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AFFECTING THE QUALITY OF NURSERY PRODUCE BY SOIL CONDITIONERS

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Abstract

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In 2006, a field trial was established in two localities. The first one was in Lednice (district Břeclav) at the experimental plot of the Department of Breeding and Propagation of Horticultural Plants, the second one in Stařeč (district Třebíč). As model plants, Acer pseudoplatanus and Quercus robur were used. TerraCottem, Agrosil LR and Hydrogel were tested as soil conditioners. Both species were planted in each locality. The plants were planted out on plots with soil conditioners mentioned above in 4 variants (including the Control variant without soil conditioners) and in 3 replications. Physiological parameters of plants were followed in the course of growing season using special equipment, viz. Porometer AP 4 (stomatal conductivity), SunScan AT (PAR) and Chlorophyllmeter CCM 200 (chlorophyll content index – CCI). Morphological parameters (i.e. length of shoots and dry mass of leafs) were measured to the end of the growing season. The obtained data were statistically analyzed using the program Statgraphics Plus. The best results were obtained in the variant with the soil conditioner Hydrogel. The soil conditioners showed a significant effect on both morphological and physiological parameters of experimental plants. Soil conditioners under study eliminated the influence of abiotic stressors on Acer pseudoplatanus and Quercus robur.

woody plants, soil conditioners, nursery produce, abiotic stressors

Woody plants growing in nurseries and/or on their permanent sites are continuously attacked by of both abiotic and biotic stressors. For plants, the lack of water represents the limiting stress factor (Procházka, 1998). In ecosystems, the cycling of water is very quick and its reserves in plants and soil can last only for a relatively short periods. In the course of growing season, the degree of resistance of plants to water stress is not constant. It is reduced at most within the so-called critical periods of growth (Kincl & Krpeš, 2000). When responding to the lack of water, plants produce a series of substances increasing the osmotic pressure in cells and especially the concentration of abscissic acid (ABA) increases. This results in closure of leaf stomata, reduction of the rate of photosynthesis and respiration, and decrease in CO_2 uptake (Bláha *et al.*, 2003). Under conditions of water stress the rate of chlorophyll degradation escalates, its concentration decreases, transport of substances slows down, accumulation of dry matter (DM) is reduced, and accumulation of toxins increases. Transpiration is reduced. When producing woody species in containers, it is very important to Control the stand microclimate (Salaš, 2004).

Of endogenous factors the following should be mentioned: anatomy of leaves as transpiration organs (structure; thickness; chemical composition of cuticle; size, number, position and diameter of stomata; thickness of cell walls of spongy parenchyma cells). The rate of stomatal transpiration of young leaves is high, in mature leaves decreased, and in senescent ones low (Kincl & Krpeš, 2000). Long-distance transport processes are less sensitive to water stress; this enables that, even under conditions of a severe water, stress plants can mobilise their reserves of organic substances stored in older organs and transfer them into younger (especially generative) organs for the sake of completing of reproduction processes (Gloser & Prášil, 1998).

Langerud (1988) observed in his experiments a negative effect of fluctuating irrigation on growth and development of young wood plants. Knox

(1989) found out that in selected woody plants grown in containers the uptake and, thus, also efficiency of irrigation water was different. Levit (1995) came to similar conclusions. Tabdush (1987) studied the resistance of roots of woody plants to draught and concluded that an exposition of roots to draught for a period of two hours did not influence their subsequent growth but that already after three hours the rate of survival dropped to 68 %. Kramer (1969, In: Kolek 1988) mentioned that the root systems of plants, which passed through a period of water stress showed a reduced penetrability for water even after several days of irrigation. There are several methods how to eliminate water stress of plants and the use of soil conditioners is one of them. Soil conditioners are substances that can, due to their properties and if adequately applied, show positive effects on soil properties and optimise the water regime of plants (Salaš, 1996).

MATERIAL A METHODS

In 2006, a field trial was established in two localities. The first one was in Lednice (district Břeclav) at the experimental plot of the Department of Breeding and Propagation of Horticultural Plants, the second one in Stařeč (district Třebíč).

