UDK 581.1

INFLUENCE OF MOTOR TRANSPORT EMISSIONS ON THE FUNCTIONAL STATE OF SEEDS OF WOOD PLANTS

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Исследовано влияние выбросов автотранспорта г. Днепропетровск на морфометрические и физиолого-биохимические показатели семян *R. pseudoacacia* L., *G. triacanthos* L., *A. negundo* L. и *A. platanoides* L. Выявлены особенности накопления в семенах тяжелых металлов, содержание белков и активность пероксидазы.

A. negundo L., A. platanoides L., R. pseudoacacia L., G. triacanthos L., тяжелые металлы, белки, пероксидаза

Heavy metals (HM) represent the greatest threat for environment on rates of their entering in biosphere and to toxicity level [1–3]. Industrial and motor transport emissions (lead, cadmium) are the basic sources of technogenic pollution in the big cities of Ukraine. In Ukraine motor transport gives approximately 30–40% of all pollution of atmosphere [4]. Thus, emissions of polluting substances by motor transport on the average make about 5,5 million tons per year (39 % of all volume of emissions in Ukraine). In large cities air pollution by exhaust gases reaches at times 70–90% of the total level of pollution. Nickel (4,0 maximum concentration limits), copper and cobalt (over 2,0 MCL) make the greatest contribution to soil pollution of Dnipropetrovsk [5]. Improvement of ecological situation in the city environment is possible only by maintaining of the high level of vital functions of plants [6]. For this purpose it is necessary to possess the sufficient information on plants adaptive possibilities which promote their survival in adverse conditions of urban area.

The aim of work is to study metabolism features in seeds of wood plants and accumulation of heavy metals in them in the conditions of influence of motor transport emissions.

MATERIALS AND METHODS

Seeds of *Acer platanoides* L., *A. negundo* L., *R. pseudoacacia* L. and *G. triacanthos* L. were chosen as objects of research. Trees as control test objects were taken from a countryside which has the minimum influence of technogenic pollution (Nikolaevka village, 100 km from Dnipropetrovsk). Seeds were collected in the streets of Dnipropetrovsk with intensive traffic of motor transport where wood plantings are located along a highway and sidewalk. Weight of 1000 seeds, contents of HM (Pb, Cd, Ni, Zn, Fe, Mn, Cu), light-soluble proteins (LSP), peroxidase activity (PA) are defined in mature seeds. Determination of the protein concentration (PC) was carried out according to the method of Bradford [7]. The activity of peroxidase was determined according to the method of Boyarkin [8]. Obtaining of acid-soluble extract for definition of the content of mobile forms of heavy metals was carried out according to Alekseyev Yu.V. Concentrations of HM were measured according to the method of flame atomic absorbtion spectrometry with spectrometer C–115 M-1.

Accumulation factor (F_a) counted as the relation of the quantitative content of an element in seeds of street plantings to their contents in control test objects [9]. Index of stability of plants (I_s) to excessive concentration of phytotoxic elements counted as a relation of morphometrical and biochemical indicator to size of this indicator in plants of control test object [10]. Statistical processing of the received data was carried out by standard techniques using of program MS Excel with confidential probability 0.95 [11].

RESULTS AND DISCUSSION

Results of definition of 1000 seeds weight, content of light-soluble proteins and peroxidase activity in mature seeds of four species of the wood plants growing in the conditions of action of motor transport emissions are presented in Table 1.

Table 1 – Morphological and biochemical parameters changing in mature seeds of wood plants in the conditions of motor transport emissions

Parameters	Species of wood plants					
	R. pseudoacacia L.			*G. triacanthos* L.		
	control	highway	I_s	control	highway	I_s
weight of 1000 seeds, g	30,0±2,81	22,0±0,72	0,73	203,8±3,65	154,3±3,20	0,76
PC, mg/ml	2,65±0,06	2,48±0,72	0,94	3,85±0,03	3,19±0,04	0,83
PA, ΔE/sec·g	78,8±4,72	124,9±0,72	1,59	84,9±0,13	107,2±0,15	1,26
	A. platanoides L.			*A. negundo* L.		
weight of 1000 seeds, g	73,5±0,38	59,8±0,27	0,81	44,7±0,13	38,5±0,18	0,86
PC, mg/ml	3,41±0,06	2,83±0,05	0,82	3,71±0,03	2,44±0,04	0,65
PA, ΔE/sec·g	65,0±1,76	102,8±0,54	1,58	67,9±1,78	106,0±1,47	1,56

