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Once-In-A-Century Herbicide - Glyphosate

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Abstract

Glyphosate is a widely used as herbicide, known for its effectiveness in killing weeds and other unwanted plants. It was first synthesized in 1950 by Swiss chemist Henry Martin, but its herbicidal properties were not discovered until 1970 by American chemist John Franz. Since then, glyphosate has become one of the most commonly used herbicides in the world, with applications in agriculture, forestry, and landscaping. The use of glyphosate as a burn down application alone, or in combination with other pre- or post-emergent herbicides, became standard practice in cropping systems throughout the world. Glyphosate is a nonselective, post-emergent herbicide known to control more than 150 weed species, including mono- and dicotyledonous plants of annual or perennial nature. The popularity of glyphosate is due in part to its broad-spectrum activity, meaning it can kill a wide range of plant species.

1. Introduction

Glyphosate is a broad-spectrum, systemic herbicide and crop desiccant. It kills almost all the green vegetation within 15 days after spraying. It is an organophosphorus compound, specifically a phosphonate, which acts by inhibiting the plant enzyme 5- enolpyruvylshikimate-3-phosphate syntheses. Due to improper application practices and excessive spray, the widespread presence of glyphosate has been observed in the aquatic and terrestrial environments. In many studies, glyphosate has been detected in soil, crop products, animals that feed on crop products, humans, freshwater, and the organisms that live there.

Since its first commercialization in the 70s Glyphosate has become the most used herbicide worldwide with about 600 to 750 thousand tonnes used annually and an expected 740 to 920 thousand tonnes to be used by 2025. In India, CIB&RC approved use of Glyphosate only in tea plantations and non-cropped areas. In India, major tea plantation states are Assam, West Bengal, Tamil Nadu and Kerala. But glyphosate consumption data showed that the consumption is higher in other non-tea growing states. The highest consumption of glyphosate in India for 2020-21 was in Uttar Pradesh (89%), followed by Gujarat (2.9 per cent), Jammu and Kashmir (2.6 per cent), Tamil Nadu (2 per cent), Assam (1.6 per cent), Madhya Pradesh (0.9 per cent) and others (PAN India, 2020). According the report by Pesticide Action Network (PAN), a non-profit

working on pesticide issues revealed that around 35 brands of glyphosate are available in India. Despite good weed control efficacy, an increasing number of more recent observations suggest a relationship between extensive glyphosate application and adverse effect on non-target agroecosystems.

Persistence in the environment

Applied as foliar spray to control weeds, glyphosate may end up in different soil pools and non-target sites. Wash-off from the foliage or in directed spray drift, death and decay of glyphosate-treated plant residues, and exudation from the roots may transport glyphosate to the soil. The release of glyphosate may even occur as exudates from undamaged roots of glyphosate-tolerant crops. Glyphosate has the affinity to bind to the soil particles and thus mostly accumulates in the top soil layer. Processes like runoff, drift, and vertical transport in soil may transport it to the ground water, surface water and water sediment. Glyphosate degradation is mainly microbial mediated process, it degrades at a relatively rapid rates in moist soil, with half-life estimated between 7 to 60 days.

Glyphosate is a weak organic acid that consists of a glycine moiety (part of a molecule) and a phosphonomethyl moiety. Technical grade glyphosate is a colourless, odourless crystalline powder, formulated as water-soluble concentrates and granules. Most formulations contain the isopropylamine ammonium salt of glyphosate (glyphosateisopropyl ammonium).

Effects on crop health

Among several concerns pertaining to unintended effects of glyphosate, its negative effects on non-target plants are of serious concern among producers. Glyphosate applied to control weeds can reach the non-target areas through several routes. The primary route is through in directed spray applications or ―spray drift‖, which can 3directly carry the herbicide chemical to crops. Research has demonstrated that off-target movement or drift of glyphosate during application can be up to 10% of the applied rate in crops like soybean and cotton . Another potential route for glyphosate accumulation and stabilization in soils is represented by the release of glyphosate from plant residues of glyphosate treated weeds. As glyphosate is fairly stable and not immediately metabolized in many plant species, substantial amounts can be extensively translocated to regions of active growth and accumulate, particularly in young tissues . After weeds eventually die, it ends up in the soil following the decay of plant parts. More intensive evaluations have revealed that glyphosate is translocated within plants, accumulated in roots, and eventually released into the rhizosphere. From the soil, glyphosate may also be reabsorbed by the target or non-target plants back through the roots after the initial application.

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Interaction with crop nutrition

Glyphosate ‘s interaction with soil occurs when a foliar spray hits the soil surface or when glyphosate is released from decomposing weed tissue. These reduced availability of nutrients as a result of external (in the soil) or internal (in the plants) interaction of glyphosate with cationic nutrients are observed in production systems that heavily rely on glyphosate for weed management. reported that glyphosate residues or drift may reduce the uptake and translocation of micro-nutrients, such as Mn and Fe, in non-target plants and suggested glyphosate–metal complex formation in plant tissues and/or plant rhizospheres. There are many similar studies that link the ability of glyphosate to inhibit the acquisition of micronutrients, such as Mn, Fe, Zn and B, in plants exposed to glyphosate, either through spray drift.

