

Weed Pressure and Management Approaches in Maize on the Žitný Ostrov Region

Szilárd György Sóki, Štefan Týr*

Slovak University of Agriculture in Nitra, Faculty of Agrobiological Sciences, Institute of Crop Production, Slovakia

Article Details: Received: 2025-11-27 | Accepted: 2026-02-23 | Available online: 2026-09-30

<https://doi.org/10.15414/afz.2026.29.03.347-352>



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Maize (*Zea mays* L.) production on the Žitný Ostrov region of Slovakia takes place under highly productive soil conditions that also promote intensive weed growth, making weed management one of the most critical agronomic challenges. This review synthesizes current knowledge and practical experiences with weed control strategies applied in the region, with a focus on the dominant weed species such as *Amaranthus retroflexus* L., *Chenopodium album* L., *Echinochloa crus-galli* (L.) P. Beauv., *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* L., and *Setaria* spp. Conventional practices in Žitný Ostrov rely primarily on chemical control, especially post-emergence herbicides, due to their efficiency, economic viability, and flexibility in targeting specific weed communities. Preventive practices such as maintaining clean seed material, crop rotation and managing weed populations on field margins are widely adopted by most farmers and play an important role in reducing overall weed pressure. Although integrated weed management (IWM) approaches combining mechanical, chemical, cultural, and biological methods offer greater ecological sustainability, their adoption in the region is still limited. Innovative strategies such as precision agriculture, thermal weed control, cover crops, and biostimulants show promising potential but face barriers including high costs, technical demands, and insufficient farmer training. Current weed management in Žitný Ostrov relies largely on conventional practices, while wider adoption of integrated and site-specific approaches will depend on improved farmer education, greater technological accessibility, and stronger links between research and on-farm decision-making.

Keywords: maize, integrated weed management, herbicide, Žitný Ostrov region

1 Introduction

The Žitný Ostrov region is one of the most productive agricultural areas in Slovakia. The combination of pleasant climate and high-quality soil allows for intensive cultivation of several crops, of which maize (*Zea mays* L.) is one of the most significant. Despite the extremely favorable conditions, maize cultivation in the region is accompanied by several agronomic challenges. One of the most significant is weed control, which significantly affects crop yields, production quality, and the economics of cultivation. Žitný Ostrov is characterized by soils formed mainly on alluvial sediments of the Danube and Little Danube, which include mainly floodplain soils, brown forest soils, and chernozems. These soil types provide above-average production conditions, but at the same time promote rapid weed growth. Water and its availability in the region vary according to the depth

and nature of the soil profile, which also influences their management (Krnáčová et al., 2025; Bara et al., 2024).

This review focuses on an overview and evaluation of experiences with weed control in maize cultivation on Žitný Ostrov. In addition to traditional agronomic and chemical practices, it also analyses modern and integrated weed management strategies, their effectiveness, impact on yields, and contribution to the long-term ecological stability of the agricultural landscape.

1.1 Characteristics of Weed Pressure in the Žitný Ostrov Region

Žitný Ostrov is characterized by highly fertile soils, mainly of the chernozem type, and sufficient water availability thanks to the presence of underground reserves. However, these conditions are not only favorable

*Corresponding Author: Štefan Týr, SUA Nitra, Faculty of Agrobiological Sciences, Institute of Crop Production, Trieda Andreja Hlinku 2, 949 01 Nitra, Slovak Republic
e-mail: stefan.tyr@uniag.sk <https://orcid.org/0000-0001-7795-7538>

