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EVALUATION OF PHYSIOLOGICAL RESPONSES OF PLANTS *CORNUS MAS* L. TO WATER DEFICIT

Helena LICHTNEROVÁ*, Viera ŠAJBIDOROVÁ, Daniela BARTOŠOVÁ KRAJČOVIČOVÁ

Slovak University of Agriculture in Nitra, Slovakia

The pot experiment with the selected plants of *Cornus mas* L. was carried out in 2013. The aim of the experiment was to assess the impact of water scarcity in the substrate on the physiological condition of the monitored plants. Following physiological characteristics: the leaf stomatal conductance and chlorophyll fluorescence were tested. We have seen the value of Fv/Fm in the range of 0.75–0.85, which represent the optimum values of F_v/F_m. Values of Φ_{PSII} and the values of R_{fd} decreased due the impact of water deficit. By measuring leaf stomatal conductance (g_s), we reported a decrease in the values of the variant with lower levels of saturation of the substrate. We can deduce that the photosynthetic activity of the plants *Cornus mas* L. was affected by lower levels of saturation of the substrate.

Keywords: *Cornus mas* L., leaf stomatal conductance, chlorophyll fluorescence

Introduction

Modern concepts in landscape planning are focused on the usage of native species plants from nature in the urban areas and landscape. Under natural conditions plants are exposed to environmental stressors with mutual interaction. Water regime of plants is a key factor affecting their survival and expansion in terms of progressive drought.

The study of drought-tolerant species of herbs and plants is a means for their effective use in landscape planning. *Cornus mas* L. is one of the spectacular native species of plants used in landscape planning, due to its early flowering period and its tolerance to drought and heat. It can resist to the habitat with sandy-loam soil rather than permanent waterlogged. It is widespread in southern and south-western Europe, extends into central Germany, the Czech Republic and Slovakia, Ukraine, Crimea and the Caucasus. It occurs on hillsides and in light forests on the limestone from lowlands to uplands (http://botany.cz/cs/cornus-mas/). The aim of the experiment is to evaluate the impact of water scarcity in the substrate on the selected physiological characteristics – the leaf stomatal conductance and chlorophyll fluorescence. These characteristics are indicators of the plant´s physiological state.

Material and metods

The selected plants *Cornus mas* L. come from generative propagation. One-year old seedlings were grown in containers. A part of the plants were exposed to 30% of the substrate saturation (variant with reduced water content in the substrate, stress variant) and another part of the plants were further hydrated as control variant in 60% of the substrate saturation. The plants were cultivated into the substrate Klasmann TS3 standard clay +20 kg m^{-3}, pH 5.5–6 + fertilizer 1 kg m^{-3} under the foiled cover. A different irrigation regime was set from August to September 2013. Within a pot experiment we monitored physiological responses of plants in relation to water scarcity. We chose the non-destructive methods of monitoring the impact of the lack of water in the soil to plants, specific measurement of leaf stomatal conductance and modulated chlorophyll fluorescence.

During the period of the differentiated water regime, we conducted two analyses to determine the selected parameters. The first analysis was conducted on the August 12th 2013, the next on the September 26th 2013 after 41 days. 20 pieces of plants reporting taxon were chosen, 10 pieces of plants of variant control (60 % of saturation of the substrate), 10 pieces of plants of variant with lower levels of substrate saturation.

When measuring modulated chlorophyll fluorescence a the fluorometer Hansatech FMS 1 was used with lasting 1 second light pulses of red light with an intensity of 895 μmol m^{-2} s^{-1} with 30 minutes of the necessary adaptation of samples to the dark. The intensity of actinic light was 34 μmol m^{-2} s^{-1} and the saturation light pulse was 10 000 μmol m^{-2} s^{-1}. Dark-adapted leaf is most commonly used to characterize the photosynthetic apparatus of measured leaf and plants (Procházka et al., 1998). From the measured values were evaluated the following parameters: F_v/F_m – the maximum quantum efficiency of PSII, Φ_{PSII} – the effective quantum yield of PSII and R_{fd} – the chlorophyll fluorescence decrease ratio

*Correspodence: Helena Lichtnerova, Slovak University of Agriculture in Nitra, Faculty of Horticulture and Landscape Engineering, Department of Planting Design and Maintenance, Slovakia, e-mail. Helena.Lichtnerova@uniag.sk

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(decrease from the maximum fluorescence (F_m) to the steady-state fluorescence (F^s).

