Agricultural Science Horizon (2025) 1(2): 17-21

A Brief Overview of the Chemical Characteristics and performance determining factors of glyphosate

Fredis Franco-Pesantez[1]

[1]Universidad Técnica de Machala, Machala, Ecuador

K E Y W O R D S

Glyphosate, Chemical properties, Factors, Glyphosate performance

A B S T R A C T

The broad-spectrum herbicide glyphosate is used globally to kill agricultural weeds. Since the 1970s, glyphosate agricultural usage has grown owing to the emergence of glyphosate-resistant transgenic crops in the 1990s. Failures in the use of glyphosate for pest management are often caused by the application of a rate that is inadequate for the species that is being targeted, in addition to the stress that the environment exerts on plants. Thus, it is essential to keep in mind that any component that slows down the development of plants will most likely also slow down the effectiveness of glyphosate. This is something that should be kept in mind. In order to lessen the possibility of control failures happening under these circumstances, it is essential to take into consideration all of the elements that have an effect on the action of herbicides. Factors that affect the performance of glyphosate such as plant type, dew, time of the day, company detail on packing, climatic factors, environmental factors, water contents as well as lack of transparency has been discussed. Moreover, dilution factors, formulation, labelling and herbicidal effects has also been addressed briefly, in this short review. With the exception of this, elements that influence the effectiveness of glyphosate have been examined. These aspects include the kind of plant, the amount of dew, the time of day, the details of the company's packaging, the climate, the environment, the amount of water, and the lack of openness pertaining to the product. Additionally, dilution factors, formulation, labeling, and herbicidal effects have been briefly discussed in this brief study. This review provides a summary of the information.

Corresponding Author Email: fredrizanoemi6@gmail.com

1. Introduction

Glyphosate, an herbicide with a wide range of activity, is used all over the world to wipe out agricultural weeds. Agricultural use of glyphosate has increased, mostly as a result of the development of transgenic crops that are resistant to glyphosate. The poisoning of the environment with glyphosate has been determined to have detrimental effects on a number of different organisms, including humans. Like the success of any other herbicide, the effectiveness of glyphosate is contingent on a variety of factors, some of which are outside the control of the person applying the herbicide (Abdel-Fattah, 2011). There is a greater degree of variance in performance that is brought about by environmental and application variables than there is by differences in the formulation. Because various weed species are inherently more or less susceptible to glyphosate, the risk of control failures varies significantly between them. This is due to naturally occurring differences in sensitivity. However, in compared to velvetleaf, giant foxtail is significantly more vulnerable to the effects of glyphosate, which indicates that the use of this herbicide to control it is less likely to be impacted by environmental circumstances. Glyphosate control failures are mostly brought on by the application of a rate that is insufficient for the species that is being targeted, as well as by the stress that the environment places on plants (Duke, 2018). Hence, it is crucial to consider that any factor that hampers the development of plants would likely also hinder the effectiveness of glyphosate. To minimize the occurrence of control failures, it is crucial to consider all the elements that impact herbicide activity. There have been several reports of adverse effects on human health since the classification of glyphosate as a possible carcinogen in the year 2015. Alternatives for the removal and treatment of glyphosate are required in order to lessen the amount of contamination in the environment and the hazards to human health. The purpose of this research was to provide a concise summary of the chemical properties of glyphosate as well as the products that include glyphosate within their composition (Sammons et al., 2014; Sen et al., 2021; Qiao et al., 2020; de Castilhos et al., 2020). With the exception of this, elements that influence the effectiveness of glyphosate have been examined. These aspects include the kind of plant, the amount of dew, the time of day, the details of the company's packaging, the climate, the environment, the amount of water, and the lack of openness pertaining to the product. Additionally, dilution factors, formulation, labeling, and herbicidal effects have been briefly discussed in this brief study. This review provides a summary of the information. With this exception,

Submission date: 17-05-2025, Revision date: 21-10-2025, Acceptance date: 30-11-2025, Published online: 30-12-2025

studies have been conducted to investigate the factors that have an impact on the efficacy of glyphosate. The kind of the plant, the quantity of dew, the time of day, the specifics of the company's packaging, the weather, the environment, the quantity of water, and the lack of transparency about the product are all examples of these characteristics. Furthermore, throughout the course of this short research, dilution variables, formulation, labeling, and herbicidal effects were briefly examined. The information is summarized in this review for your convenience.

