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PHD THESIS

RESPONSE REACTIONS AT FOLIAR LEVEL INDUCED BY AIR POLLUTANTS AT WOODEN SPECIES GROWN FOR ORNAMENTAL PURPOSES IN IAŞI CITY AREA

ABSTRACT

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Introduction

The increase number of inhabitants and the needs of modern man has led to increased industrialization process, the mechanization of agriculture, the increase in the number of vehicles etc. all contributing to air pollution and modification of natural ecosystems. Synergic effects of pollutants: plumb (Pb), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur oxides (SO_x), particulate matter (PM), photochemical oxidants such as ozone (O_3) and its precursors such as hydrocarbons and volatile organic compounds, led to a rapid deterioration of urban air quality and increasing greenhouse effect. All this affects plant life and human health.

Numerous studies have shown that woody plants have a high capacity to decrease the quantities of pollutants in the atmosphere with the ability to accumulate various pollutants. Therefore, their presence in heavily polluted urban areas proved to be necessary, not only aesthetically, but in terms of purification and urban air quality biomonitoring.

Purpose of the research was to observe and quantify the response reactions at foliar level induced by specific air pollutants at some specimens of woody plants grown for ornamental purposes in Iaşi city area.

The research material used was the leaves of some species of woody angiosperms cultivated for ornamental purposes in different areas of Iaşi city: ***Aesculus hippocastanum*** L., ***Populus x canadensis*** Moench., ***Tilia tomentosa*** Moench.

Research variants are represented by the three species of ornamental trees coming from an unpolluted area - Botanical Garden of the University "Alexandru Ioan Cuza" Iaşi and 5 polluted areas: Podul de Piatră - traffic station, Decebal Cantemir - urban background station, Oancea Tătăraşi - industrial station, Copou Sadoveanu - regional background station, Tomeşti - suburban station.

Methods of analysis used during the research were the following:

- The surface of the leaves was determined with an AM300 device;
- The total content of dry matter was determined gravimetrically after drying in a drying stove at 105 ° C, to constant weight;
- Assimilating pigments were determined in 90% acetone extract, spectrophotometrically;
- Protein was determined by the Lowry method;
- Peroxidase activity was determined spectrophotometrically;
- The physiological processes activity was determined by Lci electronic analyzer.

The results:

Observations on **morphological changes** of the leaves revealed the following:

Morphological changes observed in the leaves of plants in the experimental variants manifest as necrosis focused more on the ribs, marginal necrosis which might be due to the deficiency of water and in the form of more or less massive defoliation. Symptoms are not observed on young leaves in May, but occur in July and intensify in September when abscisic phenomenon is observed.

Symptoms are more noticeable at *Aesculus hippocastanum* species individuals rather than *Populus x canadensis* species individuals. Most necrosis on the leaf surface were found at the individuals of the three woody species investigated, grown in Podul de Piatră area.

Measurements regarding the **necrotic surface of the leaves** at the end of the growing season showed that this morphological indicator varied in higher limits, depending on the species and region of origin. The most sensitive species to pollution was *Aesculus hippocastanum*, which had the largest necrotic area: 74.36 cm^2 at the control version and 156.43 cm^2 the average of the five variants from the polluted areas. The other two species studied were more resistant to pollutants. Thus, the leaves of control version of both species showed no necrosis, while at the five variants from polluted areas, necrotic areas were averaged 81.66 cm^2 at *Populus x canadensis* species and 83.08 cm^2 at *Tilia tomentosa* species.

Pollution degree of the area influenced the necrotic surface. *Aesculus hippocastanum* species, more sensitive to pollution, has much higher differences in necrotic surfaces of leaves ranging between 74.36 cm^2 at control version and 227.87 cm^2 at Podul de Piatră version. A large necrotic surface of 179.34 cm2 was found at the variant from Tomeşti.