The site in Lednice is situated in the maize-growing region with average annual precipitation 500–600 mm. The site in Stařeč is situated in the sugar-beet growing region with average annual precipitation 550–700 mm. This is a stone pit, which was reclaimed in 2004. The pit was filled up with land waste and excavation earth. Its surface was covered with a layer of topsoil 0.15–0.20 m thick, on which was thereafter established a permanent grassland stand. Groundwater is drained.

As model plants, maple (*Acer pseudoplatanus*) and beech (*Quercus robur*) were chosen. TerraCottem, Agrosil LR and Hydrogel were tested as soil conditioners.

Both sites were prepared for planting of aforementioned woody species in the spring of 2006. Plots were treated with a herbicide and thereafter tilled with a rotary cultivator to the depth of 0.2 m. In both localities, experimental sites were divided to 24 plots. On these plots, the aforementioned soil conditioners were applied on the surface and uniformly worked-in to the depth of 0.2 m by means of the rotary cultivator.

Both model plant species were cultivated at each experimental locality. Altogether four variants (including the Control without soil conditioners) were established in three replications. In each locality, altogether 720 model plants were planted on 12 plots so that the total of 1.440 model plants were grown and tested. The number of plants per experimental plot was 60 and the size of each plot was 5.5 m^2.

In Lednice and Stařeč, plantings were performed on 10–11 May and 23–24 May 2006, respectively. Prior to planting, roots of one-year-old seedlings (1/0) were shortened. After planting, all experimental plants were uniformly irrigated. Hoeing was performed in regular weekly intervals.

Sensors Hobo and Virrib were installed in both localities shortly after planting of model plants. Hobo sensors were used for the registration of air temperature and humidity while Virrib ones recorded the water content in soil. In all variants the Virrib sensors were placed into the root zone and the measurements of water content were performed in weekly intervals.

Measurements with special equipment were started after the development of fist leaves. The following apparatuses were used: Porometer AP 4, SunScan AT, and Chlorophyll Meter CCM 200. The apparatus Porometer AP 4 was used for measurements of stomatal conductivity of leaves in $mol.m^{-2}.s^{-1}$. The apparatus Chlorophyll Meter CCM 200 served for recording of chlorophyll content (i.e. index of chlorophyll content) in leaves of model plants and SunScan AT enabled to measure photosynthetically active radiation (PAR, in mV) passing through the stand canopy. All these physiological parameters were measured in time intervals of 14 days. Morphological parameters were measured to the end of growing season (DM of leaves and the length of growth increments were the most important of them). Soil samples were taken and analysed prior to and after the end of these experiments.

RESULTS AND DISCUSSION

Experimental results were statistically analysed using the program Statgraphics Plus, Version 3.1. In both localities (Lednice, Stařeč), the observed differences were statistically significant in all experimental variants.

In Lednice, growth increments of *Acer pseudoplatanus* were better in all variants with soil conditioners than in Control (Tab. I). The difference between Control (0.29 m) and the variant with Hydrogel (0.37 m) was statistically significant. Also in Stařeč the growth increments of variants with soil conditioners were better than in Control and the observed differences were statistically significant (Tab. II). The best and worst results were recorded in the variant with Hydrogel and in Control (0.14 m *vs.* 0.08 m, resp.).

In the experiment with *Quercus robur* cultivated in Lednice, growth increments in variants with Hydrogel (0.06 m) and TerraCottem (0.06 m) were better than in Control but these differences were statistically not significant (Tab. III). In Stařeč, better results were obtained in variants with Agrosil LR and TerraCottem but also in this case the differences were statistically insignificant (Tab. IV).

The DM of leaves was the next parameter under study. In Lednice, *Acer pseudoplatanus* variants with soil conditioners showed a higher content of DM than Control (Tab. I). The differences were statistically significant. The highest and the lowest contents of DM were recorded in the variant with Hydrogel and in Control (25.29 g *vs.* 12.85 g, resp.). In Stařeč, the obtained results were similar: the highest and the lowest contents of DM were found out in the variant with Hydrogel and in Control (9.92 g *vs.* 5.01 g, resp.), (Tab. II). In Lednice, *Quercus robur* variants with Hydrogel and TerraCottem showed higher contents of DM than Control (7.44 g and 6.55 g *vs.* 5.65 g, resp.). These differences were statistically insignificant (Tab. III). Also in Stařeč, the content of DM was higher in variants with soil conditioners than in Control. A statistically significant difference was recorded between the variant with Hydrogel and Control (1.68 g *vs.* 0.93 g; Tab. IV).

