Article Type: Review
J Name: Modern Phytomorphology
Short name: MP
ISSN: ISSN 2226-3063/eISSN 2227-9555
Year: 2025
Volume: 19
Page numbers: 112-116
DOI: 10.5281/zenodo.200121
(10.5281/zenodo.2025-19)
Short Title: Pesticide use and implications for food security

REVIEW ARTICLE

Pesticide use and implications for food security

Oksana Datsko*[1], Marek Jelinek[2], Vitalii Kovalenko[3], Yevheniia Butenko[1], Natalia Kravchenko[1], Maksym Hnitetskyi[1], Roman Bordun[4], Viktor Demenko[1], Lyudmyla Kriuchko[1], Roman Badzym[1]

[1]Sumy National Agrarian University, H. Kondratieva Str., 160, Sumy, 40021, Ukraine
[2]Czech University of Life Sciences Prague, Kamycka str., 129, Prague, 16521, Prague, Czech Republic
[3]National University of Life and Environmental Sciences of Ukraine, Heroiv Oborony Str., 11, Kyiv, 03041, Kyiv, Ukraine
[4]Institute of Agriculture of Northern East of National Academy of Agrarian Sciences of Ukraine, Parkova Str., 3, Sumy region, village Sad, Sumy region, Ukraine

***Corresponding author:** Oksana Datsko, Sumy National Agrarian University, H. Kondratieva Str., 160, Sumy, 40021, Ukraine
E-mail: andb201727@ukr.net

Received: 16.01.2025, Manuscript No: mp-25-158827 | **Editor Assigned:** 18.01.2025, Pre-QC No. mp-25-158827(PQ) | **Reviewed:** 27.01.2025, QC No. mp-25-158827(Q) | **Revised:** 2.02.2025, Manuscript No. mp-25-158827(R) | **Accepted:** 8.02.2025 | **Published:** 14.02.2025

Abstract

Pesticides play a vital role in modern agriculture by protecting crops from pests, diseases, and weeds, thus ensuring high productivity. However, their extensive use poses significant risks to environmental health, including soil and water pollution, loss of biodiversity, and adverse effects on pollinators like bees. Human health is also impacted, with potential links to chronic and oncological diseases. This study examines pesticide usage in Switzerland, highlighting public concerns and initiatives to limit their use. Although proposals to ban synthetic pesticides have faced resistance, the Swiss government has introduced measures to mitigate associated risks. Alternative pest management strategies, such as organic farming and preventive methods, are explored, alongside advancements like the SYNOPS model for predicting pesticide concentrations in water. The research underscores the need for safer pesticide formulations and robust regulatory frameworks to balance agricultural productivity with environmental sustainability. Despite progress, challenges remain, including cross-contamination and food security risks. Switzerland's efforts reflect a broader move toward sustainable agriculture, providing insights for other nations striving to reduce pesticide dependency.

Keywords: Pesticides, Sustainable agriculture, Environmental impact, Environmental safety, Bioethics, Biotechnological production, Pollution, Biodiversity loss

Introduction

The use of pesticides in modern agriculture plays a critical role in food production. Their primary purpose is to ensure high productivity and protect agricultural crops from pests, diseases, and weeds. The most commonly used pesticides are insecticides, fungicides, and herbicides. These substances help control harmful organisms, including insects, fungi, and bacteria, as well as weeds, thereby reducing the risks of yield loss and diminished product quality. However, numerous studies (Rani et al., 2021; Tudi et al., 2021; Datsko, et al., 2024) have demonstrated that pesticide use has significant negative impacts on both the environment and human health. Environmental consequences include soil and water pollution, along with a decline in biodiversity and a reduction in uncultivated plant populations. Furthermore, pesticides can adversely affect human health, contributing to the development of chronic and oncological diseases. For instance, Mulla et al. (2020) reported that the use of organophosphorus pesticides leads to a substantial decrease in

biodiversity within both biocenoses and agrocenoses. The detrimental effects of pesticides on human health have also been documented by scientists in Uzbekistan (Eshkaraev et al., 2021; Sobko et al., 2024). Specifically, agricultural crops are now cultivated on former agricultural airfields that are no longer in use, and this practice has been linked to an increase in oncological diseases in the region. Additionally, pesticides contaminate freshwater sources and negatively impact pollinators such as bees (Ali et al., 2021; Datsko, et al., 2024).

