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INFLUENCE OF SALINE STRESS ON THE ABUNDANCE OF LIME APHID (*Eucallipterus tiliae* L.) ON THE LEAVES OF STREET TREES - CRIMEAN LINDEN

WPŁYW STRESU SOLNEGO NA LICZEBNOŚĆ MSZYC (*Eucallipterus tiliae* L.) NA LIŚCIACH DRZEW ULICZNYCH *TILIA* 'EUCHLORA'

Abstract: This publication presents the influence of soil salinity on the abundance of aphids on the leaves of street trees in cities. The objects of research were trees of Crimean Linden (*Tilia 'Euchlora*') planted at Zwirki and Wigury Street in Warsaw. The research included the evaluation of the trees' condition, the counting of the number of Lime Aphid (*Eucallipterus tiliae* L.), as well as the determination of chlorine and nitrogen content in the leaves. The research revealed a statistically significant influence of chlorine content in the leaves on the deterioration of their condition. The increased content of chlorine in the leaves was accompanied by a decrease in the number of aphids. This relationship was statistically significant. No nitrogen deficiency in the leaves was detected. No statistically relevant relationship between the nitrogen content and the condition of the trees was observed. There was a weak negative correlation which, however, was statistically insignificant. Using the regression function it was determined that the increase in chlorine content in leaves by 1% (from 1.0 to 2%) resulted in a decrease in the abundance of aphids by 49%. What is more, a statistically significant ($p = 0.032$) influence of nitrogen content on the abundance of aphids was proved. The increase of this element by 1% (from 2.5 to 3.5%) was accompanied by the increase in the number of aphids by 90%.

Keywords: *Tilia* 'Euchlora', *Eucallipterus tiliae* L., aphids, nitrogen, chlorine, salt stress

Street trees planted in cities are subjected to unfavorable conditions for growth and development. The use of sodium chloride to de-ice the roads in wintertime, as well as water deficiency and air pollution result in a worsening condition of street trees and their withering away on a big scale. An important factor is also the occurrence of pests with sucking mouthparts - mainly aphids and tetranychus [1-3]. In Liverpool 39% of trees planted in the last few years died no later than within five years of being planted [4]. The research carried out in Warsaw by Dmuchowski et al [5] proved that within the last 34 years more than a half of street trees have withered away. The biggest loss was observed for species such as: *Sorbus aucuparia* (94%), *Acer pseudoplatanus* (83%), *Tilia cordata* (65%) and *Tilia* 'Euchlora' (62%). The smallest loss was observed for *Tilia platyphyllos* (44%).

The result of both biotic and abiotic stresses, to which the street trees are subjected, changes in their morphology as well as in physiological and biochemical processes. Not only does it contribute to the deterioration of decorative qualities of the trees, but also, which is more important, it obstructs their biological functions [6, 7].

The aim of this research was the determination of the influence of saline stress on the abundance of Lime Aphid (*Eucallipterus tiliae* L.) on the leaves of street trees - Tilia 'Euchlora'.

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Material and methods

The objects of research were Crimean Linden (48 specimens) planted at Zwirki and Wigury Street in Warsaw. The leaves condition was evaluated in mid-September using the seven-grade scale method of direct observation [8]. The samples of leaves were collected in mid-July from the outer perimeter of the tree crown, at the height of 2÷4 meters. The chlorine amount was determined using the method of potentiometric titration with ion-selective electrode and ion-meter of Orion Type 701a [9]. The nitrogen concentration was determined using the Kjeldahl method with analyzer 1035 Foss Tecator.

The number of Lime Aphid (*Eucallipterus tiliae* L.) on the leaves was counted three times, on dates 28.05, 11.06 and 28.06 of 2010. In the final calculations, only the measurements of the abundance of aphids on the leaves made in May were taken into account. In observations made in June the number of aphids was very small. The average number of aphids on a leaf was estimated on the basis of observation of 40 randomly chosen leaves (10 per each side), separately for each of the trees.