The content of chlorophyll in leaves of model plants was another parameter investigated. In Lednice, *Acer pseudoplatanus* variants with soil conditioners showed higher content chlorophyll than Control (Tab. I). The highest and the lowest contents of chlorophyll (expressed as CCI) were measured in the variant with Agrosil LR and in Control (23.71 *vs.* 21.87, resp.). The difference was statistically significant. In Stařeč, variants with soil conditioners showed also higher CCI values than Control (Tab. II). The highest and the lowest contents of chlorophyll were recorded in the variant with Hydrogel and in Control (18.93 *vs.* 16.89, resp.). The difference was statistically significant. In Lednice *Quercus robur* variants with Agrosil LR and Hydrogel showed higher values of CCI than Control (Tab. III). As compared with Control (24.01), the highest CCI value was found out in the variant with Hydrogel (24.78). The differences were statistically non-significant. In Stařeč, variants with soil conditioners showed higher contents of chlorophyll than Control (Tab. IV). The highest and the lowest contents of chlorophyll were recorded in the variant with Agrosil LR and in Control (17.99 *vs.* 15.83, resp.). The differences were statistically significant.

The stomatal conductivity was the next parameter under study. In case of *Acer pseudoplatanus* plant, there were no statistically significant differences in both localities. In Lednice, the highest and the lowest values of stomatal conductivity were recorded in variants with Hydrogel and Agrosil LR (317.08 *vs.* 264.53 $mol.m^{-2}.s^{-1}$, resp.), (Tab. I), while in Stařeč the highest and the lowest values of stomatal conductivity were recorded in variants Agrosil LR and TerraCottem (178.30 *vs.* 158.65 $mol.m^{-2}.s^{-1}$, resp.), (Tab. II). In *Quercus robur* seedlings, the differences were statistically significant. In Lednice, a higher stomatal conductivity was recorded in all variants with soil conditioners than in Control (Tab. III). The highest and the lowest values of stomatal conductivity were recorded in variants with TerraCottem and in Control (447.99 *vs.* 377.34 $mol.m^{-2}.s^{-1}$, resp.). In Stařeč, the highest and the lowest values of stomatal conductivity were recorded in variants with Hydrogel and in Control (249.19 *vs.*, 192.72 $mol.m^{-2}.s^{-1}$, resp.), (Tab. IV).

PAR was another physiological parameter that was followed in our experiments. During the whole growing season, the highest PAR values were recorded in Controls; this observation concerned both localities and also both model plants. Results of continuous monitoring of soil humidity indicate that in case of *Quercus robur* seedlings the highest soil humidity was recorded in the variant with Hydrogel in both localities. As far as the seedlings of *Acer pseudoplatanus* were concerned, in Lednice the best values were recorded in the variant with Agrosil LR while in Stařeč in the variant with TerraCottem. However, these results were not markedly different.

The obtained experimental results indicate that all soil conditioners showed an unambiguous positive effect on morphological parameters of plants. This was largely corroborated also by results of measurements of physiological parameters (Sloup, 2005). However, in case of *Quercus robur* some important results were statistically insignificant. It can be said that the effects of soil conditioners are clearly visible especially in fast growing woody plants. In this case, the first statistically significant differences can be observed as early as in the course of the first growing season while in slow growing ones the positive effects of soil conditioners cannot be demonstrated after the end of the first growing season. However, it can expected that within this period the seedlings developed a robust root system and that the positive effects of soil conditioners will be manifested in the subsequent year.

CONCLUSIONS

Plants of *Acer pseudoplatanus* and *Quercus robur* were markedly influenced by the application of soil conditioners in both localities. Soil conditioners influenced positively both morphological and physiological parameters of experimental plants. As compared with Control, the observed differences were evaluated as statistically highly significant and/or as statistically significant. It can be concluded that the applied soil conditioners eliminated above all effects of abiotic stressors. In both localities these seedlings developed a good (and robust) root system and that to the end of the growing season their parameters were better than those of controls. The best results were obtained with soil conditioner Hydrogel in experiments with seedlings of both plant species under study.