Changing of size I_s depends on the level of pollution of plants phytoweight by toxicants and informativity of growth indicator and development of plants. Value of I_s of parameters of 1000 seeds weight and the content of proteins was lower than 1,0, that testifies the oppression of ability to vital functions of the investigated plants in the conditions of pollution of green plantings by exhaust gases of motor transport. Among the studied species the greatest decrease in weight of seeds was registered for *R. pseudoacacia* L. and *G. triacanthos* L. (on 27 and 24 % accordingly). Less degree of decrease in weight of seeds was observed at maples species which was on level 19 (*A. platanoides* L.) and 14 % (*A. negundo* L.).

The basic mechanism, which provides the realization of adaptive reactions of cells, is changing of activity of the genetic apparatus which is accompanied by corresponding corrections in biosynthesis of proteins [12]. The stability index (I_s) of protein content in seeds also was lower than 1,0. The least decrease in the content of LSP was typical for *R. pseudoacacia* L. (on 6 %), and the greatest is for *A. negundo* L. (on 35 %). It is supposed that the physiological sense of blocking of protein biosynthesis protein consists in reduction of power loading by a cell as protein biosynthesis is one of the most power-intensive metabolic processes and in adverse conditions can lead to the irreversible over-expenditure of power resources of a cell [13].

The important role in protective reactions of plants to stressful influences belongs to peroxidase which level of activity is characterised the adaptable ability of plants in unfavorauble conditions of environment. As our research has shown, catalitic activity of peroxidase in seeds of the investigated plants has raised: on 56–56 % in maples and acacia and on 26 % in seeds of gleditsia. It testifies the mobilization of antioxidant system of seeds and serves as one of protective reactions of a plant on stresses.

One of the reasons of decreasing of efficiency of fruiting and changes of a metabolism of seeds can be accumulation of heavy metals which as it is known in superfluous quantities are capable to form complex connections with cell components, proteins, amino acids, to contact SH-groups. The last plays an important role in course of many physiological and biochemical processes [14, 15]. According to Ilyin V.B. (1991) the highest quantity of HM accumulates in roots of plants, and the least is in seeds and fruits [16]. Our research has shown that seeds of the investigated plants in the conditions of influence of motor transport emissions are active enough to accumulate heavy metals (Table 2).

As our research has shown, in seeds of the studied species the content of microelements varies in following limits: Fe: 21,0–1065,3; Zn: 56,4–146,1; Cu: 7,4–27,8; Mn: 6,4–12,6; Ni: 3,6–12,4; Pb: 0,69–1,42; Cd: 0,12–0,92 mg/kg of a dry substance. The most considerable variation is marked for Fe and Cd. In seeds of plants distribution of HM has the features. Thus, in trees of *Fabaceae* L. family HM are distributed in order of decreasing as follows: Fe > Zn > Cu > Mn > Ni > Pb > Cd. In seeds the greatest degree of Zn accumulation is marked in maples. Besides, the distinction in the iron and copper content is registered: in seeds of *A. platanoides* L. the highest accumulation of copper is marked, while in *A. negundo* L. – iron. Seeds of *G. triacanthos* L. accumulate especially high quantities of iron.

Table 2 – Concentration of heavy metals in seeds of wood plants growing in the conditions of motor transport emissions

