

невий шлях надходження важких металів тому рівень їх акумуляції був вищим в коренях, ніж у лисках. Високі рівні ТБК-активних сполук у коренях проростків спостерігалися за присутності в середовищі вирощування іонів кадмію  $10^{-5}$  М, нікелю  $10^{-4}$  М та цинку  $10^{-4}$  М – уміст вторинних продуктів перевищував показники контролю майже втричі. На відміну від цього, в надземній частині кількість ТБК-активних сполук зростала у 2 рази порівняно з контролем за дії максимальних концентрацій цинку та нікелю. Мінімальні концентрації всіх токсикантів в різних варіантах дослідження індукували зростання рівня вільнорадикальних реакцій лише на 20-40% як у коренях, так і в надземній частині.

Підсумовуючи зазначимо, що вищевказаний характер розвитку оксидативного стресу пов'язаний з тим, що більша кількість досліджуваних важких металів переважно акумулювалась в тканинах кореня і в меншій кількості надходила до надземної частини проростків.

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**BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION  
OF MILLIMETER RANGE ON MEDICINAL AND AGRICULTURAL CROPS  
ON THE EARLY STAGES OF ONTOGENY**

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This article describes the influence of low-intensity electromagnetic radiation of the millimeter range on *Calendula officinalis* L. plants. Species-specific influence of the exposure depending on the frequency and time on the level of certain plant hormones, activity of antioxidant enzymes, accumulation of phenolic compounds and, as a consequence, on the growth processes on the early stages of ontogeny has been described.

We evaluated the effect of EMR on the early, and therefore, the most vulnerable the subcellular to the organismic. Understanding of this problem will allow for deliberate use of EMR for more complete realization of the potential inherent of living organisms.

Medicinal plant *Calendula officinalis* L. variety 'Machroviy 2000', Belarus was chosen for the study. Microwave electromagnetic radiation in two frequency ranges was selected to study the physical effects on the seeds of the mentioned above plants: wide range mode (the processing frequency of 53,57-78,33 GHz with the treatment exposure times of 20 min (R1), 12 min (R1.1), and 8 min (R1.2) and narrow range mode (the processing frequency of 64,00-66,00 GHz with the same treatment exposures of 20 min (R2), 12 min (R2.1), 8 min (R2.2). Seed treatment was carried out at the Institute for Nuclear problems of Belarusian State University in a laboratory microwave installation for seed treatment in a wide frequency range (37 to 120 GHz) with infinitely adjustable power from 1 to 10 mW. The evaluation of germination and seedling morphometric parameters was carried out on the 7th and 14th days of the experiment. The activity of peroxidases (PO), catalase (CAT), superoxide dismutase (SOD) were evaluated. Free phytohormones, indole-3-acetic acid (IAA), abscisic acid (ABA), and zeatin riboside (ZR), were quantified in the above-ground parts of 7-day-old *Calendula officinalis* seedlings by enzyme immunoassay (EIA) using specific to ZR, IAA, ABA rabbit sera and anti-rabbit antibodies that were labeled with peroxidase.

Specific effects of EMR of the narrow and wide frequency ranges on *C. officinalis* plants were observed. EMR in the narrow frequency range causes an increase of all studied hormones, particularly ZR, and the highest one was observed in Mode R2.1. A reduction of the IAA level was observed only in R1.2. It is also found that EMI caused a change in the ratio of phytohormones in the juvenile plants. ZR content relative to ABA in juvenile seedlings was maximal after 12 min exposure in both frequency bands, while EMR treatment for 20 min reduced the level of ZR as compared to IAA, but the total value was higher than that for the control. It was found that EMI caused a slight increase in the level of ABA from 6 to 48%, increased the contents of IAA and ZR, and thus exhibited the growth promoting and protective effect. Used EMR modes lead to the stimulation of growth processes in seedlings. However, if the seedling/root growth ratio is taken into account one can reveal that the growth processes in length and mass in all the modes except R1.2 were shifted towards the roots. The correlation between the mass of calendula seedlings and the level of ZR was revealed, i.e. increasing the amount of ZR reduced the average weight of the germ. A decrease of the PO level was observed under all the processing conditions and this effect increased by 14th day. Whereas the activity of CAT increased in the treated plants. SOD activity in the control decreased from the 7th to 14th day by a factor of 2 while EMI processing in R1 and R2 led to an increase in the enzyme activity. An increased level of phenols relatively to control was found on the 14th day. The maximum increase was observed on the 7th day for 8 min exposure in the narrow range mode and on the 14th day for 12 min exposure in two frequency bands.

All EMR modes decreased the activity of PO to varying degree. It was found that the minimum exposure increased CAT activity on 20% compared to control, and after the maximum time (20 min) the discussed parameter was sharply reduced by 43%.

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**ВОДОУТРИМУЮЧА ЗДАТНІСТЬ ЛИСТКІВ РОСЛИН PHLOX PANICULATA L.  
В УМОВАХ ЛІСОСТЕПУ УКРАЇНИ**

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**Skrypka G.<sup>1</sup>, Kytayev O.<sup>2</sup>, Kryvoshepka V.<sup>2</sup> WATER RETENTION PROPERTIES  
OF PHLOX PANICULATA L. IN THE FOREST STEPPE CONDITIONS OF UKRAINE.**

Water-retention capacity of *Phlox paniculata* L. plant leaves was studied under the forest steppe conditions of Ukraine. The rate of weight loss within 24 hours of air-dry exposure was analyzed to identify drought-resistant varieties. The varieties Tenor and Poliarnyi were determined to be the most drought-resistant.

На сьогодні у квітникарстві все більшою популярністю користуються рослини *Phlox paniculata* L., які належать до родини Polemoniaceae L. de Jussieu, порядку Polemoniales, роду *Phlox* L. (Takhtajan, 2009). За різними даними загальна кількість сортів налічує від 2000 до 3000 [Бутенкова, 2014]. Для їх успішної інтродукції велике значення має вивчення не лише декоративних ознак, а й господарсько-біологічних особливостей, зокрема - стійкості до абіотичних факторів довкілля.