Poznań University of Life Sciences, Poznań, Poland

THE ASSESSMENT OF CHEMICAL PROPERTIES OF THE SOIL, THE CHEMICAL COMPOSITION OF LEAVES AND THE OCCURRENCE OF DISEASES ON *ACER PLATANOIDES* AND *TILIA CORDATA* IN SELECTED SITES OF URBAN GREENERY IN POZNAŃ

B. Wilkaniec, W. Breś, D. Frużyńska-Jóźwiak,
B. Borowiak-Sobkowiak and A. Wilkaniec

Abstract

The environment in highly urbanized areas does not favour the growth and development of plants. In Poznań the sites of maple and small-leaved lime were selected which differ in terms of potential human pressure threat. It was proved that site location has a decisive influence on chemical properties of the studied soils. A significant tolerance of both tree species studied to unfavourable soil conditions, due to their root system morphology, was confirmed. Moreover, the trees growing along streets were more affected by pathogens than those in parks. *Uncinula bicornis* and *Rhytisma acerinum* were found on the Norway maple, and Agonomycetales (formerly: Mycelia sterilia) and decay of leaf edges (non-infectious disease) occurred on the small-leaved lime.

Key words: Norway maple, small-leaved lime, *Uncinula bicornis, Rhytisma acerinum,* salinity, chemical analysis of leaves

Introduction

The problem of proper functioning of urban greenery is important for the improvement of human life quality. As a specific environment, a city is characterised by increasing processes of xerisation of climate conditions, pollution of the air, water, soil and living creatures (Wysocki 2008). These factors greatly influence the growth and development of greenery in urbanised areas.

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The aim of the paper was to compare the condition of the Norway maple and small-leaved lime growing along transport routes and in the parks of Poznań. The conditions of tree growth and the main reasons for their weakening were described.

The paper describes the results of the research assessing the impact of abiotic factors concerning the chemical properties of the soil the trees grow in and the content of mineral elements in leaves as well as biotic factors, i.e. the occurrence of diseases on plants.

The paper by Wilkaniec et al. (2013) presents the results concerning infestation by pests and an overall evaluation of tree condition with visual method.

Material and methods

The study was performed in 2011 in the city of Poznań, central-west Poland.

Two busy Poznań streets were selected as study sites: Lechicka, which now serves as a northern link of the city's transport network (e.g. the traffic volume on the lane adjacent to the plantings on 26.09.2011 was 12,026 vehicles in 24 h, Poznań Roads Authority data) and Nowina, one of the main streets in Ogrody district (e.g. the traffic volume on the lane adjacent to the plantings on 26.09.2011 was 4,948 in 24 h; PRA data). The selection was aimed at finding areas where trees adjacent to streets are exposed to the influence of unfavourable environmental factors typical and described by many authors, characteristic of urban areas, and in particular occurring in the vicinity of busy roads (Kosmala et al. 2009, Szczepanowska 2001). Both the streets were assumed to expose their vicinity to the following factors: air pollution related to heavy traffic, soil pollution, including using salt in winter. In the case of Nowina street also the occurrence of large paved areas must be noted (the trees grow in green lane ca 4 m wide and 0.6 to 1 m away from the road edge), between the road and pavement, which could significantly influence water retention and soil structure. In Lechicka street the trees grow 4 to 10 m away from the road edge, separated from it with a drain ditch, on non-paved grass surface.

The control group was made up by trees growing around Rusałka lake. It is a vast green zone located in the western greenery wedge of Poznań city, the non-traffic area with few paved surfaces and few other factors which could be potentially adverse to tree condition.

Two tree species described in the references as fit for planting in cities (Szczepanowska 2009) were selected: the Norway maple (*Acer platanoides*) on the sites in Nowina street and by Rusałka lake and the small-leaved lime (*Tilia cordata*) on the sites in Lechicka street and by Rusałka lake.