I: *Average values and differences between variants – Acer pseudoplatanus, Lednice*

Variants	Growth increments [m]		DM of leaves [g]		Content of chlorophyll [CCI]		Stomatal conductivity [mol.m^{-2}.s^{-1}]	
Control	0.29	a	12.85	a	21.87	a	282.93	ab
Agrosil LR	0.34	bc	18.66	b	23.71	b	264.53	a
Hydrogel	0.37	c	25.29	c	22.70	ab	317.08	b
TerraCottem	0.31	ab	18.95	b	21.92	a	278.10	ab

Different letters between rows indicate significant differences at P ≤ 0.05 (Fisher´s LSD test).

II: *Average values and differences between variants – Acer pseudoplatanus, Stařeč*

Variants	Growth increments [m]		DM of leaves [g]		Content of chlorophyll [CCI]		Stomatal conductivity [mol.m^{-2}.s^{-1}]	
Control	0.08	a	5.01	a	16.89	a	165.16	ab
Agrosil LR	0.10	b	6.31	a	18.08	ab	178.30	b
Hydrogel	0.14	c	9.92	b	18.93	b	167.56	ab
TerraCottem	0.11	b	7.03	ab	17.96	ab	158.65	a

Different letters between rows indicate significant differences at P ≤ 0.05 (Fisher´s LSD test).

III: *Average values and differences between variants – Quercus robur, Lednice*

Variants	Growth increments [m]		DM of leaves [g]		Content of chlorophyll [CCI]		Stomatal conductivity [mol.m^{-2}.s^{-1}]	
Control	0.06	ab	5.65	a	24.01	a	377.34	a
Agrosil LR	0.06	a	5.37	a	24.17	a	433.60	b
Hydrogel	0.06	b	7.44	a	24.78	a	393.76	a
TerraCottem	0.06	ab	6.55	a	23.87	a	447.99	b

Different letters between rows indicate significant differences at P ≤ 0.05 (Fisher´s LSD test).

IV: *Average values and differences between variants – Quercus robur, Stařeč*

Variants	Growth increments [m]		DM of leaves [g]		Content of chlorophyll [CCI]		Stomatal conductivity [mol.m^{-2}.s^{-1}]	
Control	0.03	a	0.93	a	15.83	a	192.72	a
Agrosil LR	0.03	a	1.32	ab	17.99	b	223.18	b
Hydrogel	0.03	a	1.68	b	16.95	ab	249.19	b
TerraCottem	0.03	a	1.50	b	17.21	b	239.59	b

Different letters between rows indicate significant differences at P ≤ 0.05 (Fisher´s LSD test).

SOUHRN

Ovlivnění kvality školkařských výpěstků pomocí půdních kondicionérů

V roce 2006 byl založen pokus na dvou rozdílných stanovištích. První stanoviště bylo v Lednici (okres Břeclav) na účelovém pozemku Ústavu šlechtění a množení zahradnických rostlin Zahradnické fakulty v Lednici, druhé stanoviště ve Starči (okres Třebíč). Jako modelové rostliny byly vybrány *Acer pseudoplatanus* a *Quercus robur*. Z půdních kondicionérů byl vybrán TerraCottem, Agrosil LR a Hydrogel. Na obou stanovištích byly zastoupeny obě modelové rostliny. Byly vysazeny do parcelek, do kterých byly předem zapraveny půdní kondicionéry. Byly vytvořeny čtyři varianty, včetně kontrolní (neobsahovala půdní kondicionéry), ve třech opakováních. Během vegetace byly sledovány fyziologické parametry rostlin pomocí speciální techniky. Jednalo se o Porometer AP 4 (vodivost průduchů listů), SunScan AT (PAR pronikající do porostu) a Chlorophyll Content Meter CCM 200 (obsah chlorofylu v listech). Ke konci vegetace byly změřeny i morfologické parametry (délka přírůstků, sušina listů atd.). Výsledky byly zpracované ve statistickém programu Statgraphics Plus. Jako nejlepší byla vyhodnocena varianta Hydrogel. Půdní kondicionéry měly jednoznačný vliv na morfologické i fyziologické parametry. Půdní kondicionéry u rostlin Acer pseudoplatanus a Quercus robur jednoznačně eliminovaly abiotické stresory.

abiotické stresory, okrasné dřeviny, půdní kondicionéry, školkařská produkce

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