1.1.Chemical properties

Glyphosate is the chemical responsible for the weed-killing action of the active component. The main component of Roundup Ultra is "Glyphosate, N-(phosphonomethyl)glycine, in the form of its isopropyl amine salt," according to the product label. Although the herbicide is more often known by its popular name, "glyphosate," its exact chemical name, "N-(phosphonomethyl)glycine," is more informative. There is no difference in the active component between any glyphosate formulations, regardless of brand.

By blocking the EPSPS enzyme, the substituted amino acid glyphosate prevents the production of amino acids. The enzyme plays a crucial role in protein synthesis and is responsible for the creation of various amino acids. Several elements contribute to glyphosate's efficacy: 1) Every plant has an essential metabolic pathway that includes the EPSPS enzyme. Glyphosate forms a strong bond with the EPSPS enzyme, which is usually lethal to plants when disrupted. So, the enzyme is basically rendered useless once the herbicide reaches its target location; 3) Glyphosate does not quickly damage plant tissue since plants are not good at breaking it down; and 4) Glyphosate does not induce plants to metabolise it efficiently. Unlike herbicides that cause immediate harm to plant tissues, this approach allows the herbicide to be transported throughout the plant, resulting in a more effective demise.

1.2.Products using glyphosate

One class of chemicals is weak acids, and glyphosate is one of them. Figure 1 shows that even weak acids may give hydrogen ions to other molecules. The parent weak acid of glyphosate is modified to have a different salt (ion) in order to make it a commercially viable product. Although salt lacks herbicidal characteristics on its own, it is a byproduct of weak acids that is either more effective, simpler to work with, or blends better with other agricultural agents.

With the exception of Touchdown, all glyphosate products include glyphosate in its isopropyl amine salt (IPA) form. Glyphosate diammonium salt (DAM) is an ingredient in Touchdown IQ. The effectiveness of glyphosate is unaffected by the specific salt composition. Nevertheless, phytotoxicity may be a problem with some salts. The original Touchdown formulation resulted in the localized scorching of leaves due to the usage of trimethyl sulfonium salt (TMS). The salt caused little harm to the Roundup Ready crops' foliage, but it wasn't quite as bad as glyphosate's herbicidal effects. This is not included in the updated Touchdown IQ algorithm.

The label often specifies the concentration of glyphosate in pounds per gallon, using both the acid equivalent and active ingredient nomenclature. The amount of active component in a product is determined by adding the weight of the salt used in its formulation to the weight of the parent acid of glyphosate. No matter how much salt is combined with a product, the amount of parent acid is the sole factor taken into account when reporting the quantity of acid equivalent on the label. As the salt does not contribute to the herbicidal effect, the acid equivalent provides a more precise measure of the relative strength of glyphosate molecules. When comparing Touchdown with different glyphosate products, it is important to consider the acid equivalent rates rather than just the quantities of the active component. This is due to the use of different salts in distinct glyphosate formulations.

Between fifty and seventy-five percent of glyphosate products are inert components. In addition to boosting the product's stability and handling qualities, these components also increase compatibility and, most crucially, the herbicide's retention and absorption by plants. It is more probable that the 'inert' components than the salt of glyphosate that is responsible for any variations in performance amongst glyphosate formulations. Herbicide companies regard the details of the inert substances used in their products as confidential information, even when they are proprietary.

Among the inert compounds, surfactants have the greatest impact on herbicidal action. The effectiveness of a product is highly dependent on the surfactant type that is combined with glyphosate. But before items hit store shelves, producers pour a lot of money into formulating them. There are other elements that impact field performance more than the variations in glyphosate products' efficacy that are supposedly caused by surfactants. The labelled herbicide rates would probably change to reflect any substantial variations if there were any. Having said that, for most applications, the recommended rates of glyphosate are the same across the board.

1.3.Factors affecting glyphosate performance

Among the many reasons for glyphosate's widespread use is its reliability. Nevertheless, glyphosate's control might vary depending on a number of conditions, as is the case with every herbicide. In this post, we'll take a look at what makes glyphosate tick and how the herbicide may be adjusted to keep its effectiveness consistent.

