УДК 57.033

IMPACT OF CADMIUM ON THE GROWTH AND DEVELOPMENT OF PINUS SYLVESTRIS

**G. Valter, Assoc. Prof., Ph. D. (Biol.), Ye. Voronova, Assoc. Prof.,
N. Onats'ka, M.S., Kharkov National Automobile and Highway University**

Abstract. *The results of laboratory experiments of the effect of cadmium salt solutions on the growth processes and peroxidise activity in seedings of Pinus Sylvestris are presented.*

Key words: *cadmium salts, toxicity, sprouting energy, germination rate energy, peroxidise activity.*

ВПЛИВ КАДМІЮ НА РІСТ І РОЗВИТОК PINUS SYLVESTRIS

**Г.А. Вальтер, доц., к.б.н., Є.М. Воронова, доц., Н. М. Онацька, магістр,
Харківський національний автомобільно-дорожній університет**

Анотація. *Наведено результати лабораторного експерименту із впливу розчинів солі кадмію на ростові процеси й активність пероксидази в паростках Pinus Sylvestris.*

Ключові слова: *солі кадмію, токсичність, енергія проростання, енергія сходження, активність пероксидази.*

ВЛИЯНИЕ КАДМИЯ НА РОСТ И РАЗВИТИЕ PINUS SYLVESTRIS

**Г.А. Вальтер, доц., к.б.н., Е.М. Воронова, доц., Н.М. Онацкая, магистр,
Харьковский национальный автомобильно-дорожный университет**

Аннотация. *Представлены результаты лабораторного эксперимента по влиянию растворов соли кадмия на ростовые процессы и активность пероксидазы в проростках Pinus Sylvestris.*

Ключевые слова: *соли кадмия, токсичность, энергия проростання, энергия всхожести, активность пероксидазы.*

Introduction

In view of the increasing anthropogenic impact on the environment, the problem of emissions of heavy metals attracts more and more attention. Heavy metals is a group of metals with relative atomic weight over fifty or density higher than 5 g per cubic cm. Of the total ninety naturally occurring elements fifty three are considered to be heavy metals. Among such heavy metals as Zn, Ni, Cu, V, Co, W and Cr there are found non toxic heavy elements of low concentration. Such heavy metals as cadmium, lead, mercury, arsenic, etc., are not essential for plants and are highly phytotoxic, may inhibit vital processes or lead to death of living organisms. Heavy metals concentration in soil is considered to be toxic when it inhibits plant growth and development and decreases plant productivity by 10%–20%. However, the identification of toxic levels of heavy metals for plants is a rather complicated problem. Knowledge of environmental conditions, heavy metals forms and their stability in the environment, plant properties, etc., are of great importance for the assessment of heavy metals toxicity.

Phytotoxic amounts of heavy metals are occasionally found in soils under natural con-ditions but more frequently they are mobilized and released by technological and agricultural activities and tend to persist indefinitely, to cir-culate

and eventually to accumulate throughout the food chain, thus posing a serious threat to animals, humans, and the environment. In Europe, the polluted agricultural lands likely encompass several million hectares [3].

The similarity to essential elements makes non-essential elements potentially toxic to plants. Toxicity symptoms can be derived from interactions at cellular/molecular level, such as blocking functional groups of bio-logically important molecules, displacing and/or substituting essential elements, inactivating en-zymes, disrupting cell and organelle membrane integrity. A high amount of metals in the tissue of hyperaccumulator plants suggests the existence of protective mechanisms to avoid harmful effects caused by metals. These mechanisms are quite complex and their impor-tance may vary in accordance with the metal, its concentration, species, plants organs, and stages of the development in the same plant, etc.

Analysis of publications

Despite numerous reviews and reports on heavy metals in literature, the study of phytotoxicity mechanisms is still incomplete. The study of physiological and biochemical parameters of reproductive organs of plants tissues is of significant interest for understanding the mechanisms of generative development. In recent decades, more and more articles appeared on the growth of biosphere pollution by heavy metals, including cadmium. It represents a maximum potential danger for plants, animals and people as it has a high cumulative effect and a high rate of techno-genic accumulation in the environment [5]. According to the phytotoxicity classification, cadmium is a moderately toxic element as it inhibits the life activity of test organisms at concentrations of 1–100 mg/dm^3 [1]. Cadmium is mobile in plants and is accumulated in all plant organs and seeds as well [3]. Numerous studies highlighted in the literature, allow to assert that the flow of the most physiological processes in plants varies considerably in terms of pollution emissions, gas-smoke emissions of various businesses. Change of peroxidise activity in a stressful environment may be an indicator of phytotoxicity.

The purpose and problem statement

The aim of this work was to investigate the effects of salt solutions of cadmium on the growth processes and peroxidise activity in seedings of Pinus Sylvestris.

To achieve this purpose it was necessary to execute a series of laboratory experiments using Pinus Sylvestris seeds and cadmium salts in different concentrations.

Results of the research of cadmium salts effect on Pinus Sylvestris

This article presents the results of laboratory experiments of the effect of cadmium salt solutions on the growth processes and peroxidise activity in seedings of Pinus Sylvestris.

For the experiment there were selected seeds . In the studies it was used aqueous solutions of cadmium sulfate of different concentrations: ($2\cdot10^{-5}$; $2\cdot10^{-4}$; $2\cdot10^{-3}$; $2\cdot10^{-2}$ M). Toxicity of cadmium ions was evaluated by vigor and seed descent, linear growth of seedings and vegetative mass, changes of peroxidise activity.

