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CORRECTION OF SOWING QUALITY OF MEDICINAL PLANTS SEEDS WITH ECHINACEIA EXTRACTS

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The paper presents experimental data on the effect of echinacea extracts on the sowing qualities of medicinal herbs. The biological activity of extracts obtained from the areal part (EAP) and rhizomes with roots (ERS) of pale echinacea was investigated. The object of study was the sowing quality of the seeds of such medicinal plants as blue cornflower (Centaurea cyanus L.), purple echinacea (Echinacea purpurea (L. Moench.), pale echinacea (Echinacea pallida (Nutt.) Nutt.), St. John's wort (Hypericum perforatum L.), forest mallow (Malva sylvestris L.), which are of industrial importance for medicinal plants. The seeds were soaked in 0.01%-0.0001% solutions of extracts, under the control they were treated with water, after that they were germinated in Petri dishes by generally accepted methods according to the standards. The best results were obtained in mallow seed extracts. The solution of EAP at a concentration of 0.001% increased the energy of germination by 19.2% compared to the control, and when using ERS in all concentrations, a positive effect was obtained (by 18.2 %-23.6% to the control). Germination of variants treated with EAP solutions increased by 1.12-1.21 times, and ERS – by 1.09-1.21 times. Treatment of Echinacea purple seeds with EAP solutions was not effective, but rhizome extract treatment with roots had a positive effect on both germination energy and germination resulting 12.0%-17.3% and 8.3%-9.5% compared to the control, respectively. Similar regularities were observed in variants with the treatment of Echinacea seeds with extracts in different concentrations. The action of EAP solutions did not statistically exceed the control, but when using ERS, the results reliably exceeded the control by 10.8%-13.8% (germination energy) and by 11.0%-17.8% (germination). Treatment of St. John's wort and cornflower seeds with extracts did not lead to changes in seed quality indicators. A general trend of greater activity of extracts in concentrations of 0.01%-0.001% was observed.

Key words: *medicinal plants, seed quality, echinacea extracts, purple echinacea, pale echinacea, forest mallow, blue cornflower, St. John's wort.*

КОРЕКЦІЯ ПОСІВНИХ ЯКОСТЕЙ НАСІННЯ ЛІКАРСЬКИХ РОСЛИН ЕКСТРАКТАМИ ЕХІНАЦЕЇ

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В роботі наведено експериментальні дані щодо впливу екстрактів ехінацеї на посівні якості насіння лікарських культур. Було досліджено біологічну активність екстрактів, які отримували з надземної частини (ЕНЧ) та кореневищ з коренями (ЕКС) ехінацеї блідої. Об'єктом вивчення були посівні якості насіння таких лікарських рослин як: волошки синьої (Centaurea cyanus L.), ехінацеї пурпурової (Echinacea purpurea (L. Moench.), ехінацеї блідої (Echinacea pallida (Nutt.) Nutt.), звіробою звичайного (Hypericum perforatum L.), мальви лісової (Malva sylvestris L.), які мають промислове значення для лікарського рослинництва. Насіння замочували у 0,01 %-0,0001 % розчинах екстрактів, в контролі обробляли водою, після чого пророщували у чашках Петрі за загальноприйнятими методиками згідно стандартів. Найкращі результати були отримані за дії екстрактами насіння мальви. Розчин ЕНЧ в концентрації 0,001 % збільшив енергію проростання на 19,2 % по відношенню до контролю, а при застосуванні ЕКС в усіх концентраціях був отриманий позитивний ефект (на 18,2 %-23,6 % до контролю). Схожість на варіантах з обробкою розчинами ЕНЧ зросла в 1,12-1,21 разів, а ЕКС - в 1,09-1,21 разів. Обробка насіння ехінацеї пурпурової розчинами ЕНЧ була не ефективною, але обробка екстрактом кореневищ з коренями позитивно вплинула як на енергію проростання, та і на схожість: на 12,0 %-17,3 % та 8,3 %-9,5 % до контролю відповідно. Подібні закономірності відмічалися і на варіантах з обробкою насіння ехінацеї блідої екстрактами в різних концентраціях. Дія розчинів ЕНЧ статистично не перевищувала контроль, але при застосування ЕКС результати достовірно перевищували контроль на 10,8 %-13,8 % (енергія проростання) та на 11,0 %-17,8 % (схожість). Обробка насіння звіробою та волошки синьої екстрактами не призвела до зміни показників посівної якості. Спостерігалась загальна тенденція більшої активності екстрактів в концентраціях 0,01 %-0,001 %.