1.3.1. Formulation

In terms of formulation, the surfactant combination is what really sets this glyphosate product apart from the numerous others on the market. Plants exposed to the spray solution are able to absorb and retain more of the herbicide glyphosate when surfactants are added. Different glyphosate brands may have somewhat different surfactant blends and amounts, but they all work about the same in most situations. Iowa State University has recently performed a plethora of research to ascertain if glyphosate goods exhibit distinct field performance. In 2001, eleven field studies were carried out to evaluate the performance of Roundup UltraMax to that of other glyphosate products, including Touchdown IQ, Glyphos Gold, Glyphomax Plus, and others. Comparing goods at active comparable rates with suggested additives yielded no performance changes in 91% of the studies (Table 2). Throughout the eleven trials, foxtail, velvetleaf, and water hemp were all treated with the same glyphosate products. In two out of nine cases, Roundup UltraMax outperformed the other formulation when it came to controlling common lambs’ quarter. When tested on different species, the generic versions of Roundup UltraMax were competitive in six out of eight comparisons, with the exception of one case where the generic version outperformed the Monsanto brand. When comparing the kill rate of several glyphosate brands, no clear differences were found. Based on these numbers, it seems that choosing a glyphosate brand shouldn't be based on how well it performs.

1.3.2. Additives for sprays

AMS is recommended by all glyphosate brands under certain circumstances (refer to water quality), however surfactant recommendations vary greatly across glyphosate formulations. Label instructions for using Roundup UltraMAX alone prohibit the addition of surfactants, surfactant-containing additions, buffering agents to the spray solution. Contrarily, surfactant is not recommended for use with Glyphomax Plus, but it is with Glyphomax, according to Dow AgroSciences. The designed product's quantity and kind of surfactant determine the discrepancies in recommendations. It would be counterproductive to add more surfactants to the Roundup UltraMAX spray tank, according to Monsanto, as the product already contains the optimal combination of chemicals for maximum efficacy. On the other hand, some producers have opted to let consumers choose their own additives.

1.3.3. Company concerns

Concerning the usage of additives with glyphosate products, two concerns often come up: For companies that don't suggest them, is it beneficial to use more surfactants?2) Which surfactant is the most effective? If you asked me to answer the first question, I would say no. Adding more surfactant to glyphosate products that don't normally call for one could improve their performance on occasion. Unfortunately, because nobody can say for sure when this will happen, the surfactant vendor usually comes out ahead in these kinds of deals.

1.3.4. Lack of transparency

The lack of transparency on the active chemicals by spray additive and surfactant producers makes it difficult to choose the best product. There are so many options for this purpose that it would be foolish to compare them all. You may reduce the chances of getting a low-quality surfactant by buying goods with a lot of active chemicals, staying away from items that make exaggerated promises, and getting spray additives from the same company that sells the herbicide you're going to use them with.

The quality of the water used to transport glyphosate is an important consideration since it may have high concentrations of dissolved salts regardless of its source (a rural water association, a well, etc.). The hardness of water is a reflection of its salt content. The concentration of salt increases as the water becomes harder. It is possible that glyphosate's efficacy may be diminished when dissolved in water with certain salts, especially magnesium and calcium salts. The glyphosate product may include these positively charged salts instead of the isopropyl amine or diammonium salts because they may establish an association with the negatively charged glyphosate molecule. The glyphosate formulation included in the product container exhibits greater plant absorption efficiency compared to glyphosate combined with calcium or magnesium salts. The magnesium and calcium ions in the carrier may thereby reduce the action of glyphosate.

Although some labels may state otherwise, ammonium sulphate (AMS) is always suggested for use with glyphosate-containing products. When glyphosate is combined with AMS, its function differs significantly from that of non-ionic surfactants or crop oil concentrates (COC) often employed with postemergence herbicides. While surfactants and COCs work mostly on the surface of the leaf to increase the herbicide's absorption into the plant, AMS works mostly within the spray tank.

Applying AMS to the spray tank lowers the concentration of glyphosate that is rendered inactive by antagonistic salts in the water. Water testing may measure the hardness of the water, which in turn determines the rate of AMS needed to obtain this benefit. T Most Iowa applicators choose to estimate the necessary quantity of AMS rather than doing water hardness tests. While the majority of glyphosate labels indicate a maximum rate of 17 lb AMS per 100-gal water, it is important to note that only a small number of water sources in Iowa really possess such high levels of hardness. Therefore, 8.5 lbs per 100 gal of water should be more than enough to offset the antagonistic effects of the majority of Iowa water sources, especially in the absence of testing.

1.3.5. Water contents

under addition to making hard water ineffective, AMS has the potential to improve the efficacy of glyphosate on velvetleaf plants under any water condition. Velvetleaf has comparatively significant amounts of calcium salts on its surface. Similar to how minerals in hard water neutralize glyphosate, this calcium on the surface of the leaf may do the same. Velvetleaf leaves are less likely to develop calcium-glyphosate complexes when treated with AMS, leading to enhanced performance.