for cultivated crops, but also for weeds, which can compete with maize for light, nutrients, and water (Bara et al., 2024; Monteiro & Santos, 2022). The most common weeds in the area are: *Amaranthus retroflexus* L. (redroot pigweed) – mass germination takes place from April to August at a depth of 60–80 mm at temperatures ranging from a minimum of 10–20 °C, an optimum of 28–36 °C, to a maximum of 50–52 °C. In warmer areas at an altitude of 100–580 m, it is widespread on sandy soils. It occurs as a weed in root crops, by roadsides, on fallow land, and on arable land. *Amaranthus* species are sensitive to most soil and foliar (post-emergent) herbicides recommended for the control of annual two-leafed weeds. Herbicides applied to the leaves are generally effective up to the four- to six-leaf stage. *Amaranthus* species can also be easily controlled with non-selective herbicides such as glyphosate (Mikulka et al., 2024). Species *Chenopodium album* L. (lamb's quarters) – germinates irregularly, most often in spring between March and October, from a depth of approximately 20 mm, with fluctuating temperatures promoting germination. In spring, it germinates at a minimum temperature of 3 to 4 °C, an optimum temperature of 18 to 24 °C, and a maximum temperature of 34 to 36 °C. It is widespread throughout Slovakia and grows on all soil types. As a weed, it affects all agricultural crops, especially root crops and vegetables. An effective method of protection against *Chenopodium album* L. may be to increase the density of maize, which reduces the vegetative and floral biomass of *Amaranthus retroflexus* L. and the total dry matter of *Chenopodium album* L. Further analysis showed that the biomass of *Chenopodium album* L. decreased when the distance between corn rows was reduced from 0.76 to 0.38 m. Studies have confirmed that the presence of *Chenopodium album* L. leads to significant crop loss when it appears before maize. For every few days that *Chenopodium album* L. appears before maize, the competitive potential of maize is reduced and there is an intense reduction in yield. These findings can serve as a basis for decisions on the use of pre-emergence herbicides in maize cultivation (Mikulka & Týr, 2021). Species *Echinochloa crus-galli* (L.) P. Beauv. (barnyard grass) – the seeds have low germination rates when fresh, but after overwintering they germinate well from a depth of up to 120–140 mm in late spring at a minimum temperature of 4–6 °C, an optimum temperature of 26–28 °C, and a maximum temperature of 50–52 °C. Its habit resembles that of corn. This weed is considered an economically important weed not only at the regional level, but also in many agricultural systems around the world. Its management presents a special challenge in cereals, where the required selectivity of herbicides, rapid rooting that limits the effectiveness of mechanical weeding, and morphological similarity to cultivated grasses often prevent successful control.

Regardless of the method used chemical, mechanical, or combined, the effectiveness of any intervention ultimately depends on the precision and timing of control measures (Piskáčková & Jursík, 2023; Majchrzak et al., 2024). Species *Cirsium arvense* (L.) Scop. (creeping thistle) – sprouts germinate very well after ripening, preferably in a shallow layer in spring at minimum temperatures of 4–6 °C and maximum temperatures of 38–40 °C, from a depth of 40–50 mm. *Cirsium arvense* (L.) Scop. shows higher competitiveness against grain maize in nutrient uptake, especially in conditions of soil water deficit, but not in all cases. Lower competitiveness was found in conditions of sufficient soil moisture (Ganji & Andert, 2024). Species *Convolvulus arvensis* L. (field bindweed) – fresh seeds germinate poorly, but after overwintering, stratification, and passing through the digestive tract of animals, they germinate very well. Germination occurs at minimum temperatures of 4–6 °C, optimal temperatures of 18–24 °C, and maximum temperatures of 50–52 °C, from a depth of up to 150 mm (Ma et al., 2023). Pre-emergence treatments in maize do not control *Convolvulus arvensis*, or at best only suppress its occurrence. The key problem in controlling it in maize may be the timing of post-emergence treatment to maximize the leaf area of the weed. This can also be achieved by not tilling the soil for at least a week before sowing, so that small and viable *Convolvulus arvensis* appear earlier. The following herbicides and herbicide combinations are effective in corn: 2,4-D, dicamba, fluroxypyr, tritosulfuron, rimsulfuron, florasulam (Hettinger et al., 2023). Species *Setaria* spp. (mohars) – germinates in May and June, preferably at a depth of 20–50 mm, at an optimal temperature of 20–24 °C and a maximum of 42–44 °C (Mikulka & Týr, 2021; Šoštarčić et al., 2024). These weeds are problematic not only because of their ability to reproduce rapidly and their resistance to adverse conditions, but also because of their competitiveness with corn during its critical growth period.

