ECOLOGICAL IMPACT OF DE-ICING SALT ON *TILIA CORDATA* MILL. PLANTS FROM ROADSIDE ENVIRONMENT

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To examine the adverse effects of de-icing salt, leaves from damaged Tilia cordata *trees, located near the roadside were comparated to leaves from healthy trees, located far away from the road. The plants from roadside environment display marginal leaf necrosis accompanied by chlorosis. The transpiration in the damaged leaves was increased, compared to normal leaves. Light-microscopical pictures showed open stomata in the area of the toxicity symptoms, whereas the stomata in the healthy regions were closed. The results indicate that Na^+ toxicity inducing K^+ deficiency is responsible for the marginal necrosis of* Tilia *leaves. The reduction of chlorophyll in leaves may be explained in terms of high Cl^- concentration.*

***Key words**: de-icing salt, Tilia cordata, roadside environment, nutritional disorders*

To maintain road safety and accessibility of the road network at acceptable condition during the winter season, salts (most frequently sodium chloride and calcium chloride) are used on roadsand. The main part of salts is dispersed into the near roadside as run-off or is splashed by passing vehicles or ploughed off the road surface, thus increasing soil salinity in the roadside environment [3]. Sodium and especially chloride are mobile ions and will disperse into various parts of the roadside environment, thus increasing environmental impact such as contamination of soil, groundwater and damage of roadside trees [9, 4].

Soil salinity is an important factor causing two different types of stress in plants:

i) osmotic stress resulting from high solute concentration and low soil water potential primarily limit plant growth during the first phase of salt stress;

ii) high salt concentration causes ionic imbalance [6, 8, 14, 13]. Damage to vegetation is usually limited to the area of a few ten metres of the road. Salt-induced biotic effects include browning of needles and dieback of roadside trees, which, in time, lead to plant death [1].

MATERIAL AND METHOD

Leaf transpiration was appreciated by the dehydration rate, measured by leaves weighting after 1, 2, 3, 4, and 24 hours respectively. Stomata opening were examined microscopically using collodion impression of lower leaf epidermis [12]. The concentration of ions was determined by atomic absorption spectrometry. Chloride was extracted into hot water and measured potentiometrically by titrating with Ag [15]. The chlorophyll concentration of the acetone extract was determined spectrophotometrically [12].

RESULTS AND DISCUSSIONS

Toxicity symptoms, such as marginal leaf necrosis and chlorosis, appeared since mid-July and were favoured by the low rainfall.

Regardless the time of weightings, the dehydration rate of the leaves with toxicity symptoms was higher than in the healthy leaves, thus indicating an uncontrolled transpiration (*fig. 1*).

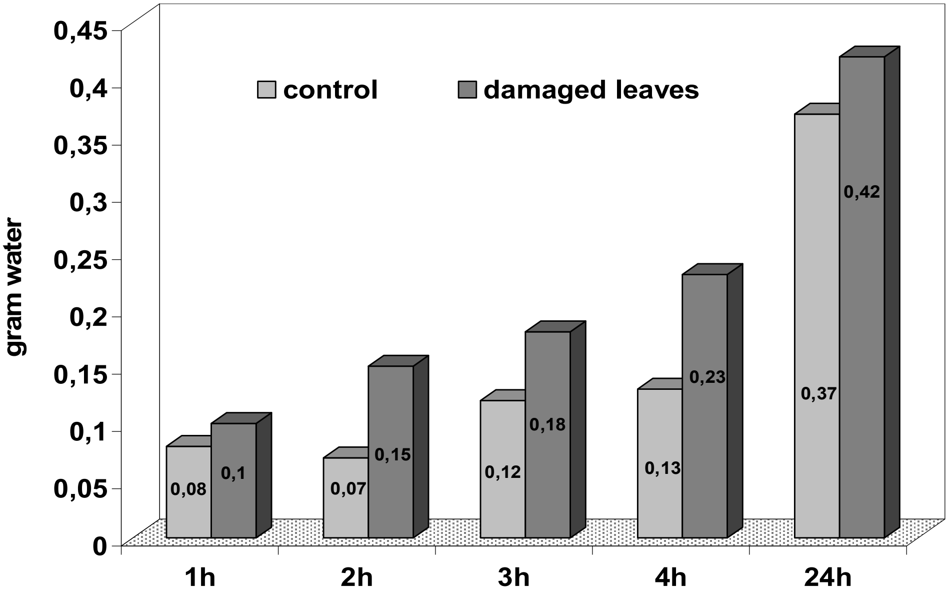

Figure 1 **Rate of leaves dehydration**

Light-microscopic pictures showed open stomata in the area of the toxicity symptoms. In contrast, stomata remained tightly closed at the surrounding epidermal surface of the leaf (*fig. 2*). It was confirmed that widely opened stomata were localized exactly within the necrotic areas.