The other two species studied were more resistant to pollutants, with smaller differences between necrotic areas. Both *Populus x canadensis* species and *Tilia tomentosa* had the largest necrotic surface of the leaves determined at the Tomeşti variant (respectively 94.07 cm^2 and 100.33 cm^2), and the smallest surface affected was determined at Podul de Piatră version (respectively 71 , 20 cm^2 and 49.71 cm^2).

Observations on the micromorphological changes showed that on the upper epidermis of the leaves of *Aesculus hippocastanum* species and *Populus x canadensis* species individuals were found rarest deposits of foreign solids, probably because they are washed by rain. Exceptions make *Tillia tomentosa* species individuals that presented deposits in the form of crusts.

The amount of solids deposited on the lower epidermis is higher in *Aesculus hippocastanum* and *Populus x canadensis* species individuals, while the leaves of the *Tillia tomentosa* species

showed numerous tector hairs wich had isolated solid deposits. These deposits can obturate the stomata ostiole, affecting physiological processes in leaves.

At the *Populus x canadiensis* species was found an epiphytic microflora health affecting it.

Measurements on the **leaves surface**, made at the end of the growing season, showed that *Aesculus hippocastanum* species had the highest leaf surface (567.00 cm^2), followed by *Tilia tomentosa* species (60.91 cm^2) and *Populus x canadensis* species (51 , 39 cm^2).

All three species, from the five polluted areas, had lower leaf surface compared with the control, an average of 1.08 times. Most affected were the *Populus x canadensis* species leaves that were less than 1.23 times compared with the control, while the least affected were *Aesculus hippocastanum* species leaves that were smaller than the control of only 1.06 times.

The degree of pollution of the five areas influenced different the growth of leaves. Thus, the lower surface of the leaf was found on plants in the Podul de Piatră area, where they averaged 1.26 times lower, reflecting poor environmental conditions.

The average intensity of the **photosynthesis process** of the plants in the control variant was higher at *Tilia tomentosa* species (3.27 micromoles $CO_2/m^2/s$), had an intermediate value at *Populus x canadensis* species (3.19 micromoles CO_2 $/m^2/s$) and were lower at *Aesculus hippocastanum* species (1.88 micromoles CO_2 $/m^2/sec$).

Pollution manifested by the fact that variants from the polluted areas had at the end of the growing season the average value of the intensity of this process less, compared to the control, 1.95 times at *Populus x canadensis* species, 1.52 times at *Tilia tomentosa* species and 1.34 times lower at *Aesculus hippocastanum* species. Less drastic decrease in the intensity of the photosynthesis process at *Aesculus hippocastanum* species was not due to the effect of pollution, but to the fact that this species has a lower intensity of photosynthesis process, compared to other species analyzed.

The lowest intensity of photosynthesis process was determined at the variants from Podul de Piatră area: 1,42 micromoles $CO_2/m^2/s$ at *Populus x canadensis* species, 0.82 micromoles $CO_2/m^2/s$ at *Tilia tomentosa* species and 0.70 micromoles $CO_2/m^2/s$ at *Aesculus hippocastanum* species, that from this point of view can be considered the most polluted area.

Intensity of **respiration process** of leaves varied depending on the species, phenophase and the degree of atmospheric pollution; was higher at *Aesculus hippocastanum* species (0.94 micromoles $CO_2/m^2/s$) and youth phase (from 1.04 to 1.28 micromoles $CO_2/m^2/s$).

Pollution manifested by the fact that variations from these areas, compared with the control, had at the end of the growing season the average value of the intensity of this process less than 2.81

times at *Aesculus hippocastanum* species, 1.40 times at *Populus x canadensis* species and 1.34 times lower at *Tilia tomentosa* species.

The lowest intensity of the respiration process was determined at the variants from the Podul de Piatră area: 0.54 micromoles $CO_2/m^2/s$ at *Populus x canadensis* species, 0.47 micromoles $CO_2/m^2/s$ at *Aesculus hippocastanum* species and 0.39 micromoles $CO_2/m^2/s$ at *Tilia tomentosa* species, which from this point of view can be considered the most polluted area.

