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FEATURES OF BIODIVERSITY CONSERVATION UNDER THE SPREAD OF INVASIVE SPECIES OF WEEDS: ANALYSIS AND PROSPECTS

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Korpita H., Shuvar I., Dudar I., Palii D., Hadzalo O. Features of biodiversity conservation under the spread of invasive species of weeds: analysis and prospects

Invasive plants can cause significant damage to agriculture, forestry and water management, as well as to protected areas, threatening human and animal health. The disappearance of native plant species leads to a loss of biodiversity and can provoke ecological imbalances. Ukraine is characterized by a high level of spread of invasive plant species, which reinforces the need to take measures for their control and management.

It has been noted that the disappearance of native plant species leads to the disappearance of native species of animals, fungi, and many microorganisms that have been building links with the native flora for thousands or millions of years, are directly dependent on it, and are organically interconnected. That is why the invasion of an alien species does not increase the number and activity of local biodiversity, but, on the contrary, leads to the death of a significant number of flora and fauna species dominated by only one or a few alien species.

In Ukraine, the impact of non-native plants on the environment is increasing every year. According to the level of adventitization of flora, Ukraine occupies a prominent place among other floras of the world. The spontaneous fraction of adventitious flora of Ukraine includes 830 species of vascular plants (including 18 % – archaeophytes and 82 % – xenophytes), which is about 14 % of the total number of flora species of the country, which has more than 6,000 species of vascular plants (including all aboriginal and adventive species), as well as the main cultivated and wild plants.

As a result of the study of the effect of herbicides on the Canadian goldenrod (Solidago canadensis L.), it was established that all three investigated herbicides – Lintur 70 WG, Dianat and Roundup Max – effectively reduce the population of this plant. However, it was found that the effectiveness of herbicides increases over time, which may be due to longer exposure of the substance to plants. Herbicides Lintur 70 WG and Roundup Max showed higher efficiency compared to Dianat.

In addition, it was established that all three investigated herbicides have a significant effect on the dry mass of Solidago canadensis L. plants on the 60th day after their application, confirming the high efficiency of their use.

Therefore, the study results emphasize the importance of considering the timing of herbicide treatments to ensure long-term protection of cultivated plants from weeds.

Keywords: biodiversity, invasion, weeds, population, control measures.

Корпіта Г., Шувар І., Дудар І., Палій Д., Гадзало О. Особливості збереження біорізноманіття в умовах поширення інвазивних видів бур'янів: аналіз та перспективи

Інвазивні рослини можуть спричиняти значні збитки для сільського, лісового та водного господарств, а також для заповідних територій, загрожуючи здоров'ю людей і тварин. Зникнення місцевих видів рослин призводить до втрати біорізноманіття і може спровокувати екологічні дисбаланси. Україна відзначається високим рівнем поширення інвазивних видів рослин, що посилює необхідність вживання заходів для їхніх контролю та управління

Зауважено, що зникнення місцевих видів рослин призводить до зникнення місцевих видів тварин, грибів та багатьох мікроорганізмів, які будували зв'язки з аборигенною флорою упродовж тисяч або мільйонів років, безпо-

середньо залежать від неї і органічно пов’язані між собою. Саме тому інвазія чужорідного виду не впливає на збільшення чисельності та активності місцевого біорізноманіття, а, навпаки, призводить до загибелі значної кількості видів флори та фауни з домінуванням лише одного або декількох видів чужинців.

Відстежено, що в Україні вплив неаборигенних рослин на довкілля зростає з кожним роком. За рівнем адвентизації флори Україна займає чільне місце серед інших флор світу. Спонтанна фракція адвентивної флори України налічує 830 видів судинних рослин (у тому числі 18 % – археофіти та 82 % – ксенофіти), що становить близько 14 % від загальної кількості видів флори країни, у банку якої понад 6000 видів судинних рослин (включно з усіма аборигенними та адвентивними видами), а також основні культивовані та здичавілі рослини.

У результаті дослідження ефекту гербіцидів на золотарник канадський (*Solidago canadensis L.)* встановлено, що всі три досліджені гербіциди – Lintur 70 WG, Dianat та Roundup Max – ефективно знижують популяцію цієї рослини. Проте виявлено, що з часом ефективність гербіцидів зростає, що може бути пов’язано з тривалішим впливом речовини на рослини. Гербіциди Lintur 70 WG та Roundup Max показали вищу ефективність порівняно з Dianat.

Зауважено, що всі три досліджені гербіциди істотно впливають на суху масу рослин *Solidago canadensis L.* на 60-й день після їхнього застосування, підтверджуючи високу ефективність їхнього використання.

Результати дослідження свідчать про важливість урахування часового аспекту у плануванні гербіцидних обробок для забезпечення тривалого захисту культурних рослин від бур’янів.

Ключові слова: біорізноманіття, інвазія, бур’яни, контролювання чисельності, заходи контролю**.**

Formulation of the problem. Biodiversity, which is the basis for the stability of ecosystems and the livelihood of mankind, faces a significant challenge in the conditions of the spread of invasive weed species. These introduced plants are able to quickly adapt to new environments, displacing native species and threatening ecosystems. In this regard, developing and implementing biodiversity conservation strategies becomes an urgent task that requires an integrated scientific, managerial and public approach.

Analysis of recent research and publications. Invasive weed species are a serious threat to biodiversity and ecological sustainability of natural ecosystems. These plants, characterized by high adaptability and rapid reproduction, can significantly influence the structure and functioning of ecosystems, competing with local species and changing natural processes. Invasive species are characterized by the following indicators:

1. Rapid spread in new ecosystems and high competitiveness enable them to effectively compete with native plants and displace them.

2. Global distribution. They often spread globally through various routes: plant trade, transportation of agricultural machinery, and other anthropogenic influences. This can lead to their displacement outside their natural ranges and settlement in new regions, where they can become a new source of problems for local biodiversity and agricultural activities.

3. Adaptability to climate change. Some invasive weed species can show high adaptability to climate changes, which makes them even more hardy and effective in new conditions. This makes it difficult to control and manage their spread, as they can successfully adapt to different climates.

4. Threat to crops. Invasive weeds can cause significant damage to agriculture by competing with crops for resources and causing crop losses.

5. Ability to allergic reaction. Some types of invasive weeds, in particular ragweed, cause allergic reactions in people, which becomes another problem for the health of citizens [1; 4].

The spread of invasive weed species can significantly alter ecosystems, disrupting the natural balance and causing a loss of biodiversity. Invasive weeds' ability to form dense populations can lead to soil degradation and reduced water availability for other plants. These environmental challenges can have further negative effects on the diversity of plant and animal species, leading to changes in the structure and functioning of ecosystems. Soil degradation can also lead to decreased fertility, deterioration of farming practices, and negatively impact agricultural production, thereby posing a threat to the country's food security.

These data demonstrate the serious problems that invasive weed species can create for ecosystems, the agricultural sector, and human health, emphasizing the need to develop and implement effective strategies for controlling their numbers and managing these species [5].

Open borders and ease of communication contribute to the spread of invasive species, the sources of which are most often: seeds, vegetable seedlings imported from abroad, decorative plants grown in containers. The introduction of seeds into the soil due to livestock grazing on pastures can also contribute to the spread of these plants. Therefore, invasive plant species use different ways for their spread, and human activity plays a key role in this process, creating favorable conditions for their success and expansion [7].

It is worth noting that the protection of biodiversity of territories and agricultural lands has recently become an important challenge for many countries of the world, including Ukraine. After all, the sustainable development of agriculture can ensure global food security and the depletion of biodiversity leads to a decrease in ecosystem services and ultimately creates a direct threat to food security.

Under modern conditions, the climate is the biggest problem for certain types of plants, so some plants die, unable to withstand long periods of drought or harsh winters. However, those plants that come from areas with similar climatic conditions quickly adapt and even conquer new territories. The mainstay at the first stages of settlement is usually ruder places of stay – port areas, railway stations, places of cargo transshipment. However, new species of plants "migrate" (carried by wind, water, etc.) and get to another substrate and begin the next stage of taking over the territory. Plants that settle on originally foreign habitats are the most expansive – they give viable offspring, often in large numbers, settle at great distances from the mother plants and colonize large areas in a short time.

Setting objectives. The purpose of the research is to identify existing invasive weed species, study the range and ways of their spread and impact on biodiversity in order to develop effective control and management methodologies to preserve ecological sustainability. Also the purpose of this study is to evaluate the effectiveness of different herbicides in controlling the invasive plant *Solidago canadensis L.*

Presenting main material. Invasive weed species pose a serious threat to biodiversity and ecological sustainability of natural ecosystems. These plants, which are characterized by high adaptability and rapid reproduction, can greatly influence the structure and functioning of ecosystems, competing with local species and changing natural processes.

According to some scientists (Mosiakin S. L., Prots B., Shuvar I., Korpita H.), the vast majority of invasive species are natives of North America, less often East Asian or Mediterranean species, almost half of them are members of the *Asteraceae* family. The list of invasive plant species of the European Union (approved by resolution 1143/2014) includes the following species: *Alternanthera philoxeroides, Gunnera tinctoria, Elodea nuttallii, Baccharis halimifolia, Hydrocotyle ranunculoides, Impatiens glandulifera,Cabomba caroliniana, Eichhornia crassipes, Asclepias syriaca, Heracleum mantegazzianum, Heracleum persicum, Heracleum sosnowskyi, Lagarosiphon major, Lysichiton americanus, Ludwigia grandiflora, Ludwigia peploides, Microstegium vimineum, Myriophyllum aquaticum, Persicaria perfoliata, Myriophyllum heterophyllum, Pennisetum setaceum, Parthenium hysterophorus, Pueraria lobata* etc. [3; 4; 6; 7]. In Ukraine, according to various estimates, there are from 600 to 800 alien plant species, which is from 14 to 14.7 % of the entire flora. Of this number, approximately 50 species are considered dangerous invasive [6; 8].

The Western Forest-Steppe of Ukraine is characterized by a specific climate and soil conditions. This zone is in the transition between forest-steppe and steppe climate. The climate of the Western Forest Steppe is characterized by moderate warm winters without significant frosts and summer periods when temperatures can reach high values. The distribution of atmospheric precipitation during the growing season is not uniform with a peak amount in summer. Such a climate is quite favorable for the growth and spread of various plants, including invasive species. The soil conditions in the Western Forest-Steppe are diverse (black soils, light and dark gray forest soils, etc.) and favorable for the settlement and highly productive development of invasive species.

Thus, the soil and climatic conditions of the Western Forest-Steppe can provide a favorable environment for the spread of invasive species. High temperatures, moisture availability, and soil diversity create ideal conditions for invasive organisms to compete with native species. This can lead to displacement of local species and disruption of the natural balance in the ecosystem, which threatens biodiversity.

Climate changes in this region may also increase the risk of the spread of new invasive species or change the limits of their range, which is an additional challenge for the preservation of biodiversity in the Western Forest-Steppe of Ukraine.

It is worth noting that global climate changes have a positive effect on the intensive invasion of still little common weeds, in particular, *Cenchrus pauciflorus Benth* and *Hordeum murinum L.* It has been established that if even 4 years ago these plants were practically impossible to find among the diversity of phytocenoses in the territory of the Western Forest-Steppe of Ukraine, then in the period of 2021–2022 in the territory of Lviv, Ivano-Frankivsk, Rivne and Ternopil regions they appeared, especially on sandy soils [11–13].

The degree of invasion success is determined by how effectively a species can expand its potential range, forming stable populations in new ecosystems. This can happen not only due to the influence of anthropogenic factors, but also due to favorable biotic

and abiotic conditions, without the need for re-introduction of diaspores in an anthropochoric way, but through natural mechanisms of distribution.

In cases of such "repeated" self-settlement, the species can slowly expand its range, as it has to overcome natural barriers in the new area. However, this process can be accelerated with the participation of anthropogenic factors. This method of range expansion is typical for most invasive species in Ukraine, such as, for example, *Ambrosia artemisiifolia, Bidens frondosa, Phalacroloma annuum* etc.

The process of expansion continues for Ambrosia artemisiifolia, actively spreading species such as *Echinocystis lobata*, *Helianthus tuberosus*, *Bidens frondosa, Heracleum mantegazzianum, H. sosnowskyi, Impatiens glandulifera, Phalacroloma annuum, Solidago canadensis*, *Rudbeckia laciniata*, *Xanthium albinum.*

Formed habitats continue to be densified, in particular, due to the development of disturbed ecosystems, such species as *Conyza canadensis, Impatiens parviflora* etc. Some species, in particular, *Bupleurum fruticosum, Symphyotrichum salignum*, although they spread moderately, they create large colonies in semi-natural plant communities. Others such as *Asclepias syriaca, Cenchrus pauciflorus*, *Parthenocissus inserta, Xanthoxalis dillenii*, show a constant tendency to active distribution, especially in semi-natural coenoses.

The influence of the anthropogenic factor on the environment is becoming more and more pronounced. Flora, which is a permanent and mobile system, undergoes changes under the influence of this factor. Some changes in the vegetation cover are irreversible, and synanthropic plants, including adventive species, expand their range, because other plants can no longer exist in radically changed ecotopes. These evolutionary changes, which are irreversible, play a positive role in the formation of synanthropic flora complexes, creating conditions for the settlement of other, more demanding plants, including native species.

The scientific community in Ukraine and the world continuously conducts scientific research and production tests aimed at studying and controlling the most dangerous plant organisms for ecosystems. These actions include the development of effective strategies to counter the penetration and spread of invasive alien species into natural ecosystems. Effective mechanisms for managing biological agents are also being studied and implemented in order to reduce their negative impact on the environment [13].

Preventive measures and early detection of new non-typical species spreading from the defined containment zone are a significant influence on slowing down the spread of invasive species. Containment steps may include inventorying and prioritizing habitat for containment, limiting activities to certain areas or to certain times of the year, minimizing travel to vulnerable areas, checking clothing and equipment to prevent transport of plant seeds, and containment and control of new growth sites.

A study on the effect of herbicides on the *Solidago canadensis L.* was carried out at Lviv National Environmental University during 2021–2023. The soil of the experimental site is dark gray, light loamy in granulometric composition. The content of humus in the arable (0–30 cm) soil layer (according to Tiurin) is 2.2–3.6 %, at a depth of 50 cm – about 1.5 %, pH – 6.2. In 1 kg of soil, the content of mobile forms of phosphorus is 91 mg, exchangeable forms of potassium are 112 mg, and easily hydrolyzable nitrogen is 48 mg. The experiment included three options (Table 1).

The sown area of the plot is 150 m^2, accounting for 120 m^2 for three repetitions of the experiment options. The percentage of damage to Solidago canadensis L. plants after the application of herbicides was evaluated by visual assessment of the degree of plant damage. This included assessing symptoms such as wilting, discolouration, necrosis, deformation and plant death. Percent damage was defined as the ratio of damaged plants to the total number of plants observed, expressed as a percentage.

Table 1

Application scheme of herbicides

Variant	Herbicide	Content of the active substance	Rate of pesticide
1	Lintur 70 WG	41 g/kg triasulfuron 659 g/kg of dicamba in the form of sodium salt	0.18 l/ha
2	Dianat	480 g/l dicamba	0.8 l/ha
3	Roundup Max	450 g/l of glyphosate in acid equivalent (551 g/l in the form of potassium salt of glyphosate)	1.0 l/ha

According to the results of the study, a general trend was revealed, which indicates that on the 60th day after the herbicide application, the degree of damage to *Solidago canadensis L.* plants is usually much higher than on the 30th day. This may be due to an increase in the time during which the herbicide has an effect on the plants, resulting in more damage. Thus, on the 60th day after the application of the herbicide Lintur 70 WG, the degree of plant damage was on average 80–84 %. The herbicides Dianat and Roundup Max showed fairly high efficiency – 70–75 % and 78–80 %, respectively (Table 2).

Table 2

Effect of herbicide on the degree of damage to *Solidago canadensis L.* (average for 2021–2023)

Variant	Herbicide	Degree of damage to *Solidago canadensis L.* plants after herbicide application, %	
		30th day	60th day
1	Lintur 70 WG	33–35	80–84
2	Dianat	25–28	70–75
3	Roundup Max	30–32	78–80

Thus, all three herbicides were effective in reducing the population of *Solidago Canadensis L.*, but their effectiveness increased over time. This is important to consider when planning herbicide treatments, especially when it is necessary to ensure long-term protection of cultivated plants from weeds.

Regarding the effectiveness of herbicide application and the dry mass of *Solidago Canadensis L.* plants, it is worth noting that all three herbicides in the experiment have high efficiency, which indicates their ability to destroy *Solidago Canadensis L.* However, Lintur 70 WG and Roundup Max showed higher efficiency compared to Dianate. The dry mass of *Solidago Canadensis L.* plants on the 60th day after herbicide application also changed, but in general was at a level sufficient to confirm the effectiveness of herbicide application (Table 3).

Table 3

Effectiveness of herbicide application (average for 2021–2023)

Variant	Herbicide	Effectiveness of herbicide use, %	Dry weight of *Solidago canadensis L.* plants on the 60th day after herbicide application, g/m^2
1	Lintur 70 WG	88.9	284
2	Dianat	81.2	311
3	Roundup Max	85.6	295

Conclusions. The conditions for the spread of invasive weed species pose a serious challenge to biodiversity conservation strategies. Analysis of the situation and consideration of prospects allow to determine effective approaches to preserve the diversity of ecosystems in these conditions.

One key strategy is to identify and monitor invasive weed species and assess their impact on local ecosystems. This helps scientists and conservation organizations respond in time to the spread of these species and implement measures to control the rate and range of their spread. Next is the development and implementation of biological methods of controlling the number of invasive weed species. This may include the introduction of natural enemies that effectively regulate populations of these plants, or the use of biologics that target invasive species without harming native organisms.

Another important strategy is to preserve natural habitats and ecosystems, as they are the foundation for diverse biodiversity. Protecting nature reserves and regulating human activity in these areas will help maintain various species and enhance the resilience of ecosystems against invasive influences.

In addition, educating the public and agricultural producers about environmentally conscious practices can play a key role in biodiversity conservation strategies. Being mindful of resource use and preventing the spread of invasive species can contribute to the sustainable management of natural resources.

A thorough analysis and consideration of these perspectives can help develop comprehensive and effective strategies for biodiversity conservation in the face of invasive weed species.

The performed research showed that all three herbicides (Lintur 70 WG, Dianat and Roundup Max) effectively reduce the population of *Solidago Canadensis L*., with the highest efficiency in Lintur 70 WG. The effectiveness of herbicides increases over time, that is confirmed by a visual assessment of the degree of plant damage and changes in the dry mass residue. The results highlight the importance of time-sensitive herbicide treatment planning for long-term weed control and effective invasive species management.

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