The assessment of chemical properties of the soil and the concentration of elements in the leaves of Norway maple and small-leaved lime

In order to determine basic properties of the soil where the trees grew in June 2011 bore-holes were made in their vicinity. Medium samples from the layers of 0–20 cm, 20–40 cm, 40–60 cm and 60–80 cm were taken down to 0.8 m. The content of the following easily available to plants forms was defined: $N\text{-}NH_4$, $N\text{-}NO_3$, P, K, Ca, Mg, Na, Cl, $S\text{-}SO_4$ (in 0.03 M solution of CH_3COOH), Fe, Mn, Zn, Cu, Pb, Cd (Lindsey's extract) as well as pH and electrolytic conductivity. Moreover, in June from each site of 10 tree crones, leaf samples were taken.

After drying and mineralisation in strong acids the total values of N, P, K, Ca, Mg, Na, Cl, Fe, Mn, Zn, Cu, Pb and Cd were determined. The evaluation of soil chemical properties and the content of mineral elements in leaves was based on recommendations for horticultural soils and plants (Nowosielski 1988, Breś et al. 2003) as well as on the results of soil research conducted outside the human pressure zone (Breś and Roszyk 1996).

The occurrence of diseases on Norway maple and small-leaved lime

In order to diagnose tree diseases five trees were selected on each site and 20 leaves were collected from each of them three times in a season. Every sample was subjected to macroscopic and microscopic tests and the degree of host plant infestation was evaluated (Adamska and Czerniawska 2007, Czerniawska et al. 2011). Fungi were identified by their morphological traits (Sutton 1980, Ellis and Ellis 1987, Mułenko et al. 2008). The tree condition was evaluated with a scale to express the level of leaf infestation, where degree 0 was no symptoms, healthy leaf; degree 1 meant traces of infestation – up to 5% of leaf blade area; degree 2 was slight infestation – up to 25% of leaf blade area; degree 3 – medium infestation – up to 50% of leaf blade area; degree 4 – heavy infestation – up to 75% of leaf blade area; level 5 – very heavy infestation – over 75% of leaf blade area. On the basis of the obtained results an indicator of general infestation level was calculated according to the formula by Townsend-Heuberger:

$$P = \frac{\Sigma(n \times v)}{N \times V} \times 100\%$$

where:

P – general level of leaf infestation (%),

n – the number of leaves infested on particular scale levels,

v – levels of leaf infestation,

N – the total of leaves analysed,

V – the highest degree of infestation.

Results and discussion

The assessment of chemical properties of the soil and the concentration of elements in the leaves of Norway maple and small-leaved lime

Taking soil samples for analyses by means of soil research drill posed many problems. Mechanical resistance in tree sites by busy streets made drilling difficult down to ca 80 cm in Lechicka and 40 cm in Nowina. Although the soils were of light type, due to strong packing of the upper layers they were very poorly aerated. Excess soil packing is now considered to be an element of soil sickness. Moreover, sodium ions that destroy its structure have a strong adverse impact on soil (Grodzinsky 1979, Stewart 1990).

In spite of different locations the investigated soils had many common features, i.e. definitely too high content of Ca, and consequently too high pH in all cases (Table 1). This resulted in reduced availability of many mineral elements for the plants. All the soils had too little nitrogen and phosphorus. In some of them also the levels of Cu (the maple planting by Rusałka lake and in Lechicka street) and Mn (the plantings of lime and maple by Rusałka) were too low.

Increased values of soil electrolytic conductivity (EC) in Lechicka indicate a potential threat to the plants. It is caused by excess concentration of Na^+ and Cl^- ions that reach the soil under trees in the form of saline aerosole, in spite of their distance from the road. It is the site of the heaviest traffic of all the locations studied. Soil salinisation on the site of lime trees by Rusałka caused by an increased, but non-toxic concentration of K^+ and Mg^{++} ions is not dangerous. However, the results indicate that fertilizing the soils with potassium and magnesium is unnecessary. The soils in Nowina and Lechicka are too poor in potassium and sulphates. The contents of other elements in the samples of soils taken from the studied sites can be considered sufficient.

The contents of cadmium and lead were compared with those in agricultural soils not located in a zone of heavy human pressure (Breś and Roszyk 1996). 4 mg Pb and 0.1 mg Cd in 1 dm^3 of soil were assumed as typical of such soils. With such a strict evaluation all the soil samples, regardless of the location of a bore-hole and depth the sample was collected from, are polluted with lead. The soil in Nowina should be considered to be cadmium polluted, while an increased content of this element was proved for soil samples from lime site by Rusałka. However, it should be noted that the contents of heavy metals were within the admissible limits equal to 50–300 mg Pb and 4–20 mg Cd per 1 kg of dry soil mass (decrees by the Minister of the Environment of 2002 – Rozporządzenie… 2002).

