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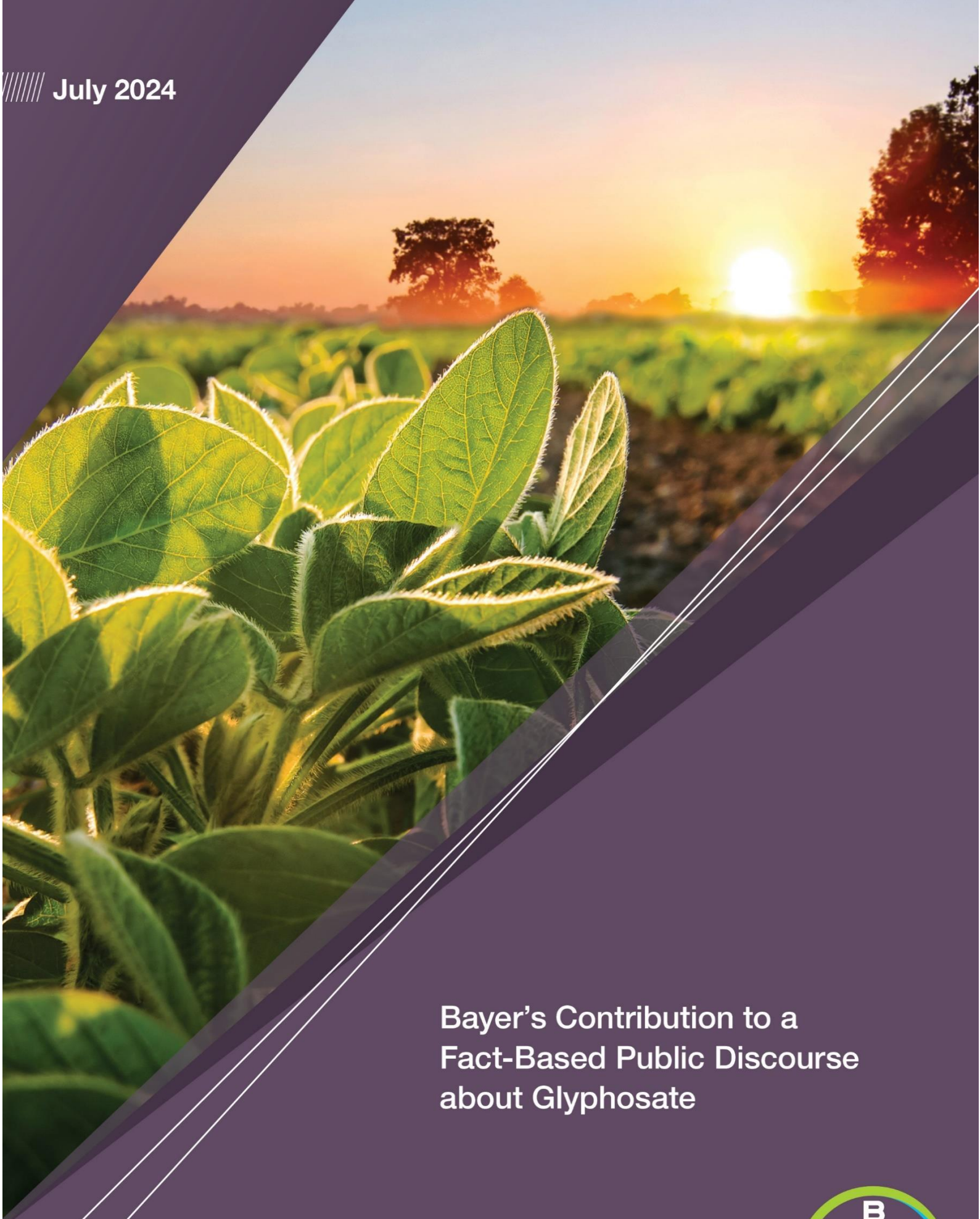

Bayer's Contribution to a Fact-Based Public Discourse about Glyphosate

Science for a better life

BAYER

Executive Summary

Report Goal

Since their introduction almost five decades ago, glyphosate-based herbicides have become some of the most widely used weed-control products in the world. (Glyphosate is the active ingredient in Roundup® brand agricultural herbicides sold by Bayer and is used as an active ingredient in products sold by other companies as well.) Despite favorable safety assessments by numerous regulatory bodies and scientific organizations worldwide, and broad farmer acceptance, glyphosate is seen by many as controversial. Bayer takes the safety of our agricultural products very seriously. Also, we have come to recognize that there is an information gap about food production and the technologies used to produce food, including herbicides like glyphosate. This report aims to address these concerns and shed additional light on glyphosate and its contribution to the global food production system. At a time when food security is threatened by external forces ranging from wars to climate change, we believe that it is important to have a fact-based conversation about effective agricultural technologies such as glyphosate.