Regulated use of Glyphosate

The Government of Kerala, in a letter to the central government dated June 20, 2019, had talked about glyphosate being widely and indiscriminately used in paddy fields by farmers and urged for the prohibiting the distribution, sale and use of Glyphosate and its derivatives. Whereas the central government, in exercise of the powers conferred by sub section (2) of section 27 of Insecticides Act, 1968 published a draft order dated 6th July 2020 for declaring its intentions to restrict the use of glyphosate and its derivatives through Pest Control Operators (PCOs)

The central government after considering the report of Expert Committee and after consultation with the Registration Committee, set up under the Insecticides Act, 1968 (46 of 1968), is satisfied that the use of Glyphosate involves health hazards and risk to human beings and animals. Thereafter in exercise of the powers conferred by the sub-section (2) of section 27 of Insecticides Act, 1968 (46 of 1968) the central government made the **Restriction on use Glyphosate order, 2022 (effective from 21/10/2022).** According to the order the use of Glyphosate is restricted and no person shall use Glyphosate except Pest Control Operators. Similarly, all the holders of certificate of registration granted for Glyphosate and its derivatives shall return the certificate of registration to the registration committee for the incorporation of warning in bold letters ―The Use of Glyphosate Formulation to Be Allowed Through Pest Control Operators‖ in the label and leaflets.

Later, MOA&FW issued the Gazette Notification on 7th March, 2023 for the draft rules further to amend the Insecticides Rule, 1971. This rule may be called as the **Insecticide Rule, (fourth amendment) 2023.**

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Glyphosate has often been termed as a — once-in-a-century herbicide because of its tremendous impact on weed management and the crop production industry. Although known to degrade relatively quickly in the soil following application, glyphosate and its metabolites can possibly persist in soil, water, and plant tissues in certain conditions. The best way to prevent these adverse crop effects related to glyphosate use is to avoid the off-target movement or spray drift‖ of this herbicide to unintended areas from the application site. In a nutshell, the extensive use of glyphosate and the environmental risks associated with it warrant awareness among its users about its judicious utilization and necessitate further intense investigations to mitigate, avoid, or remove the problems resulting from its use

Mode of Action of Glyphosate

Glyphosate is a systemic herbicide, meaning that it is absorbed by the leaves of plants and transported throughout the plant. Glyphosate impacts the crop in three steps; Entry, Translocation and Impact. In Entry glyphosate can enter plants through four potential routes: the leaves or other green tissues, the roots, the trunk, or shoots emerging from the root or the trunk. The entry and translocation of glyphosate in plants occur in several steps:

1. Absorption: Glyphosate is absorbed by plant leaves and other green tissue, primarily through the stomata (small openings on the surface of leaves) and cuticle (a waxy layer that covers the leaves). The herbicide must be in its ionized form to be absorbed by the plant. In neutral or alkaline conditions, glyphosate can form salts that are more easily absorbed by the plant.

2. Translocation: Once absorbed, glyphosate is transported throughout the plant via the phloem, which is a specialized tissue that carries nutrients and other substances from the leaves to the rest of the plant. Glyphosate is translocated from the leaves to the roots, shoots, and other parts of the plant, where it disrupts the synthesis of essential amino acids and proteins. After entering the plants, it is rapidly translocated to regions of active growth within the plant. Glyphosate works by inhibiting an enzyme called EPSP (5-enol-pyruvyl-shikimate-3- phosphate) synthase. An enzyme EPSP synthase is required for the synthesis of aromatic amino acids such as phenylalanine, tyrosine, and tryptophan, which are crucial building blocks for the production of proteins, growth regulators, and other important molecules in plants. Glyphosate binds to and blocks the active site of EPSP synthase, preventing it from functioning properly & thus disrupts the synthesis of amino acids. Glyphosate binds to and blocks the active site of EPSP synthase, preventing it from functioning properly & thus disrupts the synthesis of amino acids.

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Conclusion

In conclusion, phosphate-based herbicides, such as Roundup, have become one of the most widely used herbicides in the world due to their effectiveness in controlling weeds. The herbicide works by disrupting the synthesis of essential amino acids and proteins in plants, leading to their death. Glyphosate is absorbed by plant leaves and transported throughout the plant via the phloem, making it a systemic herbicide. However, the widespread use of phosphate-based herbicides has raised concerns about their potential impact on human health and the environment. While glyphosate is generally considered safe when used according to label instructions, there is ongoing debate about its safety and potential long-term effects. It is important to continue to study the mode of action and potential impacts of glyphosate and other herbicides to ensure safe and effective use in the future.

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