When measuring the leaf stomatal conductance (g_s) were used Delta T leaf porometer AP4. Measurement of loss of water vapor through the stomata of leaves took place before midday (best conditions for measurement were between 8:00–10:00 am). The leaf stomatal conductance was determined in mm s^{-1}, together with the recording the current time, light intensity in µmol m^{-2} s^{-1} and the current temperature in °C.

The statistic importance of relations between the amount of irrigation (30% and 60% of substrate saturation) and the selected parameters – F_v/F_m, Φ_{PSII}, R_{fd} and leaf stomatal conductance (g_s) were observed by way of a statistic programme STAT GRAPHIC Centurion XV, a analysis of variance (ANOVA) and the Fisher LSD homogenity test on the level of importance α 0,05.

Results and discussion

In the year 2013 we evaluated then impact of water scarcity in the soil on the values of chlorophyll fluorescence and leaf stomatal conductance of the woody plant *Cornus mas* L. We have found that water deficit set at 30 % saturation of the substrate had a significant effect on the chlorophyll fluorescence parameters, as well as the values of the leaf stomatal conductance.

The maximum quantum efficiency of PSII (F_v/F_m) represents the maximum photochemical capacity of PSII (Tomeková, 2010), the authors Björkman and Demming (1987) and Váňová et al. (2006) considered it as a screening indicator of plant responses to stress. The values fall below 0.75 due to impact of environmental stress, the optimum range of values is from 0.75–0.85. During the reported period, although reporting a significant difference between the variants, but their average values ranged from 0.75–0.85, which represent the optimal values of the maximum photochemical capacity of PSII (Table 1). We evaluate the plants of the selected taxon were able to tolerate the water regime at 30 % saturation of the substrate. Also Šajbidorová (2013) studied the non-sensitivity of F_v/F_m at reduced water content in the soil in *Cornus stolonifera* Michx. ´KELSEYI' and *Spiraea japonica* L. 'LITTLE PRINCESS', as well as Flagella et al. (1998) for *Triticum aestivum* L. and *Secale cereale* L., Munné-Bosch et al. (1999) for *Rosmarinus officinalis* L., Nar et al. (2009) for *Ctenanthe setosa* (Roscoe) Eichl. and Brestič and Živčák (2013) in *Triticum aestivum* L.

The effective quantum yield of PSII (Φ_{PSII}) is a real yield of active PSII reaction centers in the processing of absorbed light energy (Schreiber, 2004). It is known that the impact of environmental stress causes decrease of values Φ_{PSII}. The difference between variants with a different irrigation regimes was significant throughout the period. Values of Φ_{PSII} were significantly lower for the variant with lower levels of saturation of the substrate (Table 2).

Gallo et al. (2007) found a decrease of Φ_{PSII} under water deficit in *Quercus pubescens* Willd., as well as Peguero-Pina et al. (2008) in *Quercus coccifera* L. Weak response of Φ_{PSII} to drought presents Šajbidorová (2013) on *Cornus stolonifera* Michx. ´KELSEYI' and *Spiraea japonica* L. 'LITTLE PRINCESS', Gallo and Feller (2007) in *Fagus sylvatica* L. and Munné-Bosch et al. (1999) for *Rosmarinus officinalis* L.

The chlorophyll fluorescence decrease ratio (Rfd) is considered as the vitality index of photosynthetic apparatus (Lichtenhaler et al., 1997; Lichtenhaler, 2000). It is the ratio between the value of the maximum fluorescence (F_m) and the value of the steady-state fluorescence (F_s). $R_{fd} = F_d/F_s$, where $F_d = F_m - F_s$ (Hlízová, 2008). The effect of different stress conditions increases the steady-state fluorescence (F_s), thereby decreasing the value of F_d, as well as the value of the R_{fd} (Procházka et al., 1998). Decline in the values of R_{fd} watching in response to various suboptimal conditions. Higher values reflect