In order to compare the average number of aphids with the concentrations of nitrogen and chlorine in the leaves under different health conditions, univariate analysis of variance was applied. Multiple comparisons were made using the Tukey procedure. On the basis of the analysis mentioned above the three groups of means were separated. For the analysis the significance level was assumed at 0.05 [10].

Results and discussion

The concentration of chlorine in the leaves of Crimean Linden ranged between 0.89% and 1.95% (Fig. 1). On the basis of literature review one can conclude that for all the studied trees the chlorine toxicity threshold was exceeded (> 0.6%) [11, 12]. The presence of chlorine in the leaves results in the initially invisible changes inside the plant cells, and with the increasing amounts of this ion, in morphological changes such as chlorosis visible on the leaf lamina. Research conducted in Warsaw confirmed that even minor salinity of the soil can cause necrosis on the edges of leaves, and result in rapid withering and death of trees [13, 14]. The research confirmed a statistically relevant influence of chlorine concentration in the leaves on the deterioration of their condition. The trees with the lowest leaf-damage index contained on average 0.89% of chlorine while “sick” trees (index 4-5) contained on average 1.93% of this element. Similar results were reached by Suplat [14] and Dmuchowski and Badurek [13].

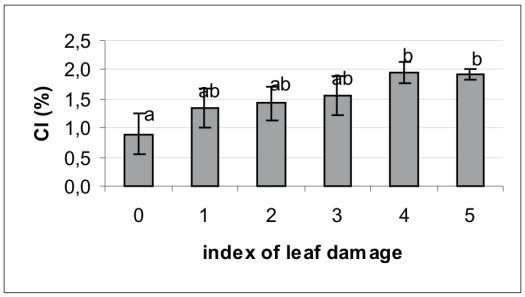

Fig. 1. The comparison of the average concentration of chlorine in leaves in different health condition

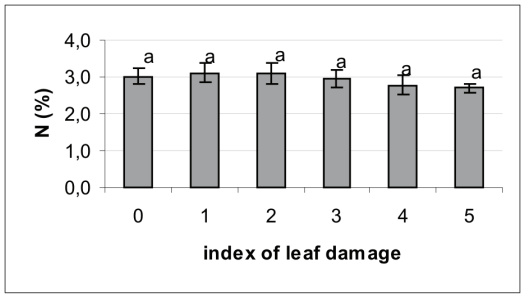

Fig. 2. The comparison of the average concentration of nitrogen in leaves in different health condition

Leaves of Crimean Linden contained from 2.70 to 3.02% of nitrogen (Fig. 2). Consequently, no deficiency levels (1.7÷2.1%) [15, 16] of this element in the examined leaves were observed. No statistically relevant relationship between the condition of the trees and the concentration of nitrogen in the leaves was detected. However, it was observed that the relatively "healthy" leaves contained higher amounts of that element (on average 3.02%) than the leaves qualified as "sick" (on average 2.73%). Markiewicz and Kleiber [17] did not record any relevant influence of salinity on the nitrogen content in the outer leaves of lettuce. Nevertheless according to Kachel-Jakubowska [18], the concentration of nitrogen is correlated with the chlorophyll content. Bach et al [6] indicated that in "sick" trees the photosynthesis does not take its normal course. The deterioration of the photosynthesis intensity results mainly from the leaf damage (withering, discoloration) obstructing the transportation and supply of carbohydrates, nitrogen compounds and plant hormones [19].

The aphids were counted three times, on dates 28.05, 11.06 and 28.06 of 2010. However, only during the observation made in May the Lime Aphid appeared in relatively large numbers. On average, the number of 5-14 aphids was observed on one leaf of Crimean Linden. In other observations the number of aphids was very small (on average 0-1 on one leaf). No statistically significant relationship between the abundance of aphids and the condition of trees was detected. Many authors claims that aphids on the linden trees develop better during cool and humid summers [20, 21]. In May 2010 the weather was quite humid and cold and consequently it is possible that the weather conditions resulted in the relatively large number of aphids in May.