Ключові слова: *лікарські рослини, посівні якості, екстракти ехінацеї, ехінацея пурпурова, ехінацея бліда, мальва лісова, волошка синя, звіробій звичайний.*

In medicinal plant production, an important factor in the successful creation of a plantation is the quality of the seed material (Vozhehova R.A. et al., 2021; Kutsenko N.I., 2016). This is dependent on the friendliness of seedlings and the further development of plants. The factors that determine seed quality can be conditionally divided into production and biological factors. The production period can include seed harvesting time, material cleaning quality, storage time and methods, etc. (Kalenska S. M., 2011). Moreover, each medicinal culture has its own specific requirements, which is explained by their biological features. For example, for valerian and milk thistle, the timing of harvesting is critical because if they are late, the harvest may not be obtained at all. In echinacea, the seeds ripen in September, but harvesting at a later date will only positively affect its germination.

In the process of acclimatization and implementation of breeding programs, the germination usually improves (Rahmetov D.B., 1999; Zhang L. et.al., 2023; Carrubba A. et al., 2023). Nevertheless, seed dormancy of agricultural crop seeds is quite natural and refers to organic dormancy. There are different ways of interrupting and overcoming it, depending on the nature of the phenomenon. For this, physical, chemical, biological methods and their combination are used, which allows to obtain the desired result.

For medicinal plants, pre-sowing seed treatment is insufficiently studied and applies to a limited number of species that have been introduced into culture for a long time. Of the species that we studied, researchers paid the most attention to the species of the Echinacea genus, which is explained by the natural low seed germination, especially narrow-leaved Echinacea (*Echinacea angustifolia* DC.) and market interest in these medicinal plants (Freund S. K., et al., 2022; Parsons J. L. et al., 2018). Thus, various methods of stratification were studied, which involved the use of low temperatures of different validity periods, the combination of dry and wet storage at low temperatures, the use of plant growth regulators against the background of storage at a temperature of 0-5 ºC (Yurteri E. et al., 2021). The use of growth regulators of synthetic and biological nature is promising, which involves the treatment of seeds for different durations, with different concentrations, in combination with trace elements (Sagvand M. et al., 2022). As for other medicinal plants, similar problems occur when growing ginseng (Ge N. et al., 2023), valerian (Bhat B. et al., 2015), St. John's wort (Güleryüz G. et al., 2021; Vicente M.J. et al., 2020; Porceddu M. et al., 2020), mallow (Chorbatdjian R., Kogan M., 2004), astragalus (Pankova O. et al., 2022), belladonna (Rudnyk-Ivashchenko O.I. et al., 2016).

It is worth noting that the phytosanitary state of the seeds of medicinal plants has a significant impact on field germination. This is explained by their presence of carbohydrates, fatty oils, and a number of substances that are favourable for the development of microflora. In this regard, the study of compounds of natural origin is a very promising direction (Pospelov S.V. et al., 2019). It was established that the extracts of medicinal plants St. John's wort, yarrow, caraway, calendula, which contain phytolectins, affect the germination of teliospores of barley fly ash. In concentrations of 0.05%-0.1%, individual extracts effectively inhibited the germination of pathogens. After separation of phytolectins from the extracts, their biological activity changed, which confirms a certain role of phytohemagglutinins in these processes.

The search for effective biologically active compounds, especially of plant origin, for the purpose of correcting the sowing qualities of the seeds of medicinal plants is primarily a production necessity, and research in this sense is promising and relevant.

The purpose of the research was to evaluate the biological activity of Echinacea palea extracts in the direction of improving the sowing qualities of the seeds of some medicinal plants that are of industrial importance.