The Executive Summary and the full report will cover:

- // The role of glyphosate in the food production system
- // Controversies over glyphosate (human health, environmental impact and potential overuse)
- // Glyphosate's contributions to sustainability (environmental, social and economic benefits)
- // Transparency commitments made by Bayer

The Role of Glyphosate in the Food Production System

Weeds are one of the most persistent challenges farmers must tackle. The Food and Agriculture Organization (FAO) of the United Nations estimates that weeds account for 5%-10% of losses in the agriculture of developed countries and up to 20%-30% of losses in developing countries.[1] Weeds can harbor pests that can further damage crops, resulting in lower yield and affecting crop quality through the presence of weed materials in harvested crops. These factors reduce production levels and farmer incomes and may require an expansion of land for crop cultivation, which would not be necessary if weeds were adequately controlled. In agriculture, weed control practices include a combination of herbicide use, land/soil preparation, and mechanical or hand/manual weeding. Since its introduction in 1974, farmers, land managers and gardeners around the world have relied on glyphosate for effective, simple and economical weed control in agriculture and non-agriculture settings. The widespread use of glyphosate-based herbicides with genetically modified[a] (GM) and non-GM crops means that glyphosate currently plays an important role in agriculture, contributing to the stability and resilience of the global food supply system.

[a] *GM crops are also referred to as GMOs (genetically modified organisms), genetic engineering (GE) or biotech crops. These terms, often used interchangeably, refer to a process that allows plant scientists to take desirable genetic material from one organism found in nature, such as a bacterium, and transfer it to a plant they want to improve. Some examples of desirable characteristics or traits commonly transferred to crop plants include resistance to insects or disease and tolerance to herbicides that allow farmers to better control weeds. Glyphosate can be sprayed on glyphosate tolerant GM crops. Due to their herbicide-resistant trait, the GM crops are not impacted by the herbicide application, while the weeds die.*

Use With GM Crops

In 2022, GM crops represented 53% of the overall seed market ($23,793 million of GM seeds versus $20,793 million of conventional seeds). Of those, glyphosate tolerant corn constituted $9,986 million, glyphosate tolerant soybeans - $5,674 million, and glyphosate tolerant cotton - $1,472 million.[2] When used with GM glyphosate-tolerant crops, glyphosate helps control weeds that compete with crops for water, nutrients and light without affecting the crop. Glyphosate-tolerant crop varieties greatly simplify weed control for corn, soybean, cotton, sugar beet, alfalfa and canola farmers, and glyphosate facilitates the adoption of conservation tillage, an agronomic practice that makes food production more sustainable. Despite the high adoption of glyphosate-tolerant crops in key agricultural markets, it is estimated that today less than 20% of glyphosate is applied over glyphosate-tolerant GM crops globally.[3]

Use With Non-GM Crops

Glyphosate also simplifies weed management and reduces the need for mechanical tillage in non-GM crops. Globally, it is estimated that over 80% of glyphosate is applied in conventional uses (to prepare the land by clearing weeds and old crop material before planting a new seasonal crop, to control weeds between crop rows and surrounding field edges and to clear weeds in a field planted with GM crops before the crop has emerged).[4] Many growers use glyphosate pre-planting to rid fields of weeds that would otherwise compete with crops for resources. An example is the use of glyphosate in conventional wheat production, which has enabled many wheat growers to adopt no-till agronomic practices. Glyphosate is also sprayed to control weeds between rows of crops as well as to control vegetation between the rows in orchards and vineyards.