The highest intensity of **transpiration process** was determined at the *Tilia tomentosa* species (1.53 micromoles $H_2O/m^2/s$), followed by *Populus x canadensis* species (1.32 micromoles $H_2O/m^2/s$) and *Aesculus hippocastanum* species (1.20 micromoles $H_2O/m^2/s$).

Young leaves (May) had the highest intensity of the transpiration process (1.43 micromol H2O / m2 / s) and during ripening, when the protective waxes increased, intensity of this process decreased to 1.19 micromoles $H_2O/m^2/s$ in June and to 0.98 micromoles $H_2O/m^2/s$ in September. At the variants from the polluted areas, where also grew the necrotic tissue surface, the decrease was higher (1.48 to 1.70 times).

The pollution caused the appearance of necrosis on the surface of the leaf lamina, which lead to the reduction of the intensity of the transpiration process, compared with the control variants, of 1.22 times at *Aesculus hippocastanum* species and *Populus x canadensis* species: and 1.47 times at *Tilia tomentosa* species.

The lowest intensity of the transpiration process was determined at *Aesculus hippocastanum* and *Tilia tomentosa* species leaves from the Podul de Piatră area and those of *Populus x canadensis* species derived from Decebal – Cantemir area.

Leaves from control variant had a higher **water content** for *Populus x canadensis* species where species (67.09%) and lowest for *Aesculus hippocastanum* species (67.09%) and *Tilia tomentosa* species (65.23%). Young leaves (May) had a higher water content (67.98 to 69.91%) and mature (September) had the lowest water content (56.67 to 68.96%).

The five variants from the polluted areas had average water content of leaves, lower compared to the control by 1.05 times at *Populus x canadensis* species, 1.09 times at *Aesculus hippocastanum* species and 1.10 times at *Tilia tomentosa* species, due to increase in areas of necrotic tissue, which have lost water. The lowest water content was determined in leaves of *Aesculus hippocastanum* and *Tilia tomentosa* species from the Podul de Piatră area and in leaves of *Populus x canadensis* species from Tomeşti area.

Total chlorophyll content (a + b) was higher in the leaves of control variants: 117.10 mg / 100g at *Tilia tomentosa* species, 151.22 mg / 100g at *Aesculus hippocastanum* species and 114.74 mg / 100 g at *Populus x canadensis* species.

The leaves had a lower total chlorophyll content in May (109.30 to 167.39 mg / 100g), it increased in July (126.07 - 183,64mg / 100g) and decreased in September (108.76 to 171.10 mg / 100g), when there was transition to senescence phase.

The average content of total chlorophyll in leaves of five variants from the polluted areas was lower in all species taken in research, thereby indicating the negative effect of pollution on the fotosintetizator pigment. In all three species, the lowest chlorophyll content was determined in leaves of plants from Oancea - Tătăraşi area and Podul de Piatră area. It ranged between 82.64 mg/ 100g and 99.15 mg/ 100g at *Aesculus hippocastanum* species, between 55.28 mg/ 100g and 59.87 at *Populus x canadensis* species and between 67.37 mg/ 100g and 81.31 mg/ 100g at *Tilia tomentosa* species.

The soluble protein content varied significantly in the investigated plant leaves, according to phenophase, with a clear reduction in all the specimens of the three species of woody plants studied from Podul de Piatră area.

Peroxidase activity increased in all specimens of the three species grown in the Podul de Piatră area, as a possible response reaction to abiotic stress incurred in that urban area (traffic area).

The values of **correlation coefficients** between air pollutants and various physiological and biochemical parameters analyzed suggest, for woody species specimens grown for ornamental purposes in Iaşi, a stronger effect of gaseous pollutants on foliage compared to the solid ones.

Whatever their nature, atmospheric pollutants clearly **exert injurious to woody plants grown for ornamental purposes** in the urban area of Iaşi. Reactions of plants to the action of air pollutants are largely physiological and biochemical, the maximum negative effects on ornamental woody vegetation being recorded in the Podul de Piatră area, traffic area.