Concerns about drinking water contamination have spurred active discussions regarding the adverse effects of pesticides. Consequently, several countries have implemented monitoring systems and regulations to address this issue (Karpenko et al., 2021; Baran et al., 2022). These efforts aim to mitigate the harmful impacts of pesticides on water resources and public health. A study by De Baan et al., (2020) suggests that an effective method to reduce pesticide concentrations in drinking water is through the development of the SYNOPS model. This model serves as the basis for a national risk indicator for aquatic environments in Switzerland.

As part of this study, the parameters of the SYNOPS model were modified to align with the geographical conditions of Switzerland. The model integrates data on pesticide use, climate, soil properties, and crop growth phases to predict pesticide concentrations in water bodies and establish corresponding exposure-toxicity relationships. Sensitivity analysis of the model revealed that slope and partition coefficients are the most influential factors affecting pesticide concentration. Moreover, discharge—or runoff—was identified as the primary pathway for pesticides entering aquatic environments.

In recent decades, the use of pesticides has increased significantly, driven by the growth of the human population. This has led to the expansion of intensive agricultural production and heightened demands for productivity. Large agricultural companies and farms, in particular, rely heavily on pesticides to achieve high yields. Notably, pesticides in such cases are often applied preventively, rather than as a reactive measure after problems arise. While this approach enhances productivity, it simultaneously exacerbates environmental pressures. Alongside their advantages, pesticides present numerous challenges, including negative consequences for ecosystems and biodiversity.

Using Google Trends data for Switzerland, Schaub et al. (2020) analyzed public concerns about pesticides and plant protection products from 2011 to 2019. The study noted a dramatic increase in public interest in these topics since 2017. This trend appears to be influenced by searches specifically related to pesticides, while interest in searches related to plant protection products remained stable. The heightened public interest may be attributed to an increasing negative perception of pesticides, particularly regarding their environmental and health impacts, as the term "pesticides" carries stronger negative connotations compared to "plant protection products." The researchers also found evidence supporting the hypothesis that growing community concerns about pesticide use contributed to the creation of two major initiatives aimed at limiting pesticide use in Switzerland. These programs, in turn, further amplified public awareness and concern.

A noteworthy study by Wuepper et al. (2021) examined how the advice farmers receive influences their pest management strategies. The researchers surveyed 733 Swiss fruit growers dealing with an outbreak of the fruit fly Drosophila suzukii. Farmers who received advice from public extension agencies were more likely to adopt preventive measures, such as the use of nets. Conversely, those who relied on private extension services linked to pesticide manufacturers were more inclined to use synthetic insecticides. The authors emphasized the importance of these findings for debates on the privatization of agricultural extension services and the broader implications for environmental and medical concerns stemming from pesticide use.

This article will examine the various aspects of pesticide use in Swiss agriculture that led to their ban. Problems related to them and ways to solve these problems. Alternative methods of pest and weed control that can help reduce the negative impact of pesticides on the environment, while maintaining the high productivity of agricultural land, will also be proposed

Literature Review

Main Body

In the Confederation of Switzerland, the initiative to ban pesticides was led by the citizen group "Future 3," whose primary goal was to make Switzerland pesticide-free. The group's spokesman, Dominic Waser, stated that their main motivation was to protect human health and the environment. However, the proposal faced significant opposition from farmers, who deemed the initiative unrealistic. Martin Rufer, the director of the Swiss Farmers' Association, warned that

such a ban could have severe consequences for the country's agriculture. Ultimately, a national referendum rejected the initiative. Nevertheless, the government introduced a counterproposal aimed at halving the risks associated with pesticide use within six years (Illien, 2021; Trotsenko et al., 2024; Davydenko et al., 2024).