Non-Agricultural Uses

In addition to extensive use on farmland, glyphosate is relied on to manage weeds cost-effectively[5] in non-agricultural settings, such as along roadways and railroads, in utility rights-of-way and around landscaping. It is also used with targeted applications in national parks and other natural habitats to protect against the impact of invasive plant species on natural plant communities. In addition, glyphosate is used to clear land prior to planting it to create wildlife habitats or prairies.[6]

Controversies Over Glyphosate

Classification as "Probable Carcinogen"

IARC Classification

The confusion about glyphosate and cancer primarily stems from one place: an opinion issued in 2015 by the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO). IARC's classification of glyphosate as a "probable carcinogen" drew a significant amount of attention because it is an outlier. It differs from that of every regulatory agency or authoritative body that has reviewed comprehensive sets of safety data (i.e., registration studies and public literature) on glyphosate. IARC is also an outlier in WHO – it is one of four programs within WHO that has evaluated the safety of glyphosate and is the only one to find an association between glyphosate and carcinogenicity. It should be noted that IARC's hazard classification system does not reflect real-world exposure levels and does not rely on a comprehensive review of all relevant data, both of which are essential to assess any risk to the human population. IARC also puts everyday substances like red meat and hot beverages in the same category as glyphosate. Moreover, every global regulatory body that has evaluated the comprehensive toxicology and human safety data for glyphosate since the IARC decision has concluded that glyphosate does not cause cancer.

Human Safety Studies and Regulatory Reviews

The IARC classification and the resulting coverage in media and on social channels needs to be examined in the context of the substantial safety data collected over more than five decades. During this time, glyphosate has undergone extensive testing and assessments to evaluate its safety. Multiple regulatory testing data sets exist that are used to support government reviews, alongside thousands of publications in peer-reviewed literature. The largest and most recent epidemiology studies, which are the most relevant studies for assessing exposure effects in the human population, found no association between real-world use of glyphosate-based herbicides and cancer.[7]

Glyphosate-based products are registered in more than 100 countries throughout the world. Our products meet regulatory requirements in all countries where they are registered and we apply additional safety standards aligned with the FAO, the WHO and the Organisation for Economic Co-operation and Development (OECD) standards. Country regulatory agencies as well as the Joint FAO/WHO Meeting on Pesticide Residues (JMPR), support the safety of glyphosate and glyphosate-based products when used as directed on labels and continue to reaffirm that glyphosate does not cause cancer.

Like with all pesticides, regulatory authorities around the world routinely review the latest safety data on glyphosate. For example, in December 2023, The European Commission re-approved glyphosate for use in the European Union (EU) for 10 years.[8] According to the EU Commission, "Member States remain responsible for national authorization of plant protection products (PPPs) containing glyphosate. When performing assessments and before granting authorizations, Member States must take into account the specific conditions set in the approval at EU-level and also their specific national circumstances (e.g., geo-climatic conditions, agricultural production systems, etc.)[9]

Litigation

The IARC report was leveraged by plaintiff's attorneys in the U.S. and became the trigger for the ensuing lawsuits against Monsanto (acquired by Bayer in 2018). We have great sympathy for anyone who suffers from disease, and we understand their search for answers. At the same time, it is important to acknowledge the discrepancy between jury verdicts for plaintiffs and the extensive body of science and regulatory evaluations, referenced in the section above, that continue to show that our products are not responsible for the illnesses alleged in litigation. For example, the latest regulatory decision by the European Chemicals Agency (ECHA) states that, "Based on a wide-ranging review of scientific evidence, the committee again concludes that classifying glyphosate as a carcinogen is not justified."[10] In May 2021, Bayer announced a five-point plan that provides a path to closure of the U.S. litigation.[11] This plan does not include any admission of liability or wrongdoing; rather, it covers the actions Bayer is taking as a result of the mass tort system in the U.S. Bayer has a winning record at trial in this litigation and overall has resolved the majority of cases filed in this litigation.

Glyphosate Residues

Another question related to glyphosate is that residues of glyphosate can be detected in certain foods and also in human urine and milk. The Environmental Protection Agency (EPA) studied exposure to glyphosate and concluded that current dietary, drinking-water and home-use exposures to glyphosate do not pose a risk to human health.[12] The JMPR came to the same conclusion regarding residues in food.[13] Beyond that, there was an allegation that glyphosate was present in human milk. The data were derived using a commercial kit that was only validated for qualitative testing of water samples. Milk is a complex substance that would require a separate method of validation and this matrix can result in false positives. Glyphosate has never been detected in human milk using a validated assay, including in annual surveys of foods conducted by the Food and Drug Administration (FDA) and EFSA.[14]

Some have speculated that glyphosate residues can inhibit the growth of certain gut bacteria, but these studies are not representative of real conditions in the gastrointestinal tract. Others have suggested that glyphosate could chelate[b] minerals in the gastrointestinal tract and prevent their absorption resulting in mineral deficiencies; however, other more potent chelators are ubiquitous in the digestive tract and are part of a healthy diet such as certain amino acids. Conclusions about safety should be based on empirical results within the limitations of model systems or experimental design. Read more on page 17.