Table 1

The comparison of the average number of aphids on the leaves in different health condition

Index of leaf damage	28.05.2010	11.06.2010	28.06.2010
0	13.83 a	1.35 a	0.51 a
1	11.25 a	1.55 a	1.08 a
2	11.81 a	1.52 a	0.78 a
3	9.13 a	1.31 a	0.61 a
4	8.85 a	1.96 a	0.29 a
5	4.71 a	0.19 a	0.54 a

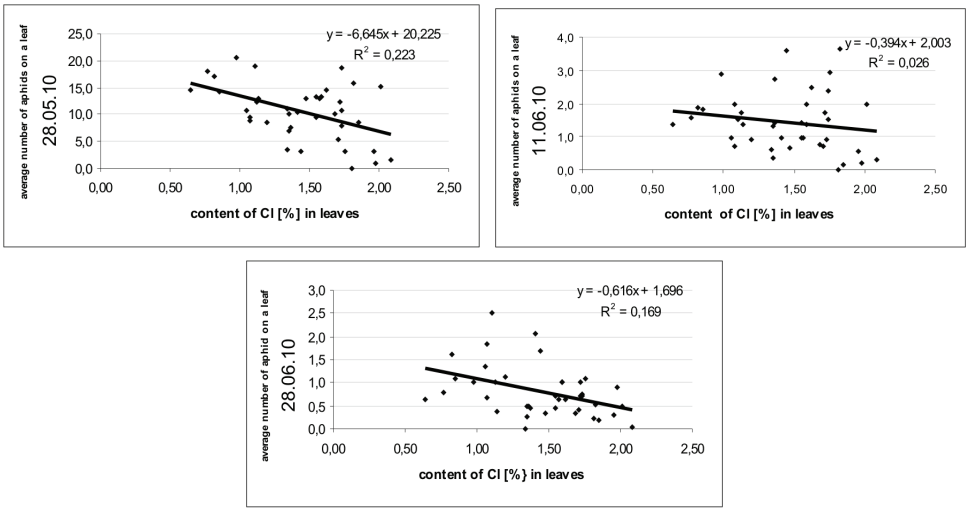

Fig. 3. The relation between chlorine content and the average number of aphids on the leaf

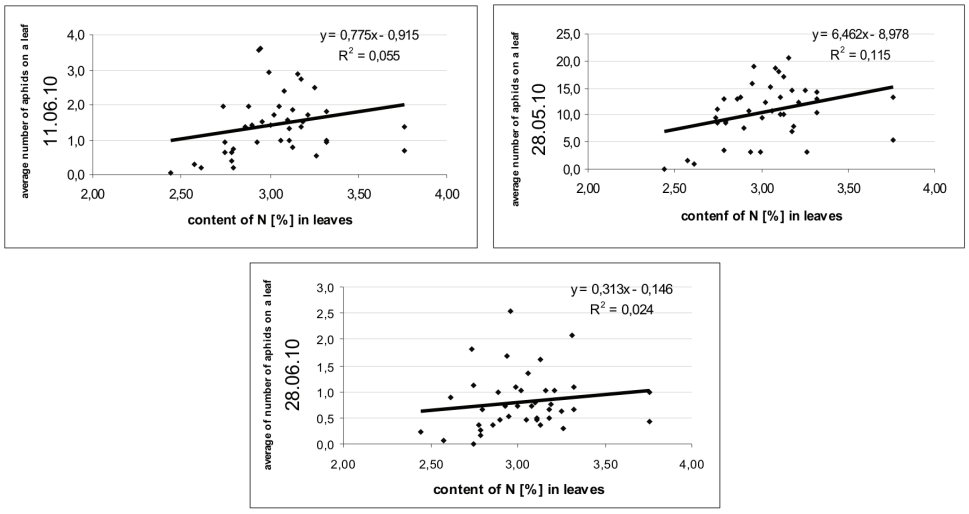

Fig. 4. The relation between chlorine content and the average number of aphids on the leaf

In this research a negative correlation was detected between the chlorine content and the number of aphids on the leaf. Using the regression function (Fig. 3) it was determined that the increase in chlorine content in the leaves by 1% (from 1.0 to 2%) resulted in a decrease in the abundance of aphids by 49%. Furthermore, a statistically relevant ($p = 0.032$) influence of nitrogen content on the abundance of aphids was proved (Fig. 4). The increase of this element by 1% (from 2.5 to 3.5%) was accompanied by the increase in the number of aphids by 90%.