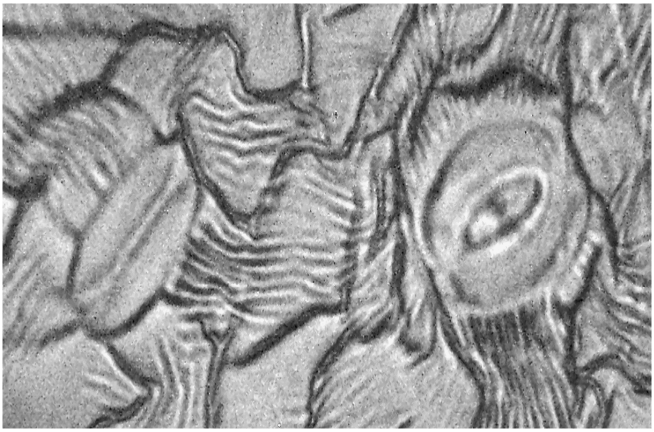

Figure 2 **Microscopic image of the lower epidermis with opened and closed stomata**

In damaged leaves, a sodium concentration five times higher than in healthy leaves was determined (*fig. 3*).

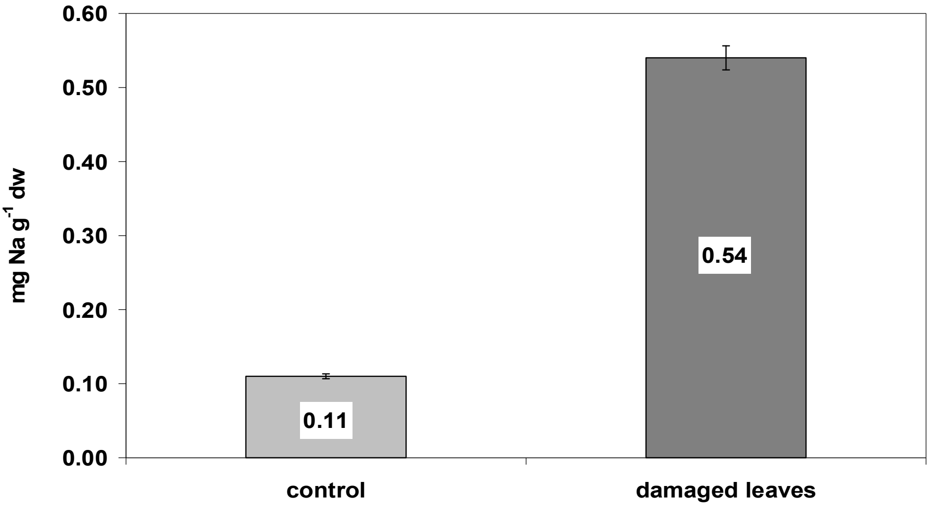

Figure 3 **Sodium concentration in healthy and damaged leaves**

Toxicity of Na^{+} in metabolic processes results from its ability to compete with K^{+} for binding sites and to inactivate enzymes and essential cellular functions. The leaf injury was related to an increased Na^{+} concentration. A high number of enzymes is known to be activated by K^{+} and deactivated by Na^{+} [2, 7, 11]. Salt-induced osmotic stress leads to a closing of stomata. This may explain the appearance of marginal necrosis. The lack of stomatal closure causes high transpiration and loss of water. Salt stress induced Na^+ toxicity, which caused an apparent K^+ deficiency primarily affecting stomatal regulation.