Element	Content of heavy metals, mg/kg					
	R. pseudoacacia L.			*G. triacanthos* L.		
	control	highway	F_a	control	highway	F_a
Mn	6,41 ± 0,04	7,88 ± 0,32	1,23	12,35 ± 0,49	11,33 ± 0,67	0,92
Cu	7,43 ± 0,02	11,61 ± 0,51	1,56	20,81 ± 0,25	22,63 ± 0,53	1,09
Fe	122,7 ± 5,87	214,3 ± 3,47	1,75	1065,29 ± 17,31	668,38± 12,4	0,63
Zn	69,6 ± 1,55	56,4 ± 1,79	0,81	77,93 ± 5,02	88,85 ± 0,91	1,14
Pb	0,77 ± 0,02	0,89 ± 0,05	1,16	1,03 ± 0,02	1,42 ± 0,03	1,38
Ni	5,31 ± 0,39	12,38 ± 0,23	2,34	7,39 ± 0,14	8,86 ± 0,31	1,20
Cd	0,12 ± 0,01	0,92 ± 0,03	7,67	-	-	-
	A. platanoides L.			*A. negundo* L.		
Mn	12,74 ± 0,68	15,60 ± 0,43	1,22	8,18 ± 0,34	9,32 ± 0,26	1,13
Cu	27,78 ± 0,61	26,62 ± 1,56	0,96	10,22 ± 0,37	19,93 ± 0,64	1,95
Fe	21,04 ± 0,78	22,31 ± 0,33	1,06	58,89 ± 1,39	63,93 ± 2,41	1,09
Zn	105,43 ± 9,14	117,01± 5,31	1,11	88,41 ± 1,88	146,14 ± 10,25	1,65
Pb	0,88 ± 0,02	0,95 ± 0,06	1,08	0,69 ± 0,04	0,98 ± 00,3	1,42
Ni	3,81 ± 0,21	4,83 ± 0,11	1,27	3,59± 0,45	5,21 ± 0,14	1,45
Cd	0,22 ± 0,01	0,26 ± 0,02	1,18	0,15 ± 0,01	0,16 ± 0,01	1,07

According to F_a in the conditions of motor transport emissions the highest ability to accumulation, in seeds of *R. pseudoacacia* L. nickel (2,34) and cadmium (7,67) have; in *A. negundo* L. – copper (1,95), zinc (1,65), lead (1,42) and nickel (1,45); in *A. platanoides* L. – nickel (1,27) and manganese (1,22). In seeds of *G. triacanthos* L. F_a values above 1.0 for lead (1,38), nickel (1,20), zinc (1,14), and copper (1,09) are registered. From all investigated plants growing in street plantings, the greatest degree of toxic elements in collected seeds was registered in *R. pseudoacacia* L. and *A. negundo* L.

Thus, the influence of motor transport emissions on accumulation of HM in seeds of wood plants appeared quite difficult. It is due to that motor transport emissions are a mixer of harmful substances, and especially, heavy metals, accumulated in ecosystems, operate independently from each other, and enter in interaction that influences the degree of their accumulation and toxicity. Thus, dependence on qualitative and quantitative structure of combinations of both summation of effects, and their antagonism was observed. So, it is known, that there is a competition between metals Zn^{2+} and Fe^{2+} which are connected with the close size of their ionic radiuses and similar coordinating ability [17]. In case of infringement of a natural parity of iron and zinc in cells, in particular at substantial growth of the maintenance of zinc as it takes place in seeds of *A. platanoides* L., replacement of ions Fe^{2+} in proteins-enzymes zinc ions is possible. Thus, it is possible to assume, that the competition between the metals arriving in excess, and the metals containing in functionally active proteins can be one of causes of infringement of the metabolism of seeds.

CONCLUDING REMARKS

1. The general lines of adaptive reactions of wood plants in urban area are the decrease of 1000 seeds weight, content of light-soluble proteins and increase of peroxidase activity which level depends on a plant genotype.
2. In seeds of the studied species the maximum concentration among heavy metals are inherent in iron (21,0–1065,3 mg/kg) and zinc (56,4–146,1 mg/kg), and minimum – to cadmium (0,12–0,92 mg/kg).
3. It is established that degree of accumulation of heavy metals depends on genotypic features of a plant: maples accumulate considerable quantities of zinc; *R. pseudoacacia* L. and *G. triacanthos* L. – iron.
4. Under influence of motor transport emissions in seeds of *R. pseudoacacia* L. the high accumulation of nickel and cadmium is observed; in *A. negundo* L. – copper, zinc, lead and nickel; in *A. platanoides* L. – nickel and manganese; in seeds of *G. triacanthos* L. – lead, nickel, zinc and copper.

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УДК 581.1

Шупранова Л.В. Вплив автотранспортних викидів на функціональний стан насіння деревних рослин / Шупранова Л.В., Таран Я.В. // Питання біоіндикації та екології. – Запоріжжя: ЗНУ, 2013. – Вип. 18, № 2. – С. 101–105.

Досліджено вплив викидів автотранспорту м. Дніпропетровськ на морфометричні і фізіолого-біохімічні показники насіння *R. pseudoacacia* L., *G. triacanthos* L., *A. negundo* L. і *A. platanoides* L.. Виявлені особливості накопичення в насінні важких металів, вмісту білків та активності пероксидази.

Бібл. 17. Табл. 2.