A change in the osmotic pressure of soil solution, which results in physiological drought, is a consequence of the salinity of the soil [22]. At the same time, water deficiency in plants results in an increase in the level of contamination by pests [23]. This is connected with the increased level of nitrogen compounds which is why those plants are preferred by phytophage pests [24]. In the leaves of linden trees planted in the vicinity of roads the relationship between sugars and phenols is also changed [21]. Hale et al [25] conducted research on the influence of drought stress of grasses on the abundance of bird cherry oat aphid (*Rhopalosiphum padi*). They concluded that the abundance of aphids is correlated with the concentration of nitrogen compounds in the phloem solution. Moreover, the aphids can modify the accumulation level of nitrogen compounds in the leaves on which they prey. Some arthropods change the chemical composition of the leaves of their host plants by saliva injection. Aphids, eriophyid mites and other phytophage pests with piercing mouthparts can cause influx of nitrogen compounds and consequently increase the level of nitrogen in those plants [24].

Honeydew produced by aphids can cause limitation of the photosynthesis and transpiration in the leaves of trees. The high abundance of aphids persisting for long periods of time on plants can deteriorate the condition (vigor) of the trees severely attacked by such pests [6]. For this reason it seems necessary to continue the research on the influence of biotic stress and salinity on the abundance of pests in the leaves of street trees.

Conclusions

1. No nitrogen deficiency levels were observed. The content of this element did not influence the condition of the trees.
2. A statistically significant influence of nitrogen concentration in the leaves on the abundance of aphids was detected. Using the regression function it was proved that the increase in the nitrogen content by 1% (from 2.5 to 3.5%) results in a decrease of the abundance of aphids by 90%.
3. The chlorine toxicity threshold in the leaves of Crimean Linden was exceeded (> 0.6%). Relatively "healthy" trees (leaf-damage index 0-3) contained less chlorine than the "sick" trees (index 4-5).
4. The increased content of chlorine in the leaves was accompanied by a decrease in the number of aphids. Using the regression function it was indicated that the increase in chlorine content in the leaves by 1% (from 1.0 to 2%) resulted in a decrease in the abundance of aphids by 49%.

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Abstrakt: Przedstawiono wpływ zasolenia gleby na liczebność mszyc na liściach drzew miejskich. Przedmiotem badań były drzewa z gatunku lipa krymska (*Tilia* 'Euchlora'), rosnące w pasie międzyjezdniowym al. Żwirki i Wigury w Warszawie. Badania polegały na ocenie stanu zdrowotnego drzew, zliczaniu mszyc zdobniczki lipowej (*Eucallipterus Tiliae* L.) oraz na określeniu zawartości chloru i azotu w liściach. Stwierdzono statystycznie istotny wpływ zawartości chloru w liściach na pogorszenie ich stanu zdrowotnego. Zwiększonej zawartości chloru w liściach towarzyszyło zmniejszenie liczebności mszyc. W przypadku zawartości azotu

w liściach nie stwierdzono występowania poziomów niedoborowych. Nie wykazano statystycznie istotnej zależności między zawartością azotu a stanem zdrowotnym drzew. Między zawartością chloru i azotu występowała słaba zależność ujemna, która jednak była nieistotna statystycznie. Na podstawie funkcji regresji stwierdzono, iż wzrost zawartości chloru w liściach o 1% (z 1,0 do 2,0%) powodował spadek liczebności mszyc o 49%. Wykazano także statystycznie istotny (p = 0,032) wpływ zawartości azotu na liczebność mszyc. Wraz ze wzrostem zawartości tego pierwiastka w liściach o 1% (z 2,5 do 3,5%) zwiększała się liczba mszyc o 90%.

Słowa kluczowe: *Tilia* 'Euchlora', *Eucallipterus Tiliae* L., mszyce, azot, chlor