One of the government's proposals was the promotion of inorganic wheat cultivation without the use of pesticides. Standards for pesticide-free wheat production were developed as part of this initiative. A survey conducted among agricultural producers revealed that, with the support of government programs, most farmers were willing to adopt pesticide-free cultivation practices. Moreover, many expressed a strong interest in preserving the environment (Karpenko et al., 2020; Parkhomenko et al., 2021; Möhring & Finger, 2022).

Research by Schläpfer (2020) estimated the external costs of agriculture, including water pollution, by analysing payments for agro-environmental protection measures. The study proposed that these payments be used to estimate external costs and reduce the negative impacts of environmental factors such as greenhouse gases, ammonia, nitrates, pesticides, soil erosion, habitat loss, and animal suffering. The findings revealed that Swiss agriculture incurs over 3 billion Swiss francs in external costs annually.

One of the reasons supporting such an initiative could be a study by Schaad et al. (2023), which convincingly demonstrated that peak contamination of "bee bread" with certain pesticides occurred precisely during their application periods. Given the critical role of bees in agriculture, this contamination poses a significant problem.

However, the issue of reducing pesticide use has been a subject of discussion for some time. For example, Mouron et al. (2016) studied the effects of abandoning pesticides in the cultivation of wheat and potatoes. Their findings indicated that eliminating pesticides could lead to decreased yields. Similarly, Möhring, Wuepper, et al. (2020) examined how agricultural producers in Sweden decided on the timing of fungicide applications to control late-onset potato diseases. Their study revealed that 36% of fungicide applications occurred earlier than recommended.

Using regression analysis, the researchers identified key factors influencing these decisions, including the economic risks of infection, the susceptibility of specific potato varieties, and annual variations in disease incidence. The results highlighted that limited availability of information and uncertainty about disease prognosis often led to non-compliance with recommended practices. To address these challenges, the authors proposed several measures, including adopting new technologies, implementing mandatory reporting systems, and creating individualized tax and insurance policies tailored to support agricultural decisions.

Möhring, Ingold, et al. (2020) emphasized the necessity of developing and registering new, safer pesticides. They also highlighted the importance of establishing a single regulatory body to process permits for active ingredients and monitor their usage and impact. To mitigate risks, an increased number of pesticide safety assessments should be conducted by anonymous accredited laboratories. This approach would enhance trust and reliability in the findings by reducing conflicts of interest associated with industry-provided data. Furthermore, environmental parameters should be integrated into risk assessments to evaluate the potential dangers posed by pesticide transformation products. Restricting the registration process to safer and more effective products would enable faster post-authorization risk assessments, reduce delays between market release and public risk studies, and improve the overall pesticide authorization process. Current risk assessments are limited to individual pesticides on specific crops; however, assessing pesticide use in real-world settings requires a broader perspective that encompasses the agroecosystem level.

While these measures could improve safety, the policy of restricting pesticide registration might also pose risks to food security and increase the likelihood of farm bankruptcies. As a response, farmers who initially complied with pesticide-free requirements actively insured their crops. Without crop insurance, pesticide-related costs would have been 6%-11% lower (Möhring, Dalhaus, et al., 2020; Karpenko et al., 2023).

It is also important to recognize that complete protection from pesticide contamination remains highly challenging. Schleiffer and Speiser (2022) examined the contamination of organic products with synthetic pesticides, despite their prohibition in organic production. Such contamination may result from illegal practices or unintended environmental pollution. Artificial pesticides are ubiquitous in the environment and can enter the food chain through various pathways, including residual effects from previously applied pesticides.

Cech et al. (2023) conducted a six-year study on pesticide residues, revealing a decline in the total number of pesticides over time. However, pesticides with endocrine disrupting or carcinogenic properties remained prevalent.

Furthermore, an increase in pesticides with reproductive toxicity and organ-specific toxicity was observed. While the risk to bees remained high, the risk to certain species of earthworms showed a slight decrease.

Despite Switzerland's efforts to reduce pesticide use, achieving full independence from pesticides proved unattainable. The cessation of pesticide use significantly threatens food security by increasing crop susceptibility to pests and diseases. This vulnerability could lead to a substantial rise in food prices, which are already higher in Switzerland compared to the rest of Europe (Mann & Kaiser, 2023; Adamchyk, et al., 2023; Lys et al., 2024).

Conclusion

In summary, the factors discussed clearly indicate that the complete abandonment of pesticides, while a progressive concept, is currently not entirely realistic. This is largely due to challenges such as the presence of pesticide residues even in organic products, which can result from cross-contamination, for instance, when nearby fields are treated with pesticides. Nevertheless, Switzerland stands out as a progressive country making significant efforts in this direction. Its initiatives and policies could serve as a model for other European nations striving to reduce pesticide dependency while maintaining agricultural productivity and environmental sustainability

References

Adamchyk Y., Kravchenko N. Kolisnyk O., Aralova T., Protasov O., Dubovyk O., Dubovyk I., Stavytskyi A. (2023). The efficiency of urea-ammonium nitrate application in inter-row feeding in maize cultivation. *Mod. Phytomorpholog.* **17**: 113-117.

Ali S., Ullah M. I., Sajjad A., Shakeel Q., Hussain A. (2021). Environmental and Health Effects of Pesticide Residues. *Springer Int. Publ.* **48**: 311-336.

Baran N., Rosenbom A. E., Kozel R., Lapworth D. (2022). Pesticides and their metabolites in European groundwater: Comparing regulations and approaches to monitoring in France, Denmark, England and Switzerland. *Sci. Total Environ.* **842**: 156696.

Cech R., Zaller J. G., Lyssimachou A., Clausing P., Hertoge K., Linhart C. (2023). Pesticide drift mitigation measures appear to reduce contamination of non-agricultural areas, but hazards to humans and the environment remain. *Sci. Total Environ.* **854**: 158814.

Datsko O., Kovalenko V., Yatsenko V., Sakhoshko M., Hotvianska A., Solohub I., Horshchar V., Dubovyk I., Kriuchko L., Tkachenko R. (2024b). Increasing soil fertility as a factor in the sustainability of agriculture and resilience to climate change. *Mod. Phytomorpholog.* **18**: 110-113.

Datsko O., Zakharchenko E., Butenko Y., Rozhko V., Karpenko O., Kravchenko N., Sakhoshko M., Davydenko M., Hnitetskiy M., Khtystenko A. (2024a). Environmental Aspects of Sustainable Corn Production and its Impact on Grain Quality. *Ecol. Eng. Environ. Technol.* **25**:163-167.

Davydenko Gennadiy, Rozhko Valentina, Karpenko Olena, Podhaietskyi Anatoliy, Kravchenko Nataliia, Toryanik Valentina, Shvets Bohdan, Hordiienko Vladyslav, Vasylenko Serhii, Badzym Roman, Zubko Sergiy. (2024). Mitigating the impact of intensive farming on the climate change. *Mod. Phytomorpholog.* **18**:219-223).

De Baan L. (2020). Sensitivity analysis of the aquatic pesticide fate models in SYNOPS and their parametrization for Switzerland. *Sci. Total Environ.* **715**: 136881.

Eshkaraev S., Turaev K., Eshkoraev S. (2021). Influence of Pesticides on Increasing Soil Radioactivity. *World J. Appl. Chem.*, **6**:49.

Illien N. (2021). Swiss Voters Reject Proposal to Ban Synthetic Pesticides. *N. Y. Times*.

Karpenko O. Yu., Rozhko V. M, Sobko M. G., Medvid S., Amons S., Zakharchenko E. A. (2023). Weed infestation of winter wheat in organic crop rotation and economic efficiency of its cultivation. *Mod. Phytomorpholog.* **17**:127-131.

Karpenko O.Y., Butenko A.O., Rozhko V.M., Tsyz O.M., Tkachenko M.A., Asanishvili N.M., Zadubynna E.V., Masyk I.M., Sobran I.V. (2021). Assimilation apparatus indices of maize plants under conditions of the right bank forest steppe of Ukraine. *Mod. Phytomorpholog.* **15**:1-5

Lys N., Kolisnyk O., Klymchuk O., Verheles P., Tkachuk N., Sakhoshko M., Rozhko V., Karpenko O., Kriuchko L., Bordun R. (2024). Economic and energy assessment of willow and poplar cultivation depending on the density of the plantation and the nutritional background. *Mod. Phytomorpholog.* **18**:130-137.