Research materials and methods. The research was carried out in the laboratory of the Department of Agriculture and Agrochemistry named after V. I. Sazanova of the Poltava State Agrarian University. Seeds of Malva sylvestris L., purple echinacea (Echinacea purpurea (L. Moench.), pale echinacea (Echinacea pallida (Nutt.)), St. John's wort (Hypericum perforatum L.) and blue cornflower (Centaurea cyanus L .) were treated in 0.01%-0.0001% solutions of the extract of the aerial part of the pale Echinacea (EAP) and the extract of the rhizomes with the roots of the Echinacea pale (EAS), after that they were germinated in Petri dishes in four replicates, the germination energy and laboratory germination were determined. In parallel, we placed on germinating seeds treated with water for control. The comparison of data served as an assessment of the effectiveness of the extracts. The determination of seed qualities was carried out according to current standards. The reliability of the obtained data was assessed by the Student's t-test (Didora V.H. et al., 2013).

Research results. Low seed quality for medicinal plants is often associated with their biological characteristics and is reflected in the relevant standards. One of such cultures is the Malva sylvestris L.. This is a multi-purpose culture that is used as fodder, decorative, food, medicinal. The raw material for which it is grown are flowers, which are added to food products, and herbal preparations. The dormancy period in mallow seeds is not definite, but the natural level is not high, which prompts to look for new approaches to their regulation. As it can be concluded from the given data (Fig. 1), seed treatment with pale Echinacea extracts had a positive effect on the seed quality of the plant.

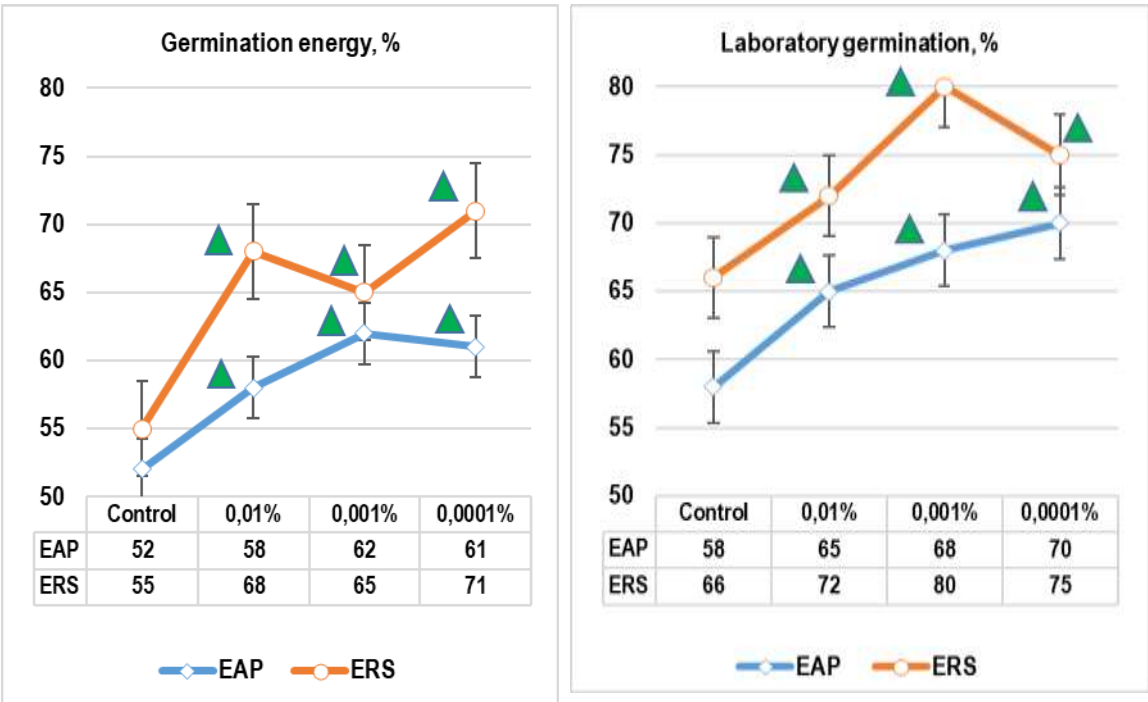

Fig. 1. **Sowing qualities of *Malva sylvestris* seeds depending on seed treatment. EAP – *extract of the aerial part of pale purple coneflower*, ERS – *extract of rhizomes with roots of pale purple coneflower*. ▲ – the difference between the control and the experiment is reliable according to the calculation of the Student's t-test.**

If in the control the energy of germination was 52%-55%, then under the treatment with extracts it increased to 58%-71% depending on the concentration. The extract of the aerial part (EAP) showed the best results at a concentration of 0.001% - the energy of germination increased by 19.2% compared to the control. In other concentrations, the positive effect was also reliable, but did not exceed 11.5%-17.3%. More effective was the treatment of seeds with rhizome extract from the roots of Echinacea palea (ERS). In all studied concentrations, the energy of germination significantly exceeded the control by 18.2%-23.6%. Moreover, the most effective was the 0.0001% concentration of the extract.

The above-mentioned regularities were preserved after accounting for laboratory germination. In the study of the extract of the areal part (EAP) in the control, the germination was 58%, while after the treatment, it reliably increased by 1.12-1.21 times. Thus, the greatest effect was obtained in the version with the use of 0.0001% of the solution with an increase in germination by 20.7%. A greater effect was achieved with the use of rhizome extract with roots (ERS). If the laboratory germination was 66% in the control, then it was 72%-80% in the experimental variants. The best result was obtained with the use of the extract at a concentration of 0.001%, that is 21.2% more than the control.

If we compare the effect of the extracts on the difference between germination and germination energy, the extract of the aerial part at a concentration of 0.0001% (increase between indicators 9%), and the extract of rhizomes with roots – 0.001% (increase in 15%) turned out to be the most effective.

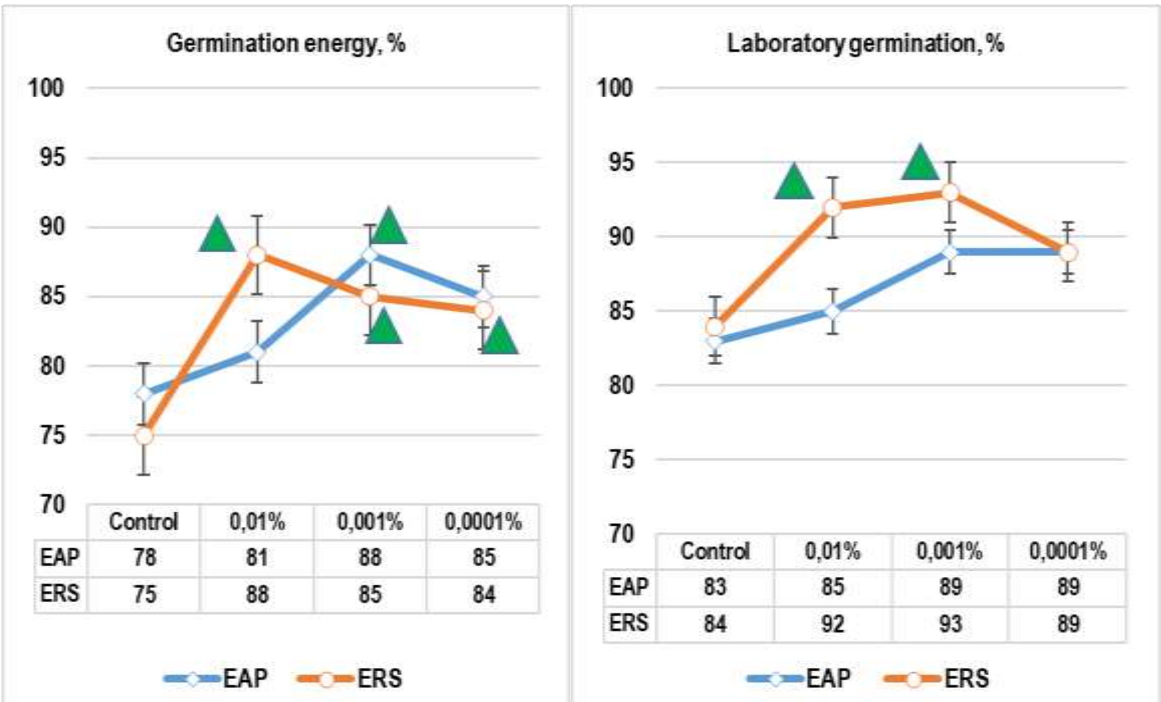

Fig. 2. **Sowing qualities of *Echinacea purpurea* seeds depending on seed treatment. EAP – *extract of the aerial part of pale purple coneflower*, ERS – *extract of rhizomes with roots of pale purple coneflower*. ▲ – the difference between the control and the experiment is reliable according to the calculation of the Student's t-test.**