1.2 Weed Control Methods

1.2.1 Mechanical Control

Mechanical methods such as plowing and inter-row cultivation are traditional and effective tools for weed control. On Žitný Ostrov, mechanical control is often used as a first step before applying chemical or biological methods. Deep plowing allows for the elimination of persistent weeds and disruption of their root system, while inter-row cultivation minimizes weed pressure during the vegetation period. Studies show that mechanical weed removal, compared to undisturbed control, disrupts the soil crust, which increases the soil's ability to rewet and increases water infiltration. This



Figure 1 Mechanical weed control in maize growth
Source: T H WHITE Agriculture, 2021

improvement can be particularly important on sandy soils, which are very sensitive to drought and can benefit significantly from improved rewetting dynamics (Beiküfner et al., 2024; Singh et al., 2024).

1.2.2 Chemical Control

The use of herbicides is one of the most widespread methods of weed control. In the Žitný Ostrov region,

selective herbicides are mainly used, which target specific types of weeds while minimizing damage to maize (Monteiro & Santos, 2022; Tataridas et al., 2022). The most used are:

- Pre-emergence herbicides (applied before weeds emerge, e.g., contain the active ingredient pendimethalin, dimethenamid, terbuthylazine).



Figure 2 Chemical weed regulation, application of post emergence herbicide
Source: Maize Farming Solutions: Crop Protection & Seed Tech|Bayer, n.d.

- Post-emergence herbicides (applied after weeds emerge, e.g., based on nicosulfuron, mesotrione, dicamba, 2,4-D, bentazone, clopyralid, tembotrione, florasulam, rimsulfuron) (Nedeljković et al., 2025; ISPOR, 2026).

It is important to time the application properly, taking into consideration the stage of development of the maize and weeds, as well as current conditions such as soil moisture and temperature. New herbicides are compounds that can be absorbed by plants through their roots and/or leaves. They can also be absorbed by young shoots and, in some cases, have even been observed to be uptaken by germinating seeds (Wolejko et al., 2022). Herbicides can be classified according to their specific mode of action in plants. However, repeated use of the same herbicide with the same mode of action inevitably encourages the selection and development of weed populations that are resistant to that substance or mode of action (Kolářová et al., 2023).

1.2.3 Mechanical Combined Chemical Control

Herbicide savings achieved through combined weed control strategies ranged from 24% to 60%. These savings were calculated as the ratio of area not treated compared to conventional chemical programs combined with mechanical methods. As studies show, this proves that the pesticide reduction targets set by the European Commission can be achieved using currently available

mechanical weed control technologies. However, the effectiveness of mechanical operations depends largely on the conditions of the environment and soil. Successful mechanical weed control requires dry soil in the early stages of weed growth, and tools such as hoeing and harrowing are generally more effective in light, loose soils than in soils with higher clay or stone content. It should also be recognized that conventional mechanical weed control is more time-consuming than chemical weed control due to lower working speeds and smaller working widths (Gerhards et al., 2024; Tataridas et al., 2022).

1.2.4 Integrated Weed Management

Integrated Weed Management (IWM) combines several approaches, including mechanical, chemical, and biological methods. This strategy is becoming increasingly popular in the Žitný Ostrov region because it offers an environmentally sustainable solution with a lower risk of weeds developing resistance to herbicides.

Proven approaches includes: Crop rotation (especially using crops that effectively suppress weeds). Use of mulching techniques to reduce weed growth. Use of natural antagonists, such as certain types of insects or fungi that attack weeds. Use of precision agriculture (Xiang et al., 2024; Restuccia & Scavo, 2023; Monteiro & Santos, 2022).

