{-1}$ d.m.]
Control soil bed	260a	10a	322a	48b	12.3a	3,82a	3.23b	3.26a	0.18e
Post-cultivation soil	210b	9a	256b	58ab	8.8b	3,61a	2.46c	2.81b	0.34d
Sandy silt	150c	6bc	185c	50b	4.45c	1.88b	2.13cd	2.08c	1.28b
Saline soil	120cd	5c	129d	62a	3.4d	0.89c	3.86a	1.98c	1.84a
Oiled soil	147c	7b	141d	51b	2.9d	0.77c	3.82a	0.98d	0.84c

a,b. – averages followed by the same letter do not differ significantly at p = 0.05 (Tukey range test)



Фиг. 1. *Криви на линеен растеж на летораслите при субстрати от увредени почви*
Fig. 1. *Curves of shoots elongation growth on degraded soil substratum*



Фиг. 2. *Участие на органите на Salix viminalis 'Bjor' [%] в общия добив при субстрати от увредени почви*
Fig. 2. *Participation of particular Salix viminalis 'Bjor' organs [%] in total yield on degraded soil substratum*

stress influence (salinity and oiling), the value of this index was much higher than in the conditions of strong soil acidity or on the permeable soil bed (sand silt).

Among the cell organelles, chloroplasts are the most sensitive to stress factors caused by high water deficit. Hence, a sudden decrease in a+b chlorophyll content in willow leaves was observed in oiled soil conditions (3-fold compared to the control) and in the case of soil salinity as well as on the sand silt.

A significant increase in proline concentration, an osmoprotectant engaged in protecting plants from stress results, was observed especially in strong soil salinity conditions. High proline level in Bjor clone with medium soil bed salinity was also demonstrated by Stolarska et al. (2008). The salinity and soil drought stress are accompanied by strong oxidation stress increasing fast synthesis of free proline in cells (Stolarska et al., 2008). In the conditions of soil bed acidity, the level of proline content was close to the control.

CONCLUSIONS

1. All the examined anthropologically changed soil beds influences the decrease in productivity and physiological activity of the basket willow of Bjor clone.
2. The growth and yielding of the willow were most significantly reduced by the sodium chloride and the petroleum derivative compounds in the soil beds, which decreased the examined physiological parameters.
3. Among the examined stress factors, the basket willow was the most sensitive to soil bed acidity.
4. Salinity was the reason for the highest concentration of proline in leaves - an osmoprotectant engaged in protecting plants from hydrous stress results.

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