

EFFECT OF HERBICIDES ON MORPHOMETRIC, PHENOLOGICAL, AND PHOTOSYNTHETIC PARAMETERS OF *SOLIDAGO CANADENSIS* L.

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The aim of this study was to evaluate the effects of different herbicides on the morphophysiological traits of *Solidago canadensis* L., including plant height, stem diameter, leaf area, number of regenerating shoots, and photosynthetic activity. The research was conducted from 2020 to 2025 in natural phytocenoses of the Western Forest-Steppe of Ukraine. Herbicide treatments were applied during the rosette stage and early phases of intensive vegetative growth to assess the maximum biological effect of systemic herbicides. The control variant did not involve the use of chemical agents. Results showed that all tested herbicides suppressed the morphometric parameters and photosynthetic activity of *S. canadensis* L., although the degree of effect varied. The strongest suppression was observed with Lintur (0.3 kg/ha), which reduced plant height, stem diameter, and leaf area, limited the number of regenerating shoots, and significantly decreased photosynthetic rate, chlorophyll content, and transpiration intensity. Roundup Max (4.0 L/ha) exhibited an intermediate effect, while Dianat (1.5 L/ha) caused moderate suppression. Phenological development was also delayed, particularly after Lintur application, as evidenced by postponed stem elongation, budding, and flowering. These findings can serve as a basis for developing regulated chemical control schemes for *S. canadensis* L., improving phytocenosis management, and conserving biodiversity in agricultural landscapes and natural ecosystems.

Keywords: herbicides, morphometric traits, photosynthetic activity, phenology, systemic control, invasive plants, Western Forest-Steppe of Ukraine.

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Introduction

The rapid spread of invasive plant species represents one of the most serious threats to biodiversity, ecosystem stability, and agricultural productivity worldwide (Svejcar L.N. et al., 2024). Among these species, *Solidago canadensis* L. has become particularly aggressive and ecologically plastic, invading much of Europe and parts of Asia. This perennial rhizomatous species, native to North America, has demonstrated remarkable adaptability to diverse soil and climatic conditions, enabling it to colonize abandoned lands, agricultural fields, road margins, and natural ecosystems (Smith A.L. et al., 2023, Spake R. et al., 2021).

Its high reproductive capacity, vegetative propagation through extensive rhizome systems, and strong competitive ability allow it to form dense monodominant stands that suppress native vegetation and alter ecosystem functioning (Anas M. et al., 2025, Byun C. et al., 2023).

The invasive success of *S. canadensis* is closely associated with its pronounced morphophysiological plasticity. The species exhibits rapid vertical growth, considerable leaf area expansion, and efficient photosynthetic activity, which together enhance its competitive dominance (Szymura M. et al., 2022).

In addition, its well-developed root and rhizome system ensures high regenerative capacity even after mechanical disturbances. Such biological traits

complicate management efforts and require the development of effective control strategies based on a clear understanding of plant physiological responses to stress factors (Davies K.W. et al., 2024, Cheng J. et al., 2021).

Chemical control remains one of the most widely used methods for managing invasive herbaceous species, particularly in agricultural and semi-natural landscapes. Herbicides provide relatively rapid suppression of aboveground biomass and can reduce regenerative potential if properly selected and applied (Vantarová K.H. et al., 2023).

However, the effectiveness of herbicide treatments depends not only on the dosage and timing of application but also on the physiological sensitivity of the target species. Herbicide-induced stress can significantly alter plant growth dynamics, photosynthetic activity, water balance, and assimilate allocation (Ye X. et al., 2025, Wang S. et al., 2025). Therefore, assessing morphophysiological parameters is essential for evaluating both immediate and long-term effectiveness of chemical control measures (Korpita H., 2025, Lin H. et al., 2023).

Despite numerous studies on the distribution and ecological impact of *S. canadensis*, less attention has been given to a detailed analysis of its morphophysiological responses to herbicide application

under controlled experimental conditions (Ye X.Q. et al., 2024). Understanding changes in plant height, stem diameter, leaf area, chlorophyll content, and formation of regenerative shoots provides valuable insight into the mechanisms of suppression and potential recovery following treatment. Such information is particularly important for optimizing herbicide selection and improving integrated management approaches (Murillo R.D.A. & Wagner V., 2025, Möhrle K. et al., 2021, Lu H. et al., 2020).