Table 1 Dominant weed species in maize production on Žitný Ostrov and their practical management implications

Weed species	Agronomic relevance	Critical growth stage	Effective control options	Notes for practice
<i>Amaranthus retroflexus</i>	high	2–6 leaf stage	early post-emergence herbicides, crop competition	risk of resistance, rapid emergence
<i>Chenopodium album</i>	high	pre- to early post-emergence	pre-emergence herbicides, narrow row spacing	early emergence causes yield loss
<i>Echinochloa crus-galli</i>	very high	early tillering	timely post-emergence, mechanical support	morphological similarity to maize
<i>Cirsium arvense</i>	medium-high	rosette stage	systemic post-emergence	moisture dependent competitiveness
<i>Convolvulus arvensis</i>	medium	full leaf development	delayed post-emergence	poor pre-emergence control

Table 2 Comparison of weed management approaches used in maize production on Žitný Ostrov

Management approach	effectiveness	cost	Adoption in region	Key limitations
Chemical only	high	low-medium	very common	resistance risk, regulatory limits
Mechanical only	medium	medium	limited	weather and soil dependent
Chemical + mechanical	high	medium	increasing	timing sensitive
Integrated (IWM)	high	medium-high	low	knowledge, technology access

1.2.5 Weed Management on Žitný Ostrov

At present, conventional weed management technologies are primarily used in the maize fields of Žitný Ostrov, based mainly on chemical control using herbicides. However, many farms supplement these practices with mechanical methods or use an integrated weed management (IWM) system, which combines various approaches to reduce dependence on chemical interventions. Post-emergence herbicides are predominantly used, mainly for economic and efficiency reasons. This approach allows for the precise identification of the weed spectrum directly in the crop and the subsequent targeted selection of an active substance or combination of substances. In this way, the effectiveness of the intervention can be optimized while minimizing the excessive application of chemicals. However, due to time constraints during spring field work, many farms also choose pre-emergence herbicide applications, which allow for preventive protection of crops in the early stages of vegetation and better distribution of work capacities. Modern methods, such as precision farming or thermal weed control, are not yet widely used in Žitný Ostrov. The main reasons for this are their high financial costs and the limited technical readiness of agricultural entities, especially in the case of the older generation of farmers, who often lack sufficient knowledge to effectively use digital technologies and data systems associated with precision crop management. Similarly, agrotechnical innovations such as the use of cover crops or the application of biostimulants are only implemented to a limited extent. The main barriers to their widespread adoption are a lack of practical experience and knowledge of technological processes, as well as farmers' skepticism about their effectiveness and economic return.

2 Conclusions

Weed management in maize production in the Žitný Ostrov region remains largely based on conventional technologies, primarily using chemical control methods, particularly post-emergence herbicide applications. These approaches are preferred for their economic efficiency and effectiveness, allowing for the targeted control of specific weed species within the crop. In addition, some farms integrate mechanical control or preventive measures to complement chemical protection and improve long-term weed suppression. Although innovative and alternative strategies, such as precision agriculture, thermal weed control, cover crops, and biostimulants, hold great potential for reducing the chemical burden on agroecosystems and enhancing sustainability, their adoption in practice remains limited. The main barriers include high implementation costs, technical complexity, and a lack of knowledge

and confidence among farmers, especially those from older generations. In the long term these alternative approaches offer significant potential for sustainable management, reducing the chemical load on the agroecosystem, and promoting soil biodiversity. Their gradual integration into practice will depend on improving the level of professional education, the availability of financial instruments, and more intensive transfer of knowledge from research to agricultural practice.

Acknowledgment

The work was supported by the project VEGA 1/0591/25: "Intercrops for improvement of ecosystem services in sustainable agriculture: focus on regenerative soil processes, crop productivity and stress resistance".

Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

Conceptualization, Š.T. and S.G.S.; data curation, S.G.S. and Š.T.; formal analysis, Š.T. and S.G.S.; funding acquisition, Š.T. and S.G.S.; investigation, S.G.S. and Š.T.; methodology, Š.T. and S.G.S.; software, Š.T. and S.G.S.; resources, Š.T. and S.G.S.; supervision, Š.T. and S.G.S.; validation, Š.T. and S.G.S.; visualization, S.G.S. and Š.T.; writing – original draft, S.G.S. and Š.T.; writing – review & editing, Š.T. and S.G.S. All authors have read and agreed to the published version of the manuscript.

AI and AI-assisted technologies use declaration

No generative AI tools/AI-assisted technologies were used during the preparation of the manuscript.

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