To determine the vigor and germinating power, of pre-sterilized seeds (50 pieces), they have been soaked in solutions of cadmium sulfate for 24 hours and then washed with distilled water and placed in a petri dish [4]. Vigor seeds (in percent) were calculated on the seventh day, and germination power (in percent) – on the 15th (GOST 13056.6-75). Seeds treated in distilled water were taken as a control option. In the study of the influence of cadmium ions on the growth processes of Pinus Sylvestris seeding presprouted seeds were transferred to cadmium salt solutions of different concentrations (20 seeds in each glass). After 15 days the seedings were measured in linear dimensions (mm).

It was determined that cadmium ions in all studied concentrations affect the growth processes (Fig. 1).

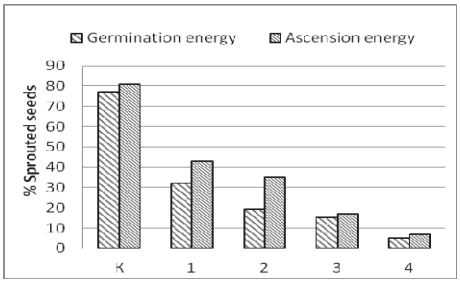

Fig. 1. Effect of cadmium ions on seed intergrowth of Pinus Sylvestris: K – control, concentration of Cd in solution: 1 – $2\cdot10^{-5}$ M; 2 – $2\cdot10^{-4}$M; 3 – $2\cdot10^{-3}$ M; 4 – $2\cdot10^{-2}$ M

Vigor and germination power of seeds decreased by 58–92 % and 48–91 % respectively.

Peroxidise activity was evaluated by the method of A. Boyarkin (Fig. 2).

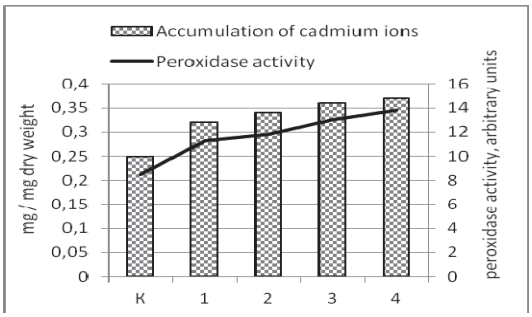

Fig. 2. Effect of cadmium ions on peroxidise activity and its accumulation in 15-day seedings of Pinus Sylvestris: K – control, concentration of Cd in solution: 1 – $2 \cdot 10^{-5}$ M; 2 – $2 \cdot 10^{-4}$ M; 3 – $2 \cdot 10^{-3}$M; 4 – $2 \cdot 10^{-2}$ M

Accumulation of cadmium ions (mg / mg dry weight) in 15-day seedings was analyzed by x-ray fluorescent spectrometer Spectroskan. The frequency of each variant of the experiment constituted fivefold. The mathematical treatment has been studied by correlation and analysis of variance.

A visual assessment of 15-day seedings have been grown in cadmium salt solutions and there it was determined the top color change to brown, blackening of it crown, there was marked a slight withering and yellowing of needles at a concentration of ($2 \cdot 10^{-2}$ M), which is associated with exposure to toxicants pigment complex and activation of free radical oxidation.

Conclusion

It was found a high correlation between the level of accumulation of cadmium in the organs of assimilation and peroxidise activity, indicating the depressing effect of the studied concentrations of cadmium ions on seeds germination and seeding growth processes P. Sylvestris. This effect is confirmed by literary sources writing that a contaminated growth increases peroxidise activity in the assimilation system Pinus Sylvestris.

However, changes in the activity of peroxidise in plant needles growing in polluted technogenic conditions may be due to the influence of various stress factors, which complicate the use of peroxidise activity indicator for bioindicators.

The last 10–15 years were marked by a considerable progress in studying of the problem of plants tolerance and adaptation to heavy metals environment pollution. However, the problem has not completely been solved yet. The further production development, the earth population increase and resource consuming, contamination of the environment, and accelerating imbalance in nature compel us to take strong measures regarding defense and maintenance of biodiversity. Therefore, the extension of knowledge of ecological adaptations of plants is of great importance.

Reference

1. Плешков Б.П. Практикум по биохимии растений/ Б.П. Плешков. – 2 изд.– М.: Колос, 1976. – 256 с.
2. Третьяков Н.Н. Практикум по физиологии растений / Н.Н. Третьяков, Т.В. Карнаухова, Л.А. Паничкин. – М.: Агропромиздат, 1990. – 272 с.
3. Pessarakli M. Hand Book of Plant and Crop Stress / M. Pessarakli. – New York: CRC Press, 2011. – 1188 p.
4. Шуберт Р. Биоиндикация загрязнений наземных экосистем / Р. Шуберт; пер. с нем. Г.И. Лойдина. – М.: Мир, 1988. – 356 с.
5. Heldt H-W. Plant Biochemistry (3rd edition)/H-W. Heldt, F. Heldt. – London: Elsevier Academic Press, 2005. – 652 p.

Рецензент: Н.В. Внукова, профессор, к. геогр. н., ХНАДУ.

Стаття поступила в редакцию 3 марта 2014 г.