Although soil properties were varied, the chemical composition of leaves depended to a greater extent on plant species than site location, e.g. the contents of N, K, Mg, Cl in maple leaves were lower than in lime leaves (Table 2). In spite of alcaline reaction the amount of macro- and microelements in leaf blades is appropriate. No excess concentration of sodium or chlorides in leaves (Dmuchowski and Badurek 2004) was noted. This is due to deep rooting of the plants, which can absorb mineral elements from several metres down, so from soil layers less exposed

Table 1

Chemical properties of the soil samples taken from selected area of Poznań

Location, tree species	Soil layer (cm)	$N-NH_4$	$N-NO_3$	P	K	Ca	Mg	Na	Cl	$S-SO_4$	Fe	Mn	Zn	Cu	Pb	Cd	pH	EC ($mS \cdot cm^{-1}$)
		$mg \cdot dm^{-3}$																
Lechicka, Norway maple	0–20	11	>1	28	80	2 425	212	339	100	24	83.3	21.0	36.9	3.8	7.2	0.11	8.0	0.35
	20–40	35	>1	46	55	2 400	159	325	126	29	69.9	14.6	34.2	4.9	9.1	0.12	8.0	0.38
	40–60	7	>1	61	44	2 564	151	338	162	25	72.6	11.1	49.5	5.9	9.9	0.12	8.1	0.41
	60–80	>1	>1	24	37	1 984	129	246	132	24	86.8	15.8	59.4	6.0	10.9	0.11	8.1	0.44
Rusałka, Norway maple	0–20	25	4	25	24	3 889	154	18	14	30	100.3	4.6	25.3	2.4	6.1	0.10	7.6	0.14
	20–40	25	7	23	32	3 375	172	19	16	16	77.5	4.0	16.7	1.5	4.8	0.08	7.7	0.15
	40–60	18	18	17	40	4 885	91	20	13	58	47.2	2.0	7.6	1.5	13.6	0.06	8.0	0.15
	60–80	18	>1	17	44	3 927	67	20	17	46	75.1	2.7	5.2	1.5	11.6	0.05	8.1	0.11
Rusałka, small-leaved lime	0–20	21	28	55	158	2 195	223	28	61	18	87.9	3.0	41.2	5.6	10.4	0.16	7.2	0.39
	20–40	18	7	23	148	3 062	206	27	81	16	75.6	2.3	33.5	6.2	9.2	0.15	7.5	0.24
	40–60	14	32	16	168	3 870	231	32	22	40	96.4	2.5	38.8	11.9	18.9	0.16	7.6	0.50
	60–80	21	21	10	172	4 258	226	33	22	58	103.3	3.7	40.9	14.9	27.5	0.24	7.7	0.34
Nowina, small-leaved lime	0–20	11	>1	12	64	4 540	133	15	56	>1	66.8	10.4	19.0	10.8	22.2	0.22	7.8	0.18
	20–40	14	>1	11	45	3 064	133	12	48	8	95.2	14.7	18.9	10.9	25.9	0.24	7.6	0.16
	40–60	11	>1	8	30	1 528	75	15	63	>1	118.6	45.1	14.7	11.9	21.9	0.20	7.4	0.16
	60–80	Śl. – Tr.	>1	7	28	914	44	11	58	>1	115.7	56.2	12.7	15.2	19.8	0.17	7.5	0.14

Table 2

Chemical composition of tree leaves growing on selected area of Poznań

Location	Tree species	N	P	K	Ca	Mg	Na	Cl	Fe	Mn	Zn	Cu	Cd	Pb
		% d.w.							$mg \cdot kg^{-1}$ d.w.					
Lechicka	Norway maple	2.78	0.25	1.78	0.77	0.58	0.01	0.30	295.4	88.5	84.1	12.5	2.3	10.4
Rusałka		2.59	0.21	1.83	1.01	0.98	0.06	0.23	265.0	37.0	47.7	8.5	2.4	11.3
Rusałka	Small-leaved lime	3.09	0.23	2.36	1.03	1.32	0.01	0.35	274.8	31.7	50.6	11.2	2.6	12.3
Nowina		3.08	0.26	2.03	1.51	1.18	0.03	0.40	252.3	37.7	61.7	12.4	2.6	12.4

to abiotic and biotic factors typical of urban areas. Also a significant expansion of roots enabling the penetration of areas located further away from the road is important, as those areas are less threatened with pollutant accumulation.