American and European researchers who studied Echinacea purple and Echinacea pale, when they were not so popular among breeders and growers, noted significant fluctuations in the germination value: 36.7%-94.0% in Echinacea purple and 3.3%-66,0% in pale echinacea (Smith-Jochum C.C. et al., 1987). According to our data, after long-term cultivation in Ukraine, seed quality has become more stable and higher, especially in pale echinacea. Nevertheless, the problem of obtaining friendly seedlings in the field remains relevant. The results of the study of the effect of Echinacea palea extracts on the sowing quality of Echinacea purple seeds are shown in Figure 2. The general positive effect is observed after seed treatment with extract solutions. After treatment with extracts of the areal part (EAP), the energy of germination increased by 3.8%-

12.8% in relation to the control, while the most effective and reliable was the treatment of Echinacea purple seeds with a 0.001% solution of EAP. Better results were obtained on the variants of seed treatment with the extract of rhizomes with the roots of Echinacea paleus, where the energy of germination reliably increased by 12.0%-17.3% in relation to the control. After recording on the 14th day, the general trends were preserved, but the difference between the control and the options for the use of EAP was statistically not reliable and amounted to 2.4%-7.2%. ERS treatment in concentrations of 0.01% and 0.001% led to a significant increase in germination to 92%-93%, or by 8.3%-9.5% in relation to the control. It is also worth noting that only with the application of 0.001% ERS, the percentage of germinated seeds increased by 8% from the 7th to the 14th day, with other options the difference was 3-5%.

Similar studies were conducted with Echinacea palea seeds (Fig. 3). As it has already been mentioned above, the seed quality of this species is slightly lower than Echinacea purple. Moreover, we were interested in investigating the presence of allelopathic effects of extracts on the seeds of the same species. As a result, the insignificant influence of EAP on seed germination energy and laboratory germination should be outlined.

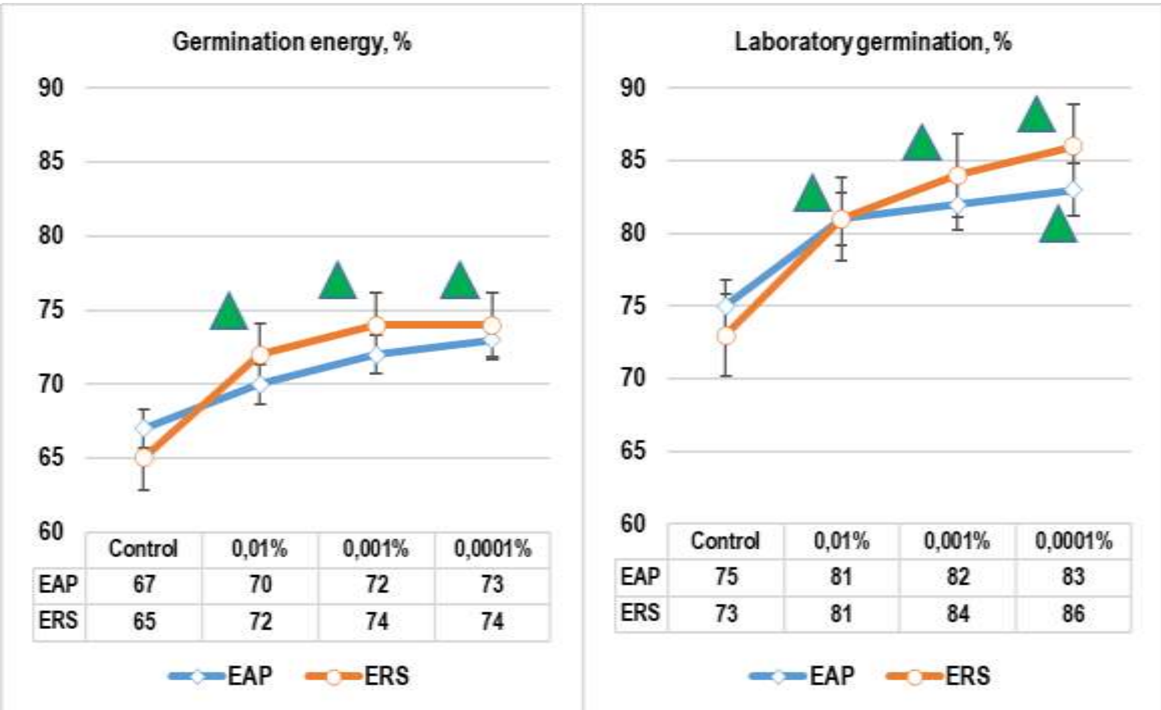

Fig. 3. **Sowing qualities of *Echinacea pallida* seeds depending on seed treatment. EAP – *extract of the aerial part of pale purple coneflower*, ERS – *extract of rhizomes with roots of pale purple coneflower*. – the difference between the control and the experiment is reliable according to the calculation of the Student's t-test.**

In relation to the control, the efficiency was 4.5%-9.0% and 8.0%-10.7%, respectively. Furthermore, a positive influence of ERS on indicators of seed quality was established. Compared to the control, the energy of germination after treatment with ERS solutions increased by 10.8%-13.8%, while the maximum indicators were obtained with 0.001% and 0.0001% (13.8%). The germination of seeds in experimental variants increased significantly by 11.0%-17.8% in relation to the control. It was also established that the difference between the indicators of germination energy and germination in the best variants was 10%-12% compared to 8% in the control, which was also an advantage of using ERS.

Blue cornflower is well-known as a pollutant of grain crops, in recent decades it has been grown for pharmaceutical and food production, used in gardening, floristry, etc. Biological features allow it to be grown in cycles throughout the year, so the seeds can be exposed to abiotic stresses. Meanwhile, preliminary studies have established that seed germination occurs in a wide range of temperatures: the minimum temperature for germination is +2 ºC, and the maximum is more than 30 ºC, from seven/ten days to two, respectively.

Despite the lack of post-harvest dormancy and high seed quality, it was important to investigate the response to pre-sowing seed treatment. It is worth noting that in our experiments we could not reliably establish a positive effect of Echinacea palea extracts on the germination of cornflower seeds, which is primarily explained by their natural high indicators (germination in the control 89%-92%). However, we can determine a stable positive trend: as a result of the treatment of seeds by EAP, their germination energy increased by 4.9%-7.4%, and germination increased by 3.4%-6.7%. After treatment with rhizome extract from the roots of Echinacea paleus (ERS), germination energy increased by 1.2%-6.0%, and germination increased by 3.3%-4.3%. In the future, a promising direction is the study of the effectiveness of the use of extracts under conditions of different temperatures during germination.

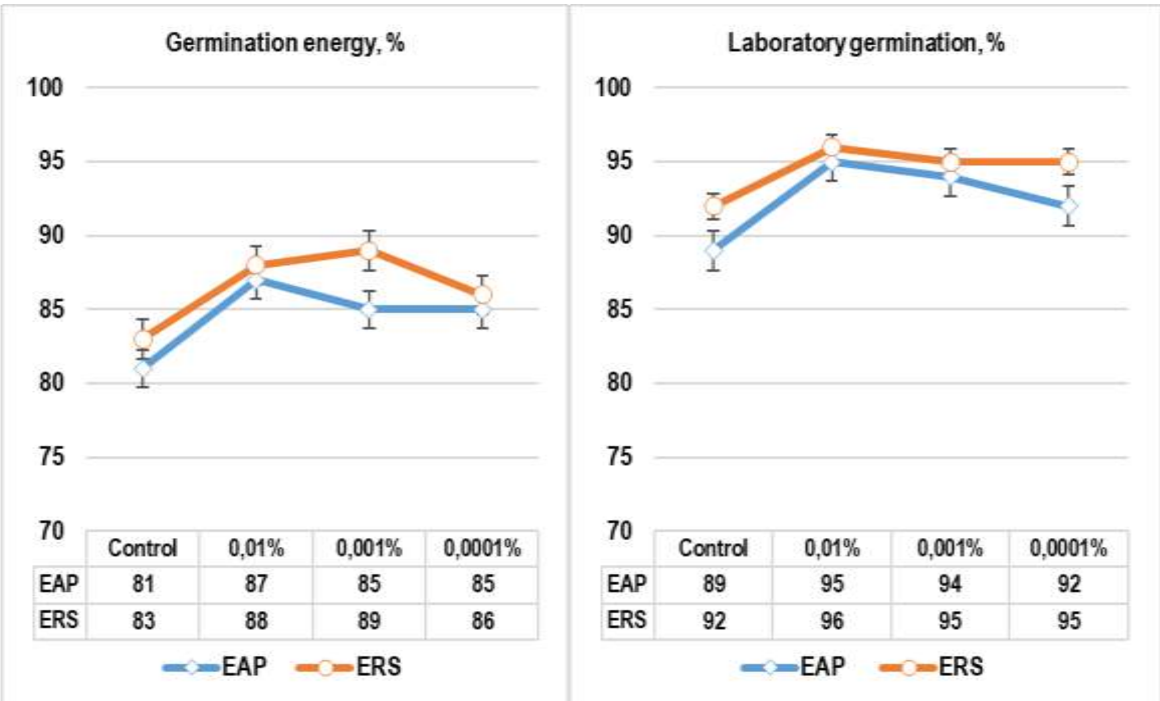

Fig. 4. **Sowing qualities of *Centaurea cyanus* depending on seed treatment. EAP – *extract of the aerial part of pale purple coneflower*, ERS – *extract of rhizomes with roots of pale purple coneflower*. There is no significant difference between control and study.**

In recent decades, attention to St. John's wort has been growing. Its raw materials are highly valued and used in the world for the production of antidepressants. Nevertheless, the quality of products collected in nature does not always meet the requirements of standards for raw materials, so companies corporately solve this problem by creating production units. Moreover, there are breeding achievements, cultivation technology is being developed (Ernst E., 2003). During cultivation, sowing and obtaining seedlings is a very problematic issue. Therefore, some aspects of seed quality regulation became the object of our research (Fig. 5). We define a significant increase in the germination energy under ERS at a concentration of 0.01% (+9.9% compared to the control). On the options, where EAP was used in different concentrations, the germination energy increased by 2.8%-5.6%, which was not significant. As for germination, some variants showed a non-significant decrease of 1.2%-2.5% compared to the control.

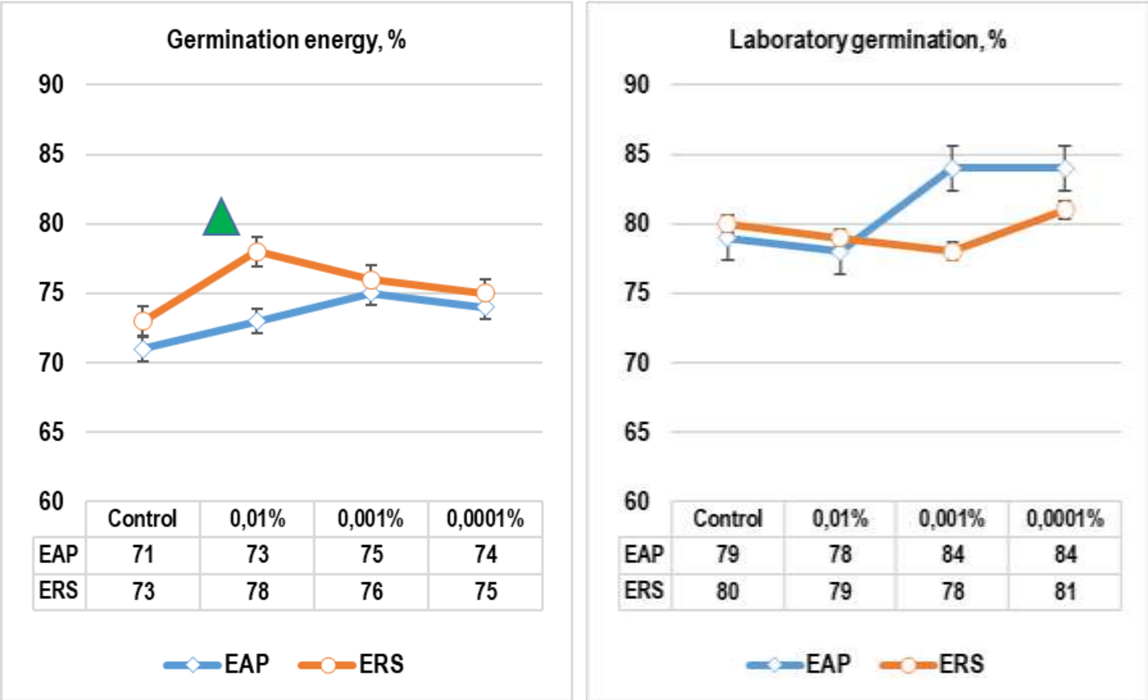

Fig. 5. **Sowing qualities of *Hypericum perforatum* seeds depending on seed treatment. EAP – *extract of the aerial part of pale purple coneflower*, ERS – *extract of rhizomes with roots of pale purple coneflower*. – the difference between the control and the experiment is reliable according to the calculation of the Student's t-test.**

Discussion. Extracts of plant origin deserve applied research, especially extracts of medicinal plants that contain various biologically active compounds. Some of them affect the physiological processes of plants and have bactericidal and bacteriostatic properties, which is the basis for the justification and development of preparations for organic crop production. Water and water-alcohol extracts can show a wide range of antimicrobial activity (Ivasivska A.S. et al., 2015, Shadid K.A. et al., 2021), which may have applied value in food technology (Dubinina A. et al., 2019).

Our earlier systematic studies of echinacea extracts allow us to draw a conclusion about their biological activity, which is explained by the presence of polysaccharides, hydroxycinnamic acid derivatives, lectins, etc. in them (Pospelov S. V., 2019). Aqueous extracts of leaves, rhizomes with roots and inflorescences of Echinacea purpurea specifically affected the growth of roots of spring barley depending on the temperature and concentration of the extract (Zdor V. M., 2019). Barley germination began during the first day, the best effect was established with leaf extracts (+21.0%-43.4%

compared to the control), rhizome extracts inhibited germination on the first day, but later the stimulation increased to 37.5% relative to control. Extracts of inflorescences showed their activity at the beginning of the experiment, later the length of the roots in the experiments and the control did not differ. The effect on the growth of barley differed in dynamics and effectiveness. At the end of the experiment, the positive effect of extracts of rhizomes with roots was up to +16.1% compared to the control. Leaf extracts inhibited growth after 1.5-2.0 days of the experiment, but active stimulation up to 69.0% compared to the control was observed later. The study of the action of the extracts at different temperatures (+25 ºC and +30 ºC) showed their higher efficiency at higher temperatures.

Studies of pale Echinacea and pharmacological study of its extracts conducted at the National Pharmaceutical University showed that the extracts contain a wide phytochemical complex and have anti-inflammatory, bactericidal and bacteriostatic effects (Diakonova Ya. V., 2009). On plant objects, it was established that Echinacea palea extract in concentrations from 10-2 to 10-11 stimulated the germination of the test object (spring barley) (Shershova S. V., 2012). The effectiveness of the action ranged from 15.7% to 66.7% and depended on the term and temperature. It has also been proven that Echinacea palea extracts in a wide range from 10% to 10-10% stimulated both pollen germination and the growth of pollen tubes of winged tobacco (Shershova S. V. et al., 2013).

The research presented above deepens and expands our knowledge about the properties of Echinacea palea extracts, revealing a specific physiological effect on the process of seed germination. In our opinion, the combination of complex polysaccharides, derivatives of hydroxycinnamic acids, lectins, hormone-like substances in the extract opens wide prospects for further research and use of various parts and organs of Echinacea palea in agricultural technologies.

Conclusions. The conducted research demonstrates high biological activity and selectivity of the action of Echinacea palea extracts on the sowing quality of the seeds of medicinal plants. The most essential effect of Echinacea palea extracts was observed after the treatment of wild mallow seeds: depending on the concentrations of EAP, the germination energy increased by 11.5%-19.2%, and germination increased by 12.1%-20.7%. The use of ERS was also effective: indicators increased by 18.2%-29.1% and 9.1%-21.2%, respectively. In Echinacea purpurea, treatment with EAP did not reliably affect seed quality, while the effect of ERS was positive: germination energy increased by 12.0%-17.3%, and germination increased by 8.3%-9.5%. The similar effect was established on variants treated with Echinacea palea seeds: germination energy and germination significantly increased under ERS action by 10.8%-13.8% and 11.0%-17.8%, respectively. The reaction of the seeds of cornflower blue and St. John's wort to treatment with extracts was low and mathematically unreliable – 1.2%-7.4% and 2.5%-7.0%, respectively. The most effective were Echinacea palea extracts in concentrations of 0.01%-0.001%.

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