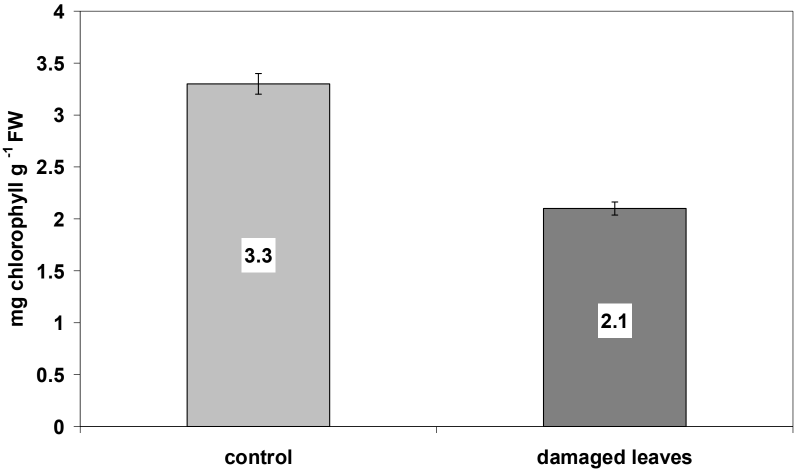

Figure 4 **Chlorophyll concentration in healthy and damaged leaves**

The chlorophyll concentration in leaves with toxicity symptoms was 2.3fold reduced compared to the control plants (*fig. 4*). On the other hand, the Cl^- and Na^+ concentrations were three and five times higher, respectively, compared to those of the control plants (*figs.4 and 5*).

Reduced chlorophyll concentration resulting from NaCl treatment was previously described for rice (*Oryza sativa*) [5] and faba bean (*Vicia faba*) [10]. The decreasing of chlorophyll content in leaves may be explained as a result of high Cl^- concentration. This effect is further amplified by a simultaneously high Na^+ concentration.

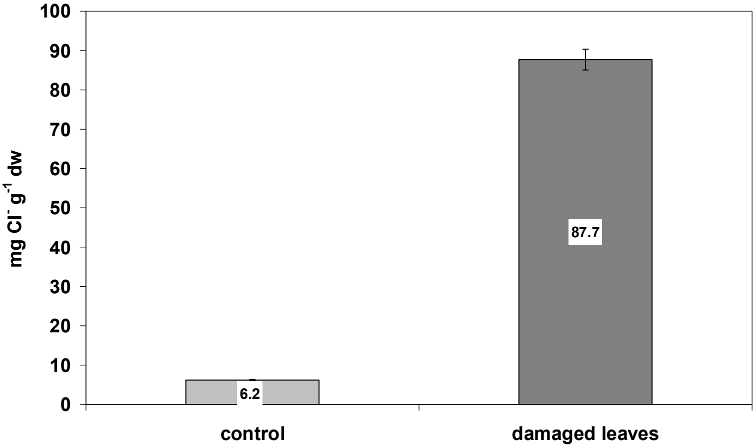

Figure 5 **Chloride concentration in the healthy and damaged leaves**

A comparison with data obtained by Bergmann [1] which prove a balanced nutrition revealed that an excess of macronutrients calcium, potasium and magnesium and a deficiency of phosphorus ions was measured in the damaged leaves (*tab. 1*).

Table 1

Macronutrient concentration in leaves of *Tilia cordata*

	Ca (mg g^{-1} dw)	K (mg g^{-1} dw)	Mg (mg g^{-1} dw)	P (mg g^{-1} dw)
Control	10.7	17.2	2.0	3.5
damaged leaves	25.6	29.3	8.0	2.4

Regarding micronutrients, an excess of copper and iron as well as deficency of manganese were measured (*tab. 2*). This result requires further research on reasons leading to the appearance of toxicity symptoms.

Table 2

Micronutrient concentration in leaves of *Tilia cordata*

	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Control	18.1	147.7	20.8	26.4
damaged leaves	20.3	412.2	10.8	24.7

CONCLUSIONS

1. The dehydration rate in leaves with toxicity symptoms was higher than in the healthy ones, indicating an uncontrolled transpiration.
2. Salt stress induced Na^+ toxicity, which caused an apparent K^+ deficiency, primarily affecting stomatal regulation.
3. The reduction of the chlorophyll content in leaves may be explained as a result of high Cl^- concentrations, which is amplified by a simultaneously high Na^+ concentration.
4. The nutritional disorders were manifested by excess of calcium, potasium magnesium, copper, iron and deficiency of phosphorus and manganese ions.

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