Table 1 The results of analysis of variance (LSD test) of statistically significant differences of mean values of F_v/F_m

Variant	Count	Mean	Homogeneous Groups
1	10	0.761	X
3	10	0.769	XX
2	10	0.794	XX
4	10	0.805	X

1, 3 variant stress, 2, 4 control variant, the *p*-value <0.05

Table 2 The results of analysis of variance (LSD test) of statistically significant differences of mean values of Φ_{PSII}

Variant	Count	Mean	Homogeneous Groups
3	10	0.065	X
1	10	0.066	X
2	10	0.113	X
4	10	0.126	X

1, 3 variant stress; 2, 4 control variant, the *p*-value <0.05

Table 3 The results of analysis of variance (LSD test) of statistically significant differences of mean values of R_{fd}

Variant	Count	Mean	Homogeneous Groups
3	10	0.884	X
1	10	0.890	X
2	10	1.254	X
4	10	1.417	X

1, 3 variant stress, 2, 4 control variant, the *p*-value <0.05

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higher photosynthetic activity (Lichtenhaler et al., 2005) and signal adaptive capacity of plants. By Pukacki and Modrzyňski (1998) plants under optimal conditions reach values of R_{fd} ≥2.3, when exposed to abiotic factors, values are falling. Lichtenhaler and Rinderle (1988) state that the values of R_{fd} ≥3 presents a high speed and efficiency of photosynthesis. In our experiment, the plants in the control treatment did not reach values of R_{fd} ≥2.3 as the authors say by woody plants under optimal conditions (Pukacki and Modrzyňski, 1998; Lichtenhaler and Rinderle, 1988), but the mean values of the variant with lower saturation of the substrate at *Cornus mas* L. were significantly lower than the mean values of the control variation throughout the period (Table 3). We can deduce that the photosynthetic activity of plants *Cornus mas* L. was affected by lower levels of saturation of the substrate.

Leaf stomatal conductance (g_s) is a physiological parameter, which we can assess the management of the plant with water. A decrease in photosynthesis as a result of mild to moderate water stress, is primarily due to stomata closure. The lower values of stomatal conductance show the adaptation of plants to extreme conditions under which the plant limits the exchange of gases (Živčák, 2006). The response of stomata is one of the most important mechanisms for the protection of plants against water deficit (Tardieu and Davis, 1993 in Živčák, 2006). Živčák (2006) observed the varietes of *Triticum aestivum* L. that have been stressed by a lack of water. During progressive dehydration of plants he reported decreased water vapour permeability values of leaves.

When assessing stomatal conductance of *Cornus mas* L. we also confirmed the statistical significance supporting differences of 95% between the variants. Mean values of stomatal conductance were lower in the variant with lower levels of saturation of the substrate after 45 days of duration of water deficit (Table 4).

Table 4 The results of analysis of variance (LSD test) of statistically significant differences of mean values of g_s

Variant	Count	Mean	Homogeneous Groups
3	10	0.522	X
1	10	0.529	X
2	10	0.656	X
4	10	1.405	X

1, 3 variant stress; 2, 4 control variant, the p-value <0.05

Conclusion

In 2013 the pot experiment with the selected plants *Cornus mas* L. was carried out to evaluate the impact of water scarcity in the substrate on the physiological condition of plants and subsequently determine their level of tolerance to drought in urban areas as well as in landscape. Based on the applied experimental methods, we came to the following conclusions:

1. Dehydration of plants limiting irrigation to 30 % of full water capacity does not affect the values of the maximum quantum efficiency of PSII (F_v/F_m). It is known that decrease of F_v/F_m is observed only at lethal levels of water deficit.
2. Values of Φ_{PSII} and values of R_{fd} were significantly lower for the variant with lower saturation of the substrate than the control treatment that can be concluded that plants were affected due to water deficit in soil.
3. Measurement of the leaf stomatal conductance can be concluded that dehydration of plants by limiting the irrigation to 30 % of the full water capacity leads to a reduction in the stomatal conductivity of leaves, indicating adaptation of the plants to extreme conditions.

Based on the one-year results, we can deduce that the photosynthetic activity of plants *Cornus mas* L. was affected by lower levels of saturation of the substrate. To confirm these conclusions another experiments are required.

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