In regions where *S. canadensis* actively spreads in agroecosystems, including Eastern Europe, the need for scientifically grounded control strategies is especially pressing. The spread of this species not only reduces crop yields but also increases production costs associated with weed management. Moreover, residual rhizome fragments in the soil can lead to reinfestation, even after visible suppression of aboveground parts (Roiloa S.R. et al., 2022, Pyšek P. et al., 2020).

The aim of this study was to evaluate the effect of herbicide application on the morphophysiological

parameters of *Solidago canadensis* L., with particular focus on plant height, stem diameter, leaf area, and photosynthetic activity.

Materials and methods

The research was conducted from 2020 to 2025 in natural phytocenoses of the Western Forest-Steppe of Ukraine. The study objects were perennial plants of *Solidago canadensis* L. Field observations were carried out on plots with relatively uniform plant cover density to ensure comparability of results.

Herbicide treatments were applied during the rosette stage and early phases of intensive vegetative growth, which are considered most sensitive to systemic herbicides. Selecting these application times allowed assessment of the maximum biological effect of herbicides at early stages of *S. canadensis* development. The control variant did not involve the use of herbicides. The working solution was applied with a trailed sprayer under controlled pressure to ensure uniform coverage of plants (Table 1).

Table 1. Application scheme of herbicides

Variant	Herbicide	Application Rate	Active Ingredient
I	Control (no herbicide applied)		
II	Lintur	0.3 kg/ha	41 g/kg triasulfuron; 659 g/kg dicamba (sodium salt)
III	Dianat	1.5 L/ha	480 g/L dicamba
IV	Roundup Max	4.0 L/ha	450 g/L glyphosate (acid equivalent); 551 g/L as potassium salt of glyphosate

Source: results of own scientific research

The physiological state of plants was assessed based on visual and morphological traits. The analysis included evaluation of growth suppression, disturbances in morphogenesis of vegetative organs, the rate of apical and lateral meristem death, and the ability of plants to regenerate after chemical treatment. Physiological changes were recorded 7, 14, 21, and 30 days after herbicide application. During this period, the appearance of leaf blade deformations, changes in growth intensity, partial or complete loss of turgor, development of chlorosis and tissue necrosis, and cessation of the main shoot growth were assessed. The physiological effect of herbicides was determined by the nature and rate of symptom development, allowing evaluation of the systemic action of the products even in the absence of quantitative biochemical indicators.

Morphometric analysis was performed to quantitatively evaluate the biological effectiveness of chemical control of *Solidago canadensis* L. Plant height, stem diameter at the base, leaf area (calculated from linear leaf measurements), and the number of regenerative shoots after treatment were recorded. Measurements were taken on fixed observation plots before herbicide application and 30 days after treatment. The obtained data were used for comparative analysis

Results and discussion

The results of the study demonstrate the effect of different herbicides on the morphometric and

between control and treated variants. Morphometric parameters allowed an objective assessment of growth suppression, structural disruption of plant organization, and the ability of plants to recover after chemical exposure.

Phenological observations were carried out to determine the effect of herbicides on the developmental rhythm and generative cycle of *S. canadensis* L. During the growing season, the timing of major developmental phases—shoot emergence, stem elongation, budding, and flowering—was recorded, along with any shifts in phenological phases following herbicide treatment.

Photosynthetic activity of *Solidago canadensis* L. was evaluated using modern portable instruments. The rate of photosynthesis (P_n , $\mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$) and transpiration intensity (T_r , $\text{mmol H}_2\text{O} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$) were measured using a portable gas exchange analyzer LI-6400XT (LI-COR, USA) on leaves from the middle part of the plant. Leaf surface condition and chlorophyll content were assessed spectrophotometrically using a SPAD-502 Plus (Konica Minolta, Japan). Data were statistically processed using descriptive statistics and analysis of variance (ANOVA) with a significance level of $p \leq 0.05$.

regenerative parameters of *Solidago canadensis* L. 30 days after treatment, allowing assessment of chemical control effectiveness at early stages of plant development. Significant growth suppression of

S. canadensis L. was observed compared to the control. Control plants reached an average height of 140 cm, with a stem diameter of approximately 1.1 cm and leaf area of 950 cm², producing an average of six regenerative shoots.