Environmental Impact

Environmental Safety: Studies and Regulatory Reviews

The environmental fate and safety of glyphosate has been extensively studied. Glyphosate does not bioaccumulate and does not persist in the environment. At environmentally realistic exposure levels, it also is not toxic to wild mammals, birds, fish, aquatic invertebrates and terrestrial invertebrates, such as earthworms, honeybees and other

[b] *A chelate is a chemical compound in which a substance is joined to a metal atom by two or more bonds (Cambridge Dictionary).*

pollinators. Regulatory agencies around the world have approved specific uses of glyphosate after concluding that it does not pose an unacceptable risk to the environment when used according to label instructions. The latest EPA reviews of glyphosate and the reauthorization of glyphosate in the EU are discussed on pages 20-21.

Biodiversity

Changes in nature, including biodiversity, are caused by several drivers: changes in land and sea use (through agriculture, fishing and coastal development), direct exploitation of organisms (hunting, logging, fishing), climate change, pollution, and invasion by alien plant and animal species.[15] Agriculture, in general, is believed to have caused the most significant change in land use and habitat loss due to mechanization and intensive farming practices. The impact of pollutants from various industries, including agriculture, is just one of the factors that impacts biodiversity. Within this context, the impact of glyphosate on biodiversity is a topic that comes up from time to time. For example, the decline in monarch butterfly populations has been attributed to the use of glyphosate on glyphosate-tolerant GM crops. Many factors are thought to contribute to the problem: loss of milkweed – a weed that impacts crops and is also larval monarch's main source of food, habitat loss in the Mexican forests where monarchs overwinter, climate change, and weather events. Bayer takes action to build and maintain monarch-friendly habitats. We collaborate with conservation groups, academic experts, farmers and government agencies to find meaningful and proactive ways to help the monarch butterfly and other pollinators thrive.

Honeybees and other pollinators may be impacted when herbicides reduce the amount of weeds that can provide pollinator habitats. To mitigate the potential impact of herbicides on pollinator food sources, farmers should consult the product labels, which indicate recommended application rates and restrictions on the timing and the number of applications. Spray drift reduction equipment and field buffers are additional measures for ensuring that herbicides, like glyphosate, do not migrate to natural habitats that serve as refuges for biodiversity.

It is worth noting that glyphosate is an important tool that is used to create and restore natural habitats and to protect native habitats from invasive species. When new, biodiversity-friendly habitats are created, glyphosate is often applied to initially help clear the land for planting. It is also used to protect native habitats, such as in national parks in the U.S., from invasive plants.[16] Additionally, glyphosate has proven successful and cost-effective in managing non-native invasive plants and noxious weeds. Because these species are responsible for destroying habitats for native plants and wildlife, glyphosate is protecting native biodiversity.

Potential Overreliance on Glyphosate and Weed Resistance Development

Reliance on a single herbicide can lead to weed resistance. All forms of weed control, including hand weeding, can lead to weed resistance when used predominantly. The popularity of glyphosate, especially when used with GM crops, has led to weed resistance in some instances. Weed resistance is a biological process that continues to evolve. We recognize that weed resistance needs to be managed and have developed a set of best management practices (BMPs) that can slow the development of weed resistance. To that end, Bayer has developed the Roundup Ready PLUS Crop Management Solutions program to provide weed management options and economic incentives for soybean, corn and cotton farmers to incorporate additional mechanisms of action into their weed-control strategy, such as the overlapping use of residual herbicides. Through industry initiatives, such as the Take Action platform, Bayer provides farmers the resources they need to adopt weed management practices.[17]

Responsible Business Conduct

Product Stewardship at Bayer

When considering critiques about how Bayer handles glyphosate, it is important to understand that we follow our own stringent and all-encompassing product stewardship standards that span throughout production, marketing, customer use and eventual disposal. Assuming responsibility for our products is always at the core of what we do. For this reason, we conform strictly to regulations and laws all over the world to ensure the development, manufacture and disposal of our products do not cause damage to people or the environment. Bayer has directives and management systems in place to implement regulatory and voluntary

product stewardship requirements, which are steered by our Public Affairs, Science, Sustainability & HSE Enabling Function and the quality functions of the divisions. We have specified our principles of responsible product management in our Group Regulation on Product Stewardship Commitment, Principles and Key Requirements.[18] We also are committed to and fully aligned with established and internationally recognized standards, such as the International Code of Conduct on Pesticide Management issued by the FAO and WHO and the guidelines of the crop protection association CropLife International. In addition, we adhere to ethical sales and marketing practices that meet the standards set by external regulations and codes of practice, as well as data protection and privacy of customer or consumer information. You can find more information on the stewardship process at Bayer on page 22-23.

