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SOYBEAN AND ITS ADAPTIVE PROPERTIES AS A WAY TO SOLVE THE GLOBAL FOOD CRISIS

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Today, the global food crisis is becoming increasingly severe. Food production is unable to meet the needs of the growing population of the planet. As a result, some countries are experiencing a severe lack of basic food. This issue is further exacerbated by rapid climate change, which negatively impacts food production and reduces its volume.

More and more attention is paid to legumes, in particular soybeans, as plants that have a balanced protein composition and can be a key link in the fight against the world food crisis.

It has been shown that soybeans are currently the largest legume crop in Ukraine by area and are grown as one of the main crops because they combine economic, agronomic, and environmental components. The climatic conditions and soil composition in all regions of Ukraine are favorable for the successful cultivation of the crop and high yields. However, regardless of this, global warming harms the entire planet, and Ukraine as well. This also applies to other European countries.

The main task of breeders today is to create varieties of a new generation that will be stress-resistant under new, radically different conditions of existence, and at the same time give high yields. Therefore, it is interesting and experimental to study the adaptive properties of soybeans by sowing it in atypical conditions of existence. In the course of research, the researchers will observe all the ontogenesis processes of Ukrainian soybean varieties in Spain, and Spanish varieties in Ukraine. Under contrasting conditions of existence (temperature indicators, humidity, soil composition and structure), it is possible to observe the plasticity of these soybean varieties and their stress resistance. The experiment will also enable the investigation of nitrogen fixation of these soybean varieties in different countries with different conditions of existence, as well as nitrogen fixation of these soybean varieties in different countries with different living conditions. This natural biologization is a unique phenomenon and requires detailed study, especially now, at a time of rapid climate change.

Keywords: soybeans, adaptation, monitoring, protein, global crises, Ukraine, Spain.

Кобиренко Ю., Панасюк Р., Сидорак І., Вавринович О. Соя та її адаптивні властивості як шлях до вирішення глобальної продовольчої кризи

Сьогодні дедалі актуальніше постає питання глобальної світової продовольчої кризи. Виробництво продуктів харчування не може задовольнити потреб усього населення планети, кількість якого щороку зростає. Як наслідок, деякі країни зіткнулися з гострою проблемою браку базових харчів. Окрім того, швидкі зміни клімату негативно позначаються на виробництві продуктів харчування, скорочуючи їхні обсяги.

Дедалі більше уваги приділяють бобовим, зокрема сої, як рослинам із збалансованим протеїновим складом і таким, що можуть бути ключовою ланкою у боротьбі зі світовою продовольчою кризою.

Досліджено, що соя – наразі найбільша за площею бобова культура в Україні, вирощується як одна з базових, бо в ній поєднані економічна, агрономічна і екологічна складові. Кліматичні умови і склад ґрунту в усіх областях України сприятливі для успішного вирощування культури й отримання високих урожаїв. Проте, незважаючи на це, глобальне потепління негативно позначається на всій планеті, зокрема й на Україні.

Зауважено, що основне завдання селекціонерів сьогодні – створення сортів нового покоління, які зможуть бути стресостійкими за нових, кардинально інших умов існування, а також забезпечувати високу врожайність. Тож цікаве й експериментальне вивчення адаптивних властивостей сої за висівання її в нетипових умовах. Досліджено всі процеси онтогенезу українських сортів сої в Іспанії, а іспанських сортів – в Україні. За контрастних умов вирощування (температурні показники, вологість, склад і структура ґрунту) є змога спостерігати пластичність і стресостійкість цих сортів сої, а також досліджувати їхню азотфіксацію в різних країнах із різними умовами існування. Така природна біологізація – унікальне явище, яке потребує детального вивчення, особливо зараз, за стрімкої зміни клімату.

Ключові слова: соя, адаптація, моніторинг, білок, глобальна криза, Україна, Іспанія.

Problem setting. In 2022, there were significant increases in food prices and widespread food shortages globally. These crises were mainly caused by geopolitical, economic, and natural factors, including extreme weather events such as heatwaves, floods, and droughts linked to climate change.

According to the FAO, world food prices in July 2022 were 13 % higher than a year ago. In the worst-case scenario, global food prices could jump another 8.5 % by 2027 (FAO, April, 2024).

Scientists are concerned that ongoing climate change may lead to a global food crisis in this century [9].

The research results by the Center for Global Development indicates that climate change could reduce food production by five to twenty percent by 2080. In some countries even more (Center for Global Development, 2024).

Leguminous crops play an important role in solving the problem of increasing the production of plant protein and ensuring food security, among which an important place belongs to soybean as a crop with high adaptive properties [1; 2].

However, scientists around the world need to solve the problem of creating soybean varieties resistant to various extreme climate changes and resistant to diseases in order to provide humanity with protein-rich food [7; 10].

Analysis of recent researches and publications. Lack of water and high temperatures disrupt almost all metabolic processes and hormonal balance in the plant, causing changes in subcellular structures. High temperature causes a change in the structure of cell membranes, disintegration of the protein-lipid complex [6]. Nuclear chromatin is destroyed, nucleic acids are denatured and disintegrated. In non-resistant forms, hydrolysis of proteins, for example, can lead to ammonia, which causes poisoning and death of the plant [3]. The degree of violations largely depends on the resistance of plants to heat and drought, as well as the severity and intensity of hydrothermal stress [5].

Different scientists hold varying opinions on the drought resistance of soybeans. Some believe soybeans are very drought-resistant due to their pubescence and well-developed root system. Others classify soybeans as moderately drought-resistant, stating that they tolerate temporary soil drought more easily than other crops [5]. Some even consider soybeans to be a rather moisture-loving crop [3].

Currently, most authors note that soybean is a crop with a differentiated need for water, it has increased requirements for providing moisture, but in different amounts during its ontogenesis.

Atmospheric drought leads to a decrease in the yield of agricultural crops. However, new research from the University of Minnesota has shown that legumes, including soybeans, may actually be more productive in drought conditions, but provided that the crops are sufficiently irrigated.

The scientists hypothesized that the vapor pressure deficit that drives atmospheric drought promotes biological nitrogen fixation. This phenomenon activates the transfer of compounds that inhibit nitrogen fixation from the root nodules, which are where nitrogen fixation takes place.

This natural process can cause a decrease in the productivity of agricultural crops. This is because higher transpiration rates can create or exacerbate pre-existing soil moisture deficits.

However, in soybean crops, a higher transpiration rate triggers nitrogen fixation processes. This causes an increase in productivity, but only if the plants are currently well-watered.

Scientists believe that this research will contribute to the creation of new climate-resistant soybean varieties that will use the phenomenon of atmospheric drought to their advantage to increase their ability to fix nitrogen [3].

Task setting. The main task of our research is to study adaptive, nitrogen-fixing properties and morphological stages of soybean development in atypical conditions of existence (weather conditions, soil structure).

Presenting main material. Soybean seeds contain an average of 36–45 % protein, 19–22 % fat, 23–28 % carbohydrates, a significant content of vitamins, enzymes, minerals and other substances. Soybean

seeds contain 40 % protein. It is a complex complex of high-molecular compounds that differ in molecular weight, amino acid composition, nitrogen, sulfur, and phosphorus content, grouped into several fractions with different solubility. The water-soluble fraction represents 88–95 % of soybean protein and includes easily soluble globulins (60–81 %), albumins – (8–25), and sparingly soluble globulins (3–7 %) [1; 8].

Soybeans from 1 hectare of land provide 655 kg of edible protein, which is enough for a person for 5 494 days.

Soybean protein, which is characterized by high functionality, is used not only in food, but also for medical purposes, as a raw material for the preparation of drugs that stimulate the central nervous system, is used in the treatment of diabetes and radiation sickness, and the removal of radionuclides from the body. Antihypotoxic and hypothermic activity of lipoxidase isolated from soybean seeds was also revealed. Soybean proteins improve blood composition and reduce the likelihood of myocardial infarction, atherosclerosis, and hypertension [1].

Soybeans are an integral part of the cycle of substances in nature, thanks to photosynthesis and the ability to biologically fix atmospheric nitrogen, its cultivation makes it possible to improve the nitrogen balance in the soil, the phytosanitary condition of crops and significantly increase the productivity of a unit of crop rotation area [7].

Soybeans have been known in world agriculture for more than 6,000 years. Most authors consider the regions of Southeast Asia and, first of all, Northern and Central China to be the homeland of cultivated soybeans. However, some scientists suggest the possibility of an earlier appearance of cultivated soybeans in India than in China or their simultaneous domestication in India and China.

Soybeans were brought to Ukraine from China in the 19th century and at first cultivated for scientific purposes. Favorable climatic conditions for soybean cultivation have developed in Ukraine, so over the past 20 years, the sown area and gross harvest of this crop have increased by 12 and 17 times, respectively. This was achieved due to the creation and introduction of new-generation soybean varieties into production, the development of varietal technology for their cultivation, and increased demand for this culture in the market. For the first time, Ukraine reached the world level of increasing protein and oil resources at the expense of soybeans [2].

The world area harvested of soybeans in 2022 was 133 791 633 hectares, and production – 34 885 642 748 tons. In Ukraine, the area of soybeans in 2022 was 1 527 200 hectares and the production reached – 3 443 800 tons (FAO, April, 2024).

The percentage of soybean in the world for 2022 was distributed as follow – Americas – 85 % (29 662 789 173 hectares), Asia – 10.1 % (3 519 872 222 hectares), Europe – 3.6 % (12 433 744 hectares), Africa – 1.3 % (453 883 929 hectares), Oceania – 0 % (57 200 hectares) (FAO, April, 2024), (Fig. 1).

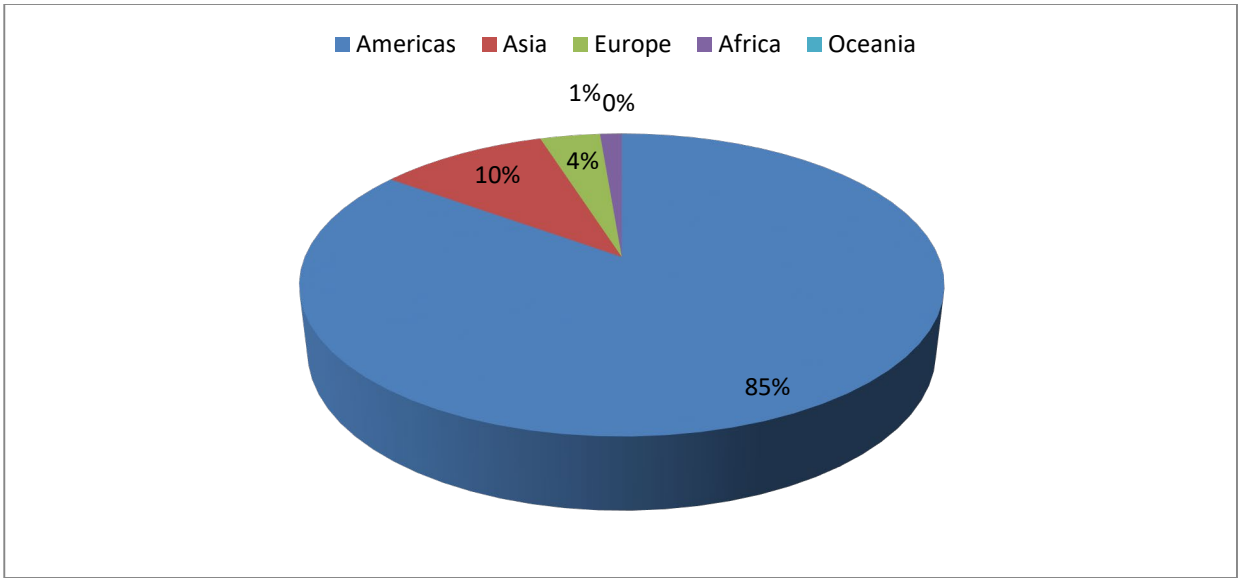

Figura 1. Production share of soybeans by region, 2022 (FAOSTAT, April, 2024)

In 2022, as in previous years, Ukraine became one of the top ten world leaders in soybean production. The top three were led by Brazil, United States of America and Argentina (FAO, April, 2024) (Fig. 2).

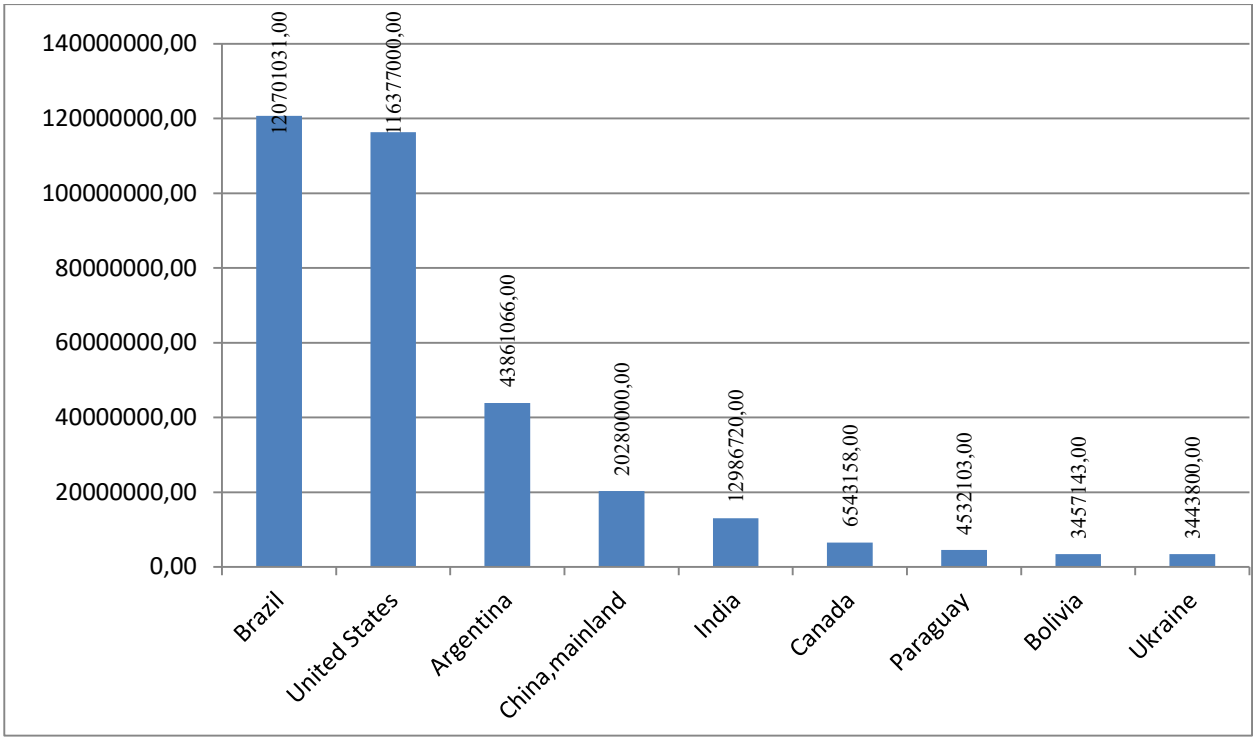

Figura 2. The top ten world leaders in soybean production, 2022 (FAOSTAT, April 2024)

Global soybean production is forecast to rise by 18.8 million tons to a record 397 million tons in the 2023/24 fiscal year, according to the German Union for the Promotion of Oil and Plant Proteins (UFOP), which cites the US Department of Agriculture (USDA) forecast (USDA, 2024).

Despite the full-scale invasion of russia (2022) and the occupation of some regions of Ukraine, in 2023 there was an increase in the sown area under soybeans – almost to 1.8 million hectares. With the average yield for the previous seven years – 2.3–2.4 t/ha – Ukraine can harvest about 4.2 million tons of soybeans (AgroPortal).

In the future, soybean production involves the formation of a soybean belt in the Forest Steppe in Ukraine. Here, the soil and climatic conditions best meet the biological needs of this culture, thanks to which it reaches full maturity and produces a high yield. In this territory, soybeans can be grown on an area of 2 million hectares, and in the future even more.

According to FAO data, 3,790 tons of soybeans were harvested in Spain in 2022 in an area of 1 330 hectares, which is slightly less than in 2021 – 4 770 tons and ten times less than in Ukraine (FAOSTAT, April 2024).

To investigate the plasticity and adaptive properties of soybeans, the authors of the study decided to conduct the research in two contrasting countries - Ukraine and Spain, which are different in temperature indicators, composition and structure of the soil, and humidity. Lviv's climate is humid continental with cold winters and warm summers. The average temperatures are − 3 °C in January and 18 °C in July. The average annual rainfall is 745 mm with the maximum in summer. Cordoba has a hot Mediterranean climate. It has the highest summer average daily temperatures in Spain and Europe, the days with temperatures over 40 °C are common in the summer months. Precipitation amounts to around 600 millimeters per year (weather spark).

For this experiment, 19 varieties from Ukrainian selection (Koroleva, Vorskva, Muza, Slavna, Azymut, Legenda, Tytan, Orfei, Millenium, Pallada, Suziria, Vyshyvanka, Samorodok, Siverka, Vilshanka, Omega Vinnytska, Diadema Podillia, Liia, Muse) were sent to the Institute of Agriculture, Cordoba, Spain, and 5 varieties from Spanish selection (A1, A2, A3, A4, A5) were sent to Lviv National Environmental University, Ukraine.

The joint experiment includes 24 varieties that will be sown in parallel in the two countries at the beginning of May 2024. The varieties are sown in two lines with 15 seeds in each and the three repetitions. It is planned to monitor the beginning of germination twice a week, which will record the dates of the beginning of germination, the date of the beginning of flowering, and the beginning of the formation of pods, as well as the accounting of the number of plants that have emerged, their height, and the color of flowers. It is also important to record some features of plant ontogenesis, such as damage by pests and diseases. It is also planned to determine the percentage of nitrogen fixation of plants of different genotypes in parallel in the two countries of Ukraine and Spain.

Conclusions. The study aims to investigate the adaptability of Ukrainian soybean varieties to the environmental conditions of Ukraine and their potential for growth in Spain, which has contrasting environmental conditions. Similarly, the study will observe the adaptability and stress resistance of Spanish soybean varieties when grown in Ukraine under different environmental conditions. This research is essential in light of global climate change, specifically the planet's warming. Developing resilient, adaptable, and productive varieties of soybeans is crucial for addressing future food crises, as legumes, especially soybeans, serve as a vital source of nutritional protein for both humans and animals. We all need to consider these factors and take action today.

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