The most effective herbicide was Lintur (0.3 kg/ha), which reduced plant height to 65 cm, stem diameter to 0.6 cm, and leaf area to 420 cm², while the number of regenerative shoots decreased to two. Treatments with Dianat (1.5 L/ha) and Roundup Max (4.0 L/ha) had a moderate effect: after Dianat, plants reached 92 cm in height, 0.8 cm in stem diameter, 630 cm² in leaf area, and produced four regenerative

shoots; Roundup Max reduced height to 110 cm, stem diameter to 0.9 cm, leaf area to 780 cm², and produced five regenerative shoots.

These results indicate that all tested herbicides suppressed morphometric parameters of plants, but Lintur exhibited the strongest systemic effect, significantly limiting growth, leaf area development, and regenerative capacity of *S. canadensis* L. This confirms the high sensitivity of this growth stage to systemic herbicides and allows recommending Lintur as the most effective chemical control agent for managing this invasive species in natural and semi-natural phytocenoses.

Table 2. Effect of herbicides on morphometric parameters of *Solidago canadensis* L. (30 days after treatment)

Variant	Height, cm	Stem diameter, cm	Leaf area, cm ²	Regenerative shoots, pcs
Control	140 ± 15	1.1 ± 0.1	950 ± 80	6 ± 1
Lintur 0.3 kg/ha	65 ± 8	0.6 ± 0.1	420 ± 50	2 ± 1
Dianat 1.5 L/ha	92 ± 10	0.8 ± 0.1	630 ± 60	4 ± 1
Roundup Max 4.0 L/ha	110 ± 12	0.9 ± 0.1	780 ± 70	5 ± 1

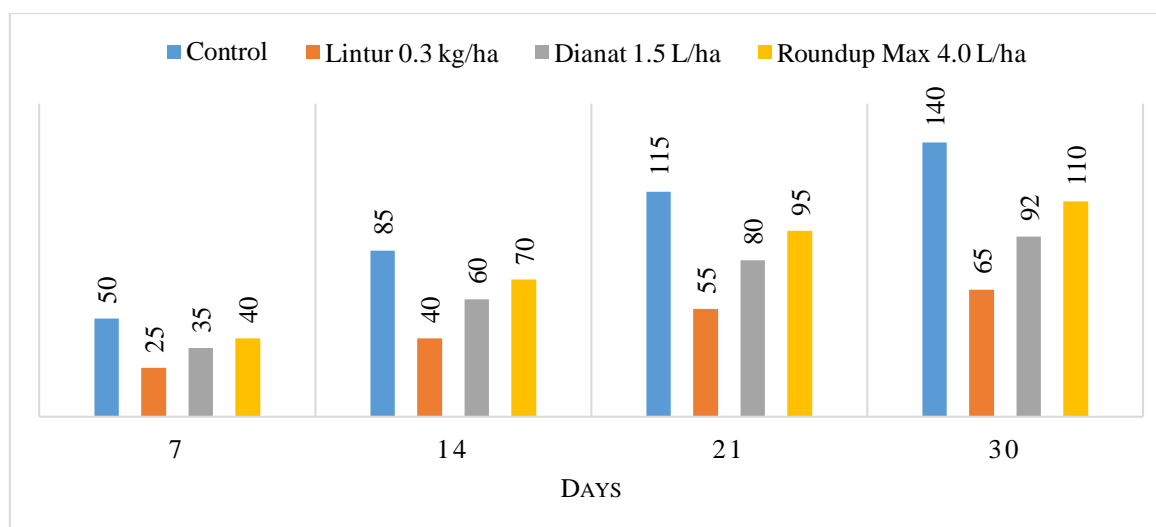
Source: results of own scientific research.