Glyphosate's Contributions to Sustainability

Environmental Benefits

Conservation Tillage

In the last 150 years, 50% of the Earth's topsoil has been lost due to erosion. Plowing or tilling – a common method of weed control – disturbs the top layer of soil, which is essential for growing plants. Glyphosate has facilitated the adoption of conservation tillage, which consists of no-till agronomic practices that do not disturb the top layer of the soil. When used in conjunction with GM crops, glyphosate reduces or altogether eliminates the need for tillage, resulting in reduced soil erosion, better soil moisture, lower carbon emissions,[19] and increases in the numbers and diversity of soil organisms. Additionally, with conservation tillage, some crop residue is left in the field, creating a protective barrier that shields the soil's surface.[20] Conservation tillage production systems exist with conventional crops as well, such as in burn-down and pre-harvest applications for small grains or other crops, or to manage cover crops and fallow ground.[21] Two essential benefits of conservation tillage are improved soil health and carbon sequestration.

Preserving Soil Health

A key environmental benefit of using glyphosate is its contribution to helping preserve soil health. By enabling conservation tillage, the use of glyphosate minimizes the disruption of biological activity within the soil and erosion. Glyphosate also makes it easier for farmers to use cover crops, which not only sequester carbon, but also preserve soil health and fertility and reduce erosion and compaction.

Carbon Sequestration

Conservation tillage, practiced with conventional as well as GM crops, limits the disturbance of the soil and keeps more carbon in the soil. This, in turn, reduces carbon emissions. According to Eurostat, in the EU27, where no GM herbicide-tolerant (HT) crops are grown, 23.2% of the total EU arable land was cultivated with reduced or no tillage in 2016.[22] It is estimated that if glyphosate were no longer available for European farmers, 20.5 million hectares (ha) would have to return to tillage and to frequent operations on the land with tractors. In turn, that would cause:

- An increase in fuel consumption of 15-44 l/ha
- An increase in carbon dioxide (CO2) emissions (due to the tractors) of 1-2.7 million tons per year
- An increase in CO2 emissions due to carbon leakage from the soil of 57 million tons per year[23]

Crop biotechnology has significantly reduced agriculture's greenhouse gas (GHG) emissions by helping farmers adopt more sustainable practices such as reduced tillage, which decreases the burning of fossil fuels and retains more carbon in the soil.[24] The fuel savings arise from making fewer insecticide applications with the use of GM insect resistant (GM IR) crop technology in maize, cotton and soybeans (in countries where farmers previously used mechanical forms of application) and the switch from conventional tillage to reduced tillage or no tillage systems facilitated by GM HT crops. Over the period 1996 to 2020, the cumulative reduction in fuel use has been about 39,147 million kg of CO2, arising from reduced fuel use of 14,662 million liters. This is equal to taking 25.9 million cars off the road for a year.[25]

For example, estimates suggest that the use of conservation tillage in conjunction with GM HT crops in North and South America between 1996 and 2020 resulted in an additional amount of carbon sequesters equivalent

to 93,745 million kg of carbon or 344,044 million kg of CO2 that has not been released into the global atmosphere, equivalent to taking about 228 million cars off the road over this period. [26]

Sustainability Commitment: Crop Protection Environmental Impact Reduction

Agriculture must strike a balance between the need for tools, like crop protection products that enable farmers to keep meeting the needs of the growing world's population, and the impact of those tools on the environment. To this end, Bayer made a commitment to reduce the environmental impact of our crop protection products and adopted a methodology to measure our crop protection environmental impact reduction (CP EIR). Specifically, we will reduce the treated-area-weighted environmental impact per hectare of Bayer's global crop protection portfolio by 30% by 2030 against a 2014–2018 average baseline.[27] Applying CP EIR allows Bayer to go beyond looking at volumes per hectare by also taking into account other variables, such as the environmental profile of the crop protection and emissions into the environment. Using the CP EIR methodology, assessments show that despite our strong global market position, Bayer products only accounted for 2% of the environmental impact from crop protection in 2021.[28] Based on the data collected between 2018 to 2022, Bayer has reduced the treated-area-weighted environmental impact per hectare of our global crop protection portfolio by 12% against the 2014 – 2018 baseline. The reduction was mainly the result of changes in our crop protection product portfolio in recent years. For the reporting period 2017 to 2021, we must restate our progress as 11% as opposed to the previously reported 14%, due to model enhancements and newly identified data corrections.[29] This reduction has been possible mainly through crop protection portfolio changes over the recent years and by applying high crop protection product development standards for decades. Glyphosate, next to other products, has been a key contributor to this reduction.