1.3.6. Labelling

Different labels indicate different amounts of water to be sprayed; for example, Roundup UltraMax proposes 3–30 gallons per acre, whereas Touchdown IQ suggests 3–40 gallons. Studies have shown that glyphosate works better in water levels lower than 10 GPA, as opposed to 20 GPA or more. This reaction is caused by two main causes. The number of antagonistic salts rises with an increase in spray gallonage. Consequently, the possibility that glyphosate might be rendered inactive by calcium or magnesium ions grows in proportion to the spray volume.

1.3.7. Dilution factors

A simple dilution effect is the second possible reason why glyphosate may not work as well when sprayed at huge quantities. One quart of Roundup in ten gallons of water is equal to one-fourth of a gallon; one quart of Roundup in twenty gallons is equal to one-eighty-thousandth of a gallon. This ratio diminishes as the spray volume rises. While the active ingredient to water ratio likely doesn't matter much, the quantity of surfactant per gallon of water reduces as the spray volume rises. Spray volume decreases surfactant concentration, which could have an adverse effect on product performance in certain cases.

1.3.8. Herbicidal effects

The herbicide's activity, the spray's target coverage, and the spray's drift potential are three considerations to keep in mind when deciding on a spray volume to employ with glyphosate. Less efficient penetration and coverage of thick plant canopies and an increased danger of drift are two possible issues with low spray volumes (Anderson, 2020; Zabaloy et al., 2022). When using spray volumes below 10 GPA, it is necessary to use relatively tiny droplets in order to get even coverage. The action of glyphosate may be enhanced by tiny droplets, although spray drift is more likely to occur with them. Low spray volumes also have the potential drawback of reducing the target's spray coverage. With a smaller spray volume, there's more room for error in where the spray droplets land, making it more likely that certain weeds won't get enough of the herbicide to kill them. As the density of the plant canopy grows, so does the variety in spray deposition. Research has shown that applying 10 to 15 gallons per acre effectively covers weeds in maize and soybeans while minimizing negative impacts on performance in most agronomic settings. When dealing with huge weeds, well-developed crop canopies, or thick weed infestations, it may be useful to use higher volumes (20 GPA).

1.3.9. Plants type

Plants are constantly adapting to their surroundings in order to withstand adverse environmental circumstances, such as heat, cold, and drought. To preserve water in dry or hot conditions, plants modify the composition and thickness of their cuticle, which is found on the surface of their leaves. Although little is known about it, environmental reactions have a major impact on plants' ability to tolerate herbicides. The majority of herbicide labels include general claims about how the environment affects the effectiveness of the product. 'Touchdown needs actively developing green plant tissue to work,' says the Touchdown IQ label. Herbicide treatments performed during the few periods of very dry or hot weather may not be effective since these conditions virtually stop plant development.

1.3.10. Environmental conditions

One of the biggest obstacles faced by those who work to manage weeds is dealing with changes in herbicide effectiveness caused by environmental factors. The intricate web of relationships between plants and their surroundings has thwarted efforts to create instruments that would assist farmers or bespoke applicators in ascertaining the optimal herbicide dosage or spray ingredient in response to current meteorological conditions. Researchers in one study combed through 60 experiments to identify the most important environmental variables influencing the efficacy of postemergence herbicides. Soil moisture deficits in the 10 days leading up to application, highest temperature on application day, and lowest temperatures seven days before had a significant impact on the herbicide's efficacy. Because various weed species have varying environmental responses, it is already a challenging effort to adapt treatment settings under changing conditions. Since most fields contain infestations of many types of weeds, a single decision guide for changing spray settings in response to weather would be useless.

1.3.11. Climatic conditions

Weather data can be used to optimize glyphosate treatments, but our knowledge of weed adaptation to environmental changes is inadequate. Nevertheless, keeping an eye on the weather and modifying the programme settings as needed helps lessen the chances of performance issues. We can't tell you exactly how much herbicide to use under certain circumstances, but we can tell you when weeds will be harder to manage. Herbicide rates should be raised or treatments should be deferred until circumstances improve.

1.3.12. Time of spray

Applying glyphosate in the evenings became a control issue shortly after Roundup Ready soybeans were introduced. Research that followed verified that glyphosate's efficacy might decrease with morning or evening treatments. Diurnal leaf motions contribute to this reaction in certain weed species. During the day, the leaves of velvetleaf and many other plants rise parallel to the ground so that they may absorb sunlight more effectively. At night, the leaves of these plants hang vertically. A weed's ability to absorb pesticide spray is affected by its leaf orientation.