It was also observed that during the first week after herbicide application, plant growth sharply slowed down in all treated variants compared to the control. The strongest growth inhibition was recorded in the Lintur treatment (25 cm), which was nearly half the height of the control. Dianat and Roundup Max also significantly reduced plant growth, reaching 35 cm and 40 cm, respectively, indicating differences in the initial activity of the herbicides, with Lintur exhibiting the fastest toxic effect on the plants.

By the 30th day, plants in the control reached a maximum height of 140 cm, demonstrating high vigor and unrestricted growth. Lintur halted plant development at 65 cm, indicating that the total growth over 30 days was only 40 cm, or approximately 28.5%

of the control. After Dianat treatment, plant height reached 92 cm, and after Roundup Max – 110 cm, corresponding to 65.7% and 78.6% of the control height, respectively. Thus, Lintur proved to be the most effective in suppressing growth, Roundup Max had a moderate effect, and Dianat showed weak growth inhibition.

Analysis of growth dynamics shows that herbicides not only reduce maximum height but also slow the growth rate at all developmental stages. The greatest inhibition occurred during the early growth stages (7–14 days), after which growth partially recovered, especially in the Dianat and Roundup Max variants, whereas Lintur consistently suppressed growth throughout the entire observation period (Fig. 1).



Source: results of own scientific research

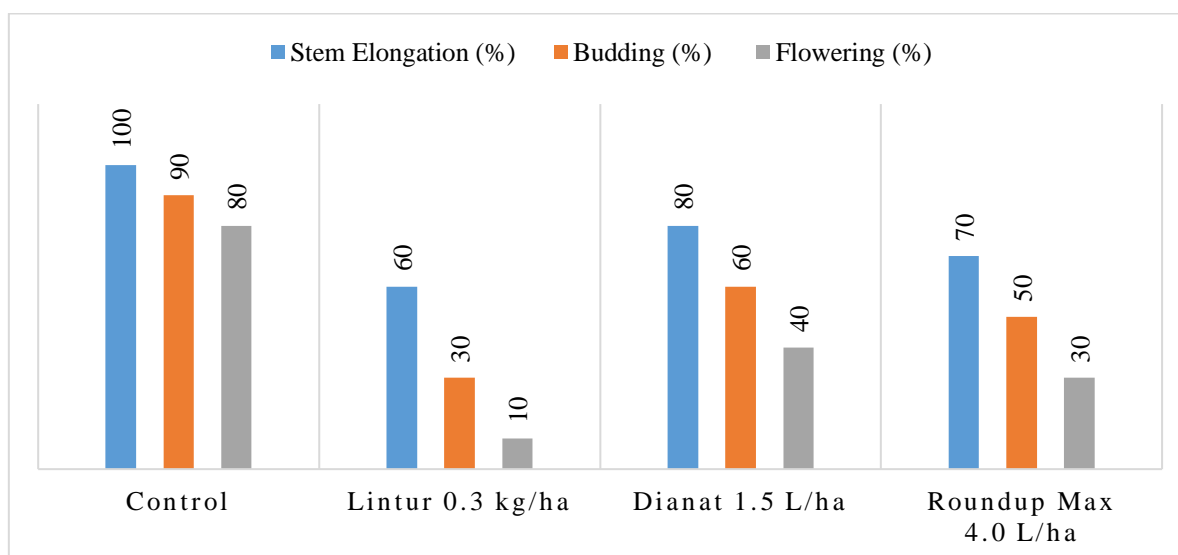
Figure 1. Dynamics of plant height of *Solidago canadensis* L. (cm)

The study showed that the progression of phenological phases of *Solidago canadensis* L. closely correlates with plant growth dynamics and herbicide effectiveness. In the control variant, all plants reached the stem elongation phase, with 90% of plants entering the budding stage and 80% reaching flowering. This indicates active and unhindered development, which aligns with the high growth rate and maximum plant height observed in the control (140 cm by day 30).

Application of Lintur significantly slowed phenological development. Only 60% of plants reached stem elongation, while 30% and 10% reached budding and flowering, respectively. This demonstrates a strong inhibitory effect of the herbicide not only on plant height but also on reproductive development. This effect can be attributed to Lintur slowing the growth and development of the apical meristem, directly impacting bud and flower formation.

The herbicide Dianat exhibited moderate suppression of phenological development: 80% of plants reached stem elongation, 60% reached budding, and 40% reached flowering. During early stages, plants partially continued to grow, which corresponds with the previously reported height data (growth up to 92 cm by day 30); however, the pace of phase progression was lower than in the control. This indicates that Dianat inhibits phenological development less strongly than Lintur, though it still slows development, particularly during the budding stage.

Roundup Max showed an intermediate effect between Lintur and Dianat. Stem elongation was reached by 70% of plants, budding by 50%, and flowering by 30%. Roundup Max slows plant development at all stages, with a less pronounced effect during early stem elongation compared to Lintur, but a stronger effect during budding and flowering (Fig. 2).



Note: Data are presented as % of plants that reached the corresponding phase.
Source: results of own scientific research

Figure 2. Progression of phenological phases of *Solidago canadensis* L. (%)

The study of the photosynthetic activity of *Solidago canadensis* L. after herbicide application showed a clear dependence of the photosynthesis rate (Pn) on time and the effectiveness of the applied herbicide. On the 7th day after treatment, control plants demonstrated an average photosynthesis rate of $12.5 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, corresponding to the initial active growth phase. The strongest suppression was observed in the Lintur treatment, where Pn was only $6.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, reflecting the high toxic effect of the herbicide at early developmental stages. Dianat and Roundup Max showed intermediate values of 8.0 and $7.5 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, respectively, indicating moderate inhibition of photosynthetic activity.

By the 14th day, control plants actively increased photosynthesis, reaching $18.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, correlating with increased height and leaf

area. Lintur continued to maintain a low Pn at $8.5 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, indicating stable suppression of growth processes, whereas Dianat and Roundup Max allowed partial recovery of photosynthesis, reaching 12.0 and $11.5 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, respectively.

On the 21st day, control plants reached $22.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, demonstrating high physiological activity during the intensive growth and budding phases. Lintur remained the strongest suppressor, maintaining Pn at $10.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$. Dianat and Roundup Max gradually increased photosynthesis to 15.0 and $14.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, reflecting moderate recovery of photosynthetic activity.

By the 30th day, control plants reached the maximum Pn of $24.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, coinciding with the flowering phase and completion of generative

development. Lintur maintained the lowest photosynthesis level at $11.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, demonstrating prolonged and stable suppression of physiological activity. Dianat and Roundup Max reached 16.5 and $17.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, respectively,

indicating their partial effectiveness and moderate inhibition of growth and development in the later stages (Table 3).

Table 3. Dynamics of photosynthetic activity of *Solidago canadensis* L. after herbicide treatment, Pn ($\mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{c}^{-1}$)

Variant	7 days	14 days	21 days	30 days
Control	12.5 ± 1.2	18.0 ± 1.5	22.0 ± 1.8	24.0 ± 2.0
Lintur 0.3 kg/ha	6.0 ± 0.8	8.5 ± 1.0	10.0 ± 1.2	11.0 ± 1.3
Dianat 1.5 L/ha	8.0 ± 0.9	12.0 ± 1.2	15.0 ± 1.5	16.5 ± 1.6
Roundup Max 4.0 L/ha	7.5 ± 0.9	11.5 ± 1.3	14.0 ± 1.5	17.0 ± 1.7

Source: results of own scientific research

Photosynthetic parameters correlated with leaf surface condition and transpiration intensity. Thirty days after herbicide application, control plants exhibited high chlorophyll content (SPAD – 42 ± 3 arbitrary units) and maximum transpiration rate ($\text{Tr} - 5.0 \pm 0.5 \text{ mmol H}_2\text{O} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$), reflecting active physiological activity and unobstructed leaf development. Treatment with Lintur at 0.3 kg/ha caused a significant reduction in both indicators: SPAD decreased to 28 ± 2 , and Tr to 2.5 ± 0.3 ,

indicating strong suppression of the photosynthetic apparatus, reduced chlorophyll content, and impaired water exchange. Dianat at 1.5 l/ha and Roundup Max at 4.0 l/ha showed intermediate effects. In Dianat-treated plants, SPAD was 34 ± 3 , and Tr – 3.5 ± 0.4 , whereas in the Roundup Max variant, SPAD reached 36 ± 3 , and Tr – 4.0 ± 0.4 , indicating moderate suppression of physiological activity compared to the control (Table 4).

Table 4. SPAD and leaf transpiration (Tr) of *Solidago canadensis* L. (30 Days)

Variant	SPAD	Tr ($\text{mmol H}_2\text{O} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$)
Control	42 ± 3	5.0 ± 0.5
Lintur 0.3 kg/ha	28 ± 2	2.5 ± 0.3
Dianat 1.5 L/ha	34 ± 3	3.5 ± 0.4
Roundup Max 4.0 L/ha	36 ± 3	4.0 ± 0.4

Source: results of own scientific research

Thus, the SPAD and transpiration data confirm the conclusions from the photosynthesis dynamics: Lintur most strongly suppresses the physiological activity of plants, inhibiting both photosynthesis and water exchange, whereas the effects of Dianat and Roundup Max are less pronounced, allowing plants to partially maintain photosynthetic activity and leaf turgor. These results are consistent with the morphometric and phenological parameters, demonstrating that herbicide effectiveness directly correlates with reductions in photosynthetic activity and leaf condition.

Conclusions

The conducted study demonstrated that herbicide application during the early growth phases of *Solidago canadensis* L. significantly affects the morphometric, phenological, and photosynthetic parameters of the plants. Control plants, after 30 days, reached an average height of 140 cm , stem diameter of 1.1 cm , leaf area of 950 cm^2 , and formed an average of six regenerative shoots, with photosynthesis rate (Pn) of $24.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, chlorophyll content (SPAD)

of 42 arbitrary units, and transpiration intensity (Tr) of $5.0 \text{ mmol H}_2\text{O} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$. Therefore, the study showed that herbicides significantly affect the morphometric, phenological, and photosynthetic parameters of *Solidago canadensis* L. The strongest suppression of growth, reproductive organ development, and photosynthetic activity was observed in the variant treated with Lintur (0.3 kg/ha), manifested as reductions in plant height and stem diameter, leaf area, number of regenerative shoots, photosynthesis rate, chlorophyll content, and transpiration intensity. Roundup Max (4.0 l/ha) exhibited an intermediate effect, while Dianat (1.5 l/ha) caused moderate inhibition of plant physiological activity.

of 42 arbitrary units, and transpiration intensity (Tr) of $5.0 \text{ mmol H}_2\text{O} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$.

The most effective herbicide was Lintur (0.3 kg/ha), which reduced plant height to 65 cm , stem diameter to 0.6 cm , leaf area to 420 cm^2 , number of regenerative shoots to two, photosynthesis rate to $11.0 \mu\text{mol CO}_2 \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, SPAD to 28 units, and transpiration to $2.5 \text{ mmol H}_2\text{O} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$. Treatment with Dianat (1.5 l/ha) and Roundup Max (4.0 l/ha) had

moderate effects: plant heights were 92 cm and 110 cm, stem diameters 0.8 cm and 0.9 cm, leaf areas 630 cm² and 780 cm², regenerative shoots 4 and 5, Pn 16.5 and 17.0 μmol CO₂·m⁻²·s⁻¹, SPAD 34 and 36 units, and Tr 3.5 and 4.0 mmol H₂O·m⁻²·s⁻¹, respectively.

References

- Anas M., Huang Z.-Y., Xiong H., Imran M., Yan M.-T., Javed Q., Ren G., Qi S.-S., Li J., Dai Z.-C., Du D.-L. (2025). Response of invasive *Solidago canadensis* to foliar application of natural herbicide and glyphosate. *Journal of Environmental Management*. 394. P. 127522. DOI: <https://doi.org/10.1016/j.jenvman.2025.127522>.
- Byun C., Kettenring K.M., Tarsa E.E., de Blois S. (2023). Applying ecological principles to maximize resistance to invasion in restored plant communities. *Ecological Engineering*. 190: 106926. DOI: <https://doi.org/10.1016/j.ecoleng.2023.106926>.
- Cheng J., Li J., Zhang Z., Lu H., Chen G., Yao B., Dong Y., Ma L., Yuan X., Xu J., et al. (2021). Autopolyploidy-driven range expansion of a temperate -originated plant to pan-tropic under global change. *Ecological Monographs*. 91(3): e01445. https://www.researchgate.net/publication/346973899_Autopolyploidy-driven_range_expansion_of_a_temperate-originated_plant_to_pan-tropic_under_global_change.
- Davies K.W., Clenet D.R., Madsen M.D., Brown V.S., Ritchie A.L., Svejcar L.N. (2024). Activated carbon seed technologies: Innovative solutions to assist in the restoration and revegetation of invaded drylands. *Journal of Environmental Management*. 371: 123281. DOI: <https://doi.org/10.1016/j.jenvman.2024.123281>.
- Hutchinson R.A., Fremier A.K., Viers J.H. (2020). Interaction of restored hydrological connectivity and herbicide suppresses dominance of a floodplain invasive species. *Restoration Ecology*. 28(6): 1551–1560. DOI: <https://doi.org/10.1111/rec.13240>.
- Korpita H. Weed control - agronomic responsibility. *Scientific Papers of the International Academy of Applied Sciences Lomza*. Vol. 98 No. 2 (2025) C. 92-105. <https://ojs.mans.edu.pl/index.php/sjiaas/article/view/411/139>.
- Lin H., Chen L., Li J. (2023). Multiple introductions and distinct genetic groups of Canada goldenrod (*Solidago canadensis*) in China revealed by genomic single-nucleotide polymorphisms. *Plants*. 12(1): 173. <https://pubmed.ncbi.nlm.nih.gov/37176791/>
- Lu H., Xue L., Cheng J., Yang X., Xie H., Song X., Qiang S. (2020). Polyploidization-driven differentiation of freezing tolerance in *Solidago canadensis*. *Plant, Cell & Environment*. 43(6): 1394–1403. <https://pubmed.ncbi.nlm.nih.gov/32092164>.
- Möhrle K., Reyes-Aldana H.E., Kollmann J., Teixeira L.H. (2021). Suppression of an invasive native plant species by designed grassland communities. *Plants*. 10(4): 775. DOI: <https://doi.org/10.3390/plants10040775>.
- Murillo R.D.A., Wagner V. (2025). Propagule pressure and soil disturbance diminish plant community resistance to invasion across habitat types. *Journal of Vegetation Science*. 36(2): e70033. https://www.researchgate.net/publication/390579473_Propagule_Pressure_and_Soil_Disturbance_Diminish_Plant_Community_Resistance_to_Invasion_Across_Habitat_Types.
- Pyšek P., Hulme P.E., Simberloff D., Bacher S., Blackburn T.M., Carlton J.T., Dawson W., Essl F., Foxcroft L.C., Genovesi P., et al. (2020). Scientists' warning on invasive alien species. *Biological Reviews*. 95(5): 1511–1534. DOI: <https://doi.org/10.1111/brv.12627>.
- Roiloa S.R., Yu F.H., Barreiro R. (2022). Effects of glyphosate application on physiologically integrated clones of the invasive plant *Carpobrotus edulis*. *Diversity*. 14: 47. DOI: 10.3390/d14030047.
- Smith A.L., Kanjithanda R.M., Hayashi T., French J., Milner R.N.C. (2023). Reducing herbicide input and optimizing spray method can minimize nontarget impacts on native grassland plant species. *Ecological Applications*. 33(5): e2864. DOI: <https://doi.org/10.1002/eap.2864>.
- Spake R., Soga M., Catford J.A., Eigenbrod F. (2021). Applying the stress-gradient hypothesis to curb the spread of invasive bamboo. *Journal of Applied Ecology*. 58(9): 1993–2003. <https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.13945>.
- Svejcar L.N., Martyn T.E., Edlund H.R., Davies K.W. (2024). A Test of activated carbon and soil seed enhancements for improved sub-shrub and grass seedling survival with and without herbicide application. *Plants*. 13(21): 3074. DOI: <https://doi.org/10.3390/plants13213074>.
- Szymura M., Świercz S., Szymura T.H. (2022). Restoration of ecologically valuable grassland on sites degraded by invasive *Solidago*: Lessons from a 6-year experiment. *Land Degradation & Development*. 33(10): 1985–1998. <https://www.researchgate.net/publication/359849777>



Restoration_of_ecologically_valuable_grassland_on_sites_degraded_by_invasive_Solidago_lessons_from_a_6-year_experiment.

Vantarová K.H., Eliáš P., Jr., Jiménez-Ruiz J., Tokarska-Guzik B., Cires E. (2023). Biological invasions in the twenty-first century: A global risk. *Biologia*. 78(8): 1211–1218. <https://link.springer.com/article/10.1007/s11756-023-01394-7>.

Wang S., Liao Z.Y., Cao P., Schmid M.W., Zhang L., Bi J., Endriss S.B., Zhao Y., Parepa M., Hu W.Y., et al. (2025). General-purpose genotypes and evolution of higher plasticity in clonality underlie

knotweed invasion. *New Phytologist*. 246(3): 758–768. <https://nph.onlinelibrary.wiley.com/doi/10.1111/nph.20452>.

Ye X., Gu C., Meng J., Wu M. (2025). Differences in the Response of Invasive *Solidago canadensis* and Native *Imperata cylindrica* to Glyphosate. *Plants*. 14(17): 2640 <https://neobiota.pensoft.net/article/129863>.

Ye X.Q., Meng J.L., Ma R.X., Liang J.L., Wu M., Man R.Z., Yu F.H. (2024). Winter leaf phenology differences facilitate selective control of an invasive plant species by herbicide. *NeoBiota*. 96: 67–87. <https://neobiota.pensoft.net/article/129863>.

ВПЛИВ ГЕРБІЦИДІВ НА МОРФОМЕТРИЧНІ, ФЕНОЛОГІЧНІ ТА ФОТОСИНТЕТИЧНІ ПОКАЗНИКИ *SOLIDAGO CANADENSIS L.*

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Метою дослідження було оцінювання впливу різних гербіцидів на морфологічні показники *Solidago canadensis L.*, зокрема висоту рослин, діаметр стебла, площу листової поверхні, кількість відновних пагонів, а також фотосинтетичну активність. Дослідження висонано у 2020–2025 рр. у природних фітоценозах західного Лісостепу України. Гербіцидну обробку виконували у фазі розетки та на ранніх етапах інтенсивного росту рослин, що дозволяло оцінити максимальний біологічний ефект системних препаратів. Варіант контролю не передбачав застосування хімічних засобів.

Результати показали, що всі досліджені гербіциди пригнічують морфометричні показники та фотосинтетичну активність *S. canadensis L.*, проте ступінь ефекту різнився. Найбільше пригнічення спостерігалося після обробки гербіцидом Лінтур (0,3 кг/га), який зменшував висоту рослин, діаметр стебла та площу листків, обмежував кількість відновних пагонів та суттєво знижував швидкість фотосинтезу, вміст хлорофілу та інтенсивність транспірації. Раундап Макс (4,0 л/га) демонстрував проміжний ефект, тоді як Діанат (1,5 л/га) пригнічував рослини помірно.

Фенологічний розвиток рослин також уповільнювався, особливо після застосування гербіциду Лінтур, що проявлялося у затримці стеблуння, бутонізації та цвітіння. Отримані дані можуть слугувати основою для розробки регламентованих схем хімічного контролю *S. canadensis L.*, підвищення ефективності управління фітоценозами та збереження біорізноманіття на агроландшафтах і природних територіях.

Ключові слова: гербіциди, морфометричні показники, фотосинтетична активність, фенологія, системний контроль, інвазивні рослини, західний Лісостеп України

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