Glyphosate's Systemic Role in Preserving Food Security

Weeds compete with crops for nutrients, water, oxygen and sunlight and can reduce yields when left unmanaged. Reduced yields can contribute to increased food prices. For example, if glyphosate were no longer used in the EU on conventional crops, yields would drop by 8%-18% for wheat, 8%-19% for barley and 1%-3% for grape.[30] A study published in 2017 estimated the impacts that would arise if restrictions on glyphosate resulted in the world no longer planting HT GM crops and replacing them with conventional seeds. The global production of soybeans, corn and canola would fall by 3.7%, 0.6% and 0.7%, respectively. World prices of all grains, oilseeds and sugar are expected to rise, especially soybeans (+5.4%) and canola (+2%). Price increases would be highest in the U.S., Canada, Brazil and other South American countries. The welfare impacts are mostly negative, with global welfare falling by $7,408 million per year and the largest losses in the U.S. and South America, especially Argentina and Brazil.[31] More details are available on page 28.

Socioeconomic Benefits for Farmers

Glyphosate Use in North and South America

Farmers embraced glyphosate-tolerant crops because in many instances they reduced farm household labor requirements and enabled an increase in off-farm income. Combining a broad-spectrum herbicide like glyphosate with crops tolerant to that herbicide enabled simplified and efficient weed control that reduced the need for tillage and hand labor. Following the introduction and adoption of glyphosate-tolerant crops (soybean, cotton, corn, canola, alfalfa and sugar beet), glyphosate replaced several other herbicides, lowered the cost of weed management[32], reduced the amount of labor needed to manage weeds in these crops,[33] and increased off-farm household income.[34] For example, in global terms, the farm-level impact of using GM HT technology in soybeans (excluding "Intacta soybeans" which have been grown widely in South America since 2013 and combine GM herbicide tolerance with GM insect resistance traits in soybeans) was $4.12 billion in 2020. If the second crop benefits arising in Argentina and Paraguay are included the total is $5.64 billion. Cumulatively since 1996, the farm income benefit has been (in nominal terms) $57 billion ($74.65 billion if second crop gains in Argentina and Paraguay are included).[35]

Glyphosate Use in Asia-Pacific

Today, glyphosate is one of the most widely used herbicides in Asia-Pacific to prepare fields for planting as well as to control weeds. As some countries in Asia take steps towards restricting the use of glyphosate or considering mandates to allow glyphosate to be applied only by licensed operators, growers are expected to face higher weed-control costs and likely lower yields. Data indicates that restricting glyphosate use in these countries would lead to increased use of alternative herbicides and additional manual and mechanical weed-control methods that will cost farms between $22 and $30 per hectare and increase weed-control costs by $1.4 billion to $1.9 billion/year.[36] Indian rice and tea farmers, for example, would see a 17%-19% increase in weed management costs as well as a 18%-19% decrease in yields if they had to switch to other herbicides.[37] In Sri Lanka, the glyphosate ban, combined with other bans or restrictions on the use of inputs, caused corn smallholder incomes to plummet by up to 94% and spurred the use of more hazardous herbicides. This, in turn, promoted the influx of smuggled products into the country.[38] Additionally, some farms in Asia-Pacific countries still rely on hand and mechanical weeding to a significant extent, but as populations migrate away from rural areas, these regions are experiencing a depleted agricultural workforce. Having access to effective herbicides like glyphosate is critical to offset labor shortages while still producing enough food crops.

Glyphosate Use in Europe

In Europe, glyphosate-based products have been used safely for nearly 40 years. They still play a critical role in both Integrated Weed Management (IWM) and sustainable agriculture, helping farmers implement effective and environmentally friendly practices, such as minimum- or no-till farming. European farmers use glyphosate for a broad range of crops: wheat, barley, sugar beet, corn, grape wine, olives, and fruits and vegetables. A ban of glyphosate in the EU would have a significant impact. