

Phosphorus Chemicals in Agriculture: Applications and Innovations

NON-FERTILIZER USES OF PHOSPHORUS – SERIES

JULY 2025

HOW PHOSPHORUS COMPOUNDS SHAPE AGRICULTURAL PRODUCTIVITY

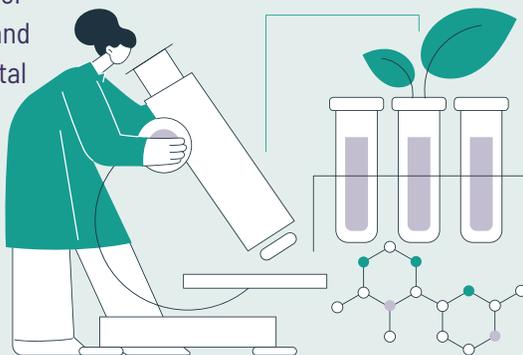
Phosphorus-based chemicals are central to modern agricultural practices, addressing challenges posed by weeds, pests, and crop storage. These compounds, derived from various phosphorus intermediates, play critical roles in herbicides, insecticides, and fumigation technologies. This article explores key applications and the underlying chemistry of phosphorus-based agrochemicals.



HERBICIDES: THE GLYPHOSATE SYSTEM

Glyphosate is one of the most widely used herbicides globally, synthesized from white phosphorus through phosphorus trichloride. Its mechanism of action involves inhibiting a plant-specific enzyme, **5-enolpyruvylshikimate-3-phosphate synthase (EPSPS)**, crucial for the biosynthesis of aromatic amino acids.

This specificity allows glyphosate to target weeds without affecting crops genetically modified to resist it, such as glyphosate-resistant soybean and maize. The combination of these genetically engineered seeds and glyphosate has streamlined weed management, reducing labor and enhancing productivity. The integration of glyphosate in agricultural systems underscores its efficacy and adaptability, though concerns over resistance and environmental impact are areas of ongoing research.



INSECTICIDES: THION-BASED COMPOUNDS

The development of thion insecticides in the 1960s introduced a new class of compounds derived from phosphorus pentasulfide. These insecticides, such as parathion and malathion, exploit the reactivity of the phosphorus-sulfur bond to disrupt insect nervous systems by inhibiting acetylcholinesterase.

- **Parathion:** While highly effective, its acute toxicity to humans limited its long-term use.
- **Malathion:** A safer alternative, malathion exhibits reduced acute toxicity and remains an important tool in controlling pests and diseases like West Nile virus. Its applications extend beyond agriculture, including its use in shampoos to treat head lice.

Despite their utility, many organophosphate insecticides, including dichlorvos and monocrotophos, are being phased out due to their toxicity to humans and non-target species. Regulatory restrictions in regions like the U.S. and EU highlight the need for safer, next-generation alternatives.



FUMIGATION: PHOSPHINE GAS APPLICATIONS

Phosphine gas is a critical fumigant for protecting stored grains from insect infestations and rodent intrusions. It is deployed in two primary forms:

1. **Direct Dosing:** Phosphine is delivered from gas cylinders in controlled concentrations.
2. **Chemical Generation:** Aluminum phosphide pellets react with moisture to release phosphine gas.

Phosphine's high toxicity ensures efficacy in eradicating pests, but its application requires stringent safety protocols to prevent human and environmental exposure. Its widespread use in silos underscores its importance in maintaining post-harvest grain quality and preventing losses.



REFERENCES

This factsheet is based on insights from the GPI report : **Non-Fertilizer Uses of Phosphorus, an Overview**, prepared by *Willem Schipper Consulting*.

If you wish to cite this factsheet, use the following : Global Phosphorus Institute (2025) | Phosphorus Factsheet | Non-FERTILIZER Uses of Phosphorus – Series | GPI-FS#7 | JULY 2025: Metal Treatment with Phosphorus Compounds.

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CHALLENGES AND FUTURE DIRECTIONS

While phosphorus-based chemicals have significantly advanced agricultural productivity, their use necessitates careful management to mitigate health and environmental risks. Efforts to develop safer formulations, explore alternative pest control strategies, and enhance the biodegradability of these compounds are critical to sustaining their benefits.

Phosphorus chemistry continues to be a cornerstone of agricultural innovation, enabling efficient pest management and crop protection while supporting global food security. Further research and regulatory oversight will shape its role in the future of sustainable agriculture.



ABOUT THE GLOBAL PHOSPHORUS INSTITUTE (GPI)

The Global Phosphorus Institute (GPI) is a global organization dedicated to ensuring the responsible use of phosphorus through cutting-edge science and stakeholder dialogue. With a holistic vision and worldwide participation, GPI fosters sustainable practices to advance phosphorus-related technologies and applications.

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