The contents of most elements are comparable with data in publications on environmental pollution in other greater city zones (Oslo – Fostad and Pedersen 1998, Belgrade – Tomašević and Aničić 2010).

Research showing that *A. platanoides* and *T. cordata* reacted quite well to unfavourable habitat conditions (Šomšak et al. 2007), classified them as amelioration trees accumulating high numbers of heavy metals. Such high accumulation of Cd and Pb by these species was also indicated during research in Cracow (Bach et al. 2006). The study by Šomšak et al. (2007) showed that cadmium, copper, nickel, zinc and partially lead are preferentially accumulated by the wood and not leaves of *Tilia*, while *Acer* accumulates significantly more pollutants in its leaves than in wood.

Plants have created a number of various defence strategies enabling them to adapt better to changing environmental conditions. They can also reduce the effects of unfavourable factors or tolerate stress-induced changes (Kacperska 2002). The reaction of plants to stress depends on many factors: the time and strength of stressor, developmental stage and species, its location and resistance. Plants can react to stress in many ways. Acclimation to different environmental changes is crucial for plant growth and survival. For example, plants adapt to low-phosphorus stress by developing mechanisms increasing inorganic phosphate uptake and mobilization, e.g. roots secrete organic acids or acid phosphatases to soil. In the initial stage of phosphorus deficiency in soil the root system modifies: the root weight and length increases, while the root diameter decreases, root hairs become elongated and more dense and more radicles are formed (Ciereszko and Rychter 1995). Radicles penetrate mainly the surface layer of soil, which often has more phosphorus available than layers deeper down. Those changes enable the plant to find the lacking element in soil by maximising the absorption surface (Ciereszko 2000).

The occurrence of diseases on Norway maple and small-leaved lime

Cleistothecia of powdery mildew pathogen were found on the leaves of Norway maple on both sites with various degrees of infestation. Microscopic study confirmed the formation of fruiting bodies with characteristic hooked endings formed by *Uncinula bicornis* fungus. In fruiting bodies – unripe cleistothecias – sacks filled with granular protoplasma could be observed. In cleistothecias which started ripening the protoplasma in sacks divided into portions and outlines of ascospores occurred. In ripe sacks the ascospores were clearly formed, most often there were eight of them. On the site in Lechicka in July on few leaves of *A. platanoides* chlorotic stains of ca 1 cm diameter were seen. Based on inspection in September a slight intensification of infestation by *Rhytisma acerinum* fungus was found, the perfect stage of *Melasmia acerina*. In spite of slight infestation, few but characteristic black spots were seen on the leaf, forming a homogeneous tar-like, shiny surface with yellow halo. Microscopic study corroborated the spores of conidial stage of the pathogen.

In the collected and studied material powdery mildew *Uncinula bicornis* was found on the leaves of *A. platanoides* particularly in the third observation, when the infestation index was over 90% (Fig. 1). In the case of tar spot on *A. platanoides* the infestation index was evaluated at 24% (Fig. 2). Such a course of disease symptoms development was influenced by weather conditions in 2011, while in 2010 almost 100% leaves of *A. platanoides* were infested with *R. acerinum*. This fungus is very common in moderate climate countries; it limits the leaves assimilation abilities, which in turn reduces new growth and reduces aesthetic value of maples as decorative trees in parks and other green areas. The pathogenic factor for most deciduous trees such as sycamores, beeches, oak trees, lime trees, maples are fungi whose teleomorph belongs to *Apiognomonia* genus. Pathogenic characteristics of these fungi depend on weather conditions, they are favoured by cool and humid weather (Madej 1975, Redlin and Stack 1988, Butin 1995, Przybył 2002, Mańka 2005).