Mann S., Kaiser A. (2023). Why is agricultural policy not more environmentally ambitious? Comparing failed attempts in Switzerland. Resources, *Environment and Sustainability*, **11**: 100096.

Möhring N., Finger R. (2022). Pesticide-free but not organic: Adoption of a large-scale wheat production standard in Switzerland. *Food Policy* **106**: 102188.

Möhring N., Ingold K., Kudsk P., Martin-Laurent F., Niggli U., Siegrist M., Studer B., Walter A., Finger R. (2020). Pathways for advancing pesticide policies. *Nat. Food.* **1**:535-540.

Möhring N., Wuepper D., Musa T., Finger R. (2020). Why farmers deviate from recommended pesticide timing: The role of uncertainty and information. *Pest Manag. Sci.* **76**:2787-2798.

Mouron P., Calabrese C., Breitenmoser S., Spycher S., Baur R. (2016). Sustainability Assessment of Plant Protection Strategies in Swiss Winter Wheat and Potato Production. *Agriculture.* **6**:3.

Mulla S. I., Ameen F., Talwar M. P., Eqani S. A. M. A. S., Bharagava R. N., Saxena G., Tallur P. N., Ninnekar H. Z. (2020). Organophosphate Pesticides: Impact on Environment, Toxicity, and Their Degradation. B G. Saxena & R. N. Bharagava, Bioremediation of Industrial Waste for Environmental Safety. *Springer Singap.* **265**-290.

Parkhomenko M. M., Lychuk A. I., Butenko A. O., Karpenko O. Yu., Rozhko V. M., Tsyz O. M., Chernega T. O., Tymoshenko O. P., Chmel O. P. (2021). Nitrogen balance in short crop rotations undervarious systems forrestoringsod-podzolic soil fertility. *Ukr. J. Ecol.* **11**:67-71.

Rani L., Thapa K., Kanojia N., Sharma N., Singh S., Grewal A. S., Srivastav A. L., Kaushal J. (2021). An extensive review on the consequences of chemical pesticides on human health and environment. *J. Clean. Prod.* **283**: 124657.

Schaad E., Fracheboud M., Droz B., Kast C. (2023). Quantitation of pesticides in bee bread collected from honey bee colonies in an agricultural environment in Switzerland. *Environ. Sci. Pollut. Res.* **30**: 56353–56367.

Schaub S., Huber R., Finger R. (2020). Tracking societal concerns on pesticides – a Google Trends analysis. *Environ. Res. Lett.* **15**: 084049.

Schläpfer F. (2020). External Costs of Agriculture Derived from Payments for Agri-Environment Measures: Framework and Application to Switzerland. *Sustainability.* **12**: 6126.

Schleiffer M., Speiser B. (2022). Presence of pesticides in the environment, transition into organic food, and implications for quality assurance along the European organic food chain – A review. *Environ. Pollut.* **313**: 120116.

Sobko Mykola, Zakharchenko Elina, Kolisnyk Oleg, Medvid Svitlana, Kysylchuk Andrii, Krokhin Stanislav, Rudska Nina, Amons Sergey, Omelianenko Oleksandr, Bondarets Roman, Surzhykov Mykola. (2024). Yield and energy efficiency of sunflower cultivation under different primary soil tillage methods. *Mod. Phytomorphology.* **18**: 200-204. Zenodo.

Trotsenko V., Butenko Y., Ivchenko O., Zakharchenko E., Datsko O., Yatsenko V. (2024). Phytoremediation potential of Pisum sativum L.: Iron and Chromium uptake efficiency. *Mod. Phytomorphology.* **18**:158-162.

Tudi M., Daniel Ruan H., Wang L., Lyu J., Sadler R., Connell D., Chu C., Phung D. T. (2021). Agriculture Development, Pesticide Application and Its Impact on the Environment. *Int. J. Environ. Res. Public Health.* **18**:1112.

Wuepper D., Roleff N., Finger R. (2021). Does it matter who advises farmers? Pest management choices with public and private extension. *Food Policy*, **99**: 101995.