In order to determine the effect of glyphosate treatment timing on various weed species, researchers in Arkansas compiled their findings in Table 3. Hemp sesbania and sicklepod have diurnal leaf motions; during the day, their leaves are around 10 degrees from horizontal, and at night and in the morning, they are 80 degrees. Due of the difference in leaf direction, weeds intercepted around 70% less pesticide when applied at night compared to day. When applied in the morning or evening, hemp sesbania had a control rate of less than 50%, but when applied at 11 AM, the control rate increased to 80%, suggesting a strong correlation with leaf orientation. While there was some variation in sickle pod control with treatment time, the correlation between Roundup performance and leaf orientation was not as strong as it was on hemp sesbania.

1.3.13. Dew

When it comes to the effect of dew on the efficacy of herbicides, farmers have different opinions. Light dew on weed leaves, according to some, improves herbicide efficacy, but heavy dew drastically lowers weed control, according to others. Recent research looked at how spray volume and humidity affect glyphosate effectiveness (Table 4). When sprayed at smaller volumes (16 and 32 GPA), glyphosate action was unaffected by dew. On the other hand, when administered at 48 GPA, glyphosate resulted in less control even when 100% dew covering was present on the leaf. When comparing the lower spray volumes to 48 GPA at all dew levels, glyphosate activity was also shown to be decreased. According to the researchers, spray runoff from wet leaf surfaces may explain why glyphosate action is reduced at high spray volumes with 100% humidity. At the usual spray quantities, they found that glyphosate would be unaffected by modest amounts of dew.

2. Conclusion

Like any herbicide, glyphosate's effectiveness depends on a number of variables, some of which are beyond the control of the applicator. There is more variation in performance induced by environmental and application factors than by variations in the formulation. Because different weed species are naturally more or less sensitive to glyphosate, the likelihood of control failures varies substantially between them. Because big foxtail is so much more vulnerable to glyphosate, its control using this herbicide is less likely to be impacted by environmental factors compared to velvetleaf. Glyphosate control failures are mostly caused by using a rate that is too low for the target species and by environmental stress on plants. Any factor that slows down plant development will likely also slow down glyphosate's effectiveness, so keep that in mind. Minimize the probability of control failures under these settings by considering all elements that impact herbicide action.

3. Conflict of interest

Authors declared no conflict of interest each other

4. Acknowledgments

Authors are highly thankful to Universidad Técnica de Machala, Machala, Ecuador for their moral support.

5. Contributions

Authors contributed equally in the present manuscript.

References

Abdel-Fattah, S. (2011). Aquatic Invasive Species Early Detection and Rapid Response-Assessment of Chemical Response Tools. *Report to the International Joint Commission, Great Lakes Regional Office, Detroit, Michigan*.

Duke, S. O. (2018). The history and current status of glyphosate. *Pest management science*, *74*(5), 1027-1034.

Sammons, R. D., & Gaines, T. A. (2014). Glyphosate resistance: state of knowledge. *Pest management science*, *70*(9), 1367-1377.

Sen, K., & Chattoraj, S. (2021). A comprehensive review of glyphosate adsorption with factors influencing mechanism: Kinetics, isotherms, thermodynamics study. *Intelligent Environmental Data Monitoring for Pollution Management*, 93-125.

Qiao, C., Wang, C., Pang, R., Tian, F., Han, L., Guo, L., ... & Fang, J. (2020). Environmental behavior and influencing factors of glyphosate in peach orchard ecosystem. *Ecotoxicology and Environmental Safety*, *206*, 111209.

de Castilhos Ghisi, N., Zuanazzi, N. R., Fabrin, T. M. C., & Oliveira, E. C. (2020). Glyphosate and its toxicology: A scientometric review. *Science of the Total Environment*, *733*, 139359.

Anderson, G. (2022). Amyotrophic Lateral Sclerosis Pathoetiology and Pathophysiology: Roles of Astrocytes, Gut Microbiome, and Muscle Interactions via the Mitochondrial Melatonergic Pathway, with Disruption by Glyphosate-Based Herbicides. *International Journal of Molecular Sciences*, *24*(1), 587.

Zabaloy, M. C., Allegrini, M., Hernandez Guijarro, K., Behrends Kraemer, F., Morrás, H., & Erijman, L. (2022). Microbiomes and glyphosate biodegradation in edaphic and aquatic environments: recent issues and trends. *World Journal of Microbiology and Biotechnology*, *38*(6), 98.