Leaf edge decay was found on all the lime trees in Nowina street. It is a non-infectious disease, during which in summer (July) leaf edges along all the blade become yellow, then brown and then they wither (September). Those symptoms are most often due to insufficient supply of water to plant (low level of ground water), salinisation of soil, destruction of soil as root development habitat (Przybył 2002). Such symptoms are also increased by too small soft landscape area, excessive packing of the soil, which can result in the disappearance of soil microorganisms. Also

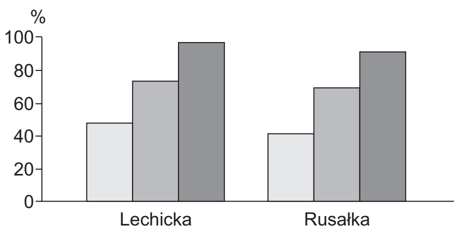

Fig. 1. The level of *Acer platanoides* leaf infestation by *Uncinula bicornis* at the Lechicka street side and the Rusałka park site in Poznań in 2011

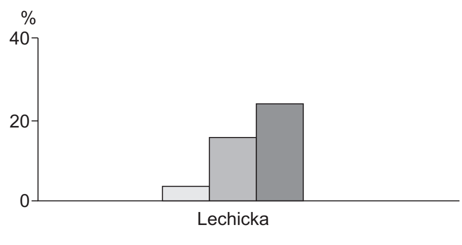

Fig. 2. The level of *Acer platanoides* leaf infestation by *Rhytisma acerinum* at the Lechicka street side in Poznań in 2011

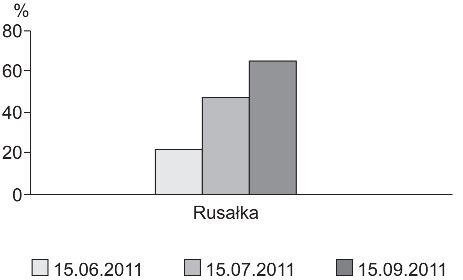

Fig. 3. The level of *Tilia cordata* leaf infestation by *Apiognomonia tiliae* at the Rusałka park site in Poznań in 2011

most leaves, ca 80%, were covered with dark, easy-to-wipe mildew which resembled soot. Dark fungi belonging to mitosporic fungi of the *Alternaria* or *Cladosporium* genus were found. They reduce the ornamental value of the plants and also reduce photosynthesis, which adversely influences plant growth.

In the park planting by Rusałka lake yellow-green spots were seen on tree leaves in June, in later observations the spots were found to be slightly red and clearly tended to become brown; they were round or oval of 2–4 mm diameter. With the development of the disease and intensification of symptoms the spots united and underwent necrosis. Microscopic and parametric study helped to find conidial spores forming in the acervuli of *Discula* sp. syn. *Gleosporium tiliae* (the perfect stage of *Apiognomonia tiliae*). The disease found was antracnosis of lime (Fig. 3).

Conclusions

1. There is a potential threat to plants growing along streets, expressed in soil poor aeration (high packing of upper layers), too high pH (limited availability of many mineral elements) and increased electrolytic conductivity (excess concentration of Na^+ and Cl^- ions).

2. Trees growing along streets were more infested by diseases than those in parks. *Uncinula bicornis* and *Rhytisma acerinum* fungi were found on the Norway maple, while on the small-leaved lime mitosporic fungi and leaf edge decay (non-infectious disease) were found.

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Authors' addresses:
Prof. Dr. hab. Barbara Wilkaniec, Dr. Beata Borowiak-Sobkowiak, Department of Entomology and Environmental Protection, Poznań University of Life Sciences, ul. Dąbrowskiego 159, 60-594 Poznań, Poland, e-mail: wilk@up.poznan.pl
Prof. Dr. hab. Włodzimierz Breś, Department of Horticultural Plant Nutrition, Poznań University of Life Sciences, ul. Zgorzelecka 4, 60-198 Poznań, Poland
Dr. Dorota Frużyńska-Jóźwiak, Department of Phytopathology, Poznań University of Life Sciences, ul. Dąbrowskiego 159, 60-594 Poznań, Poland
Dr. Agnieszka Wilkaniec, Department of Landscape Architecture, Poznań University of Life Sciences, ul. Dąbrowskiego 159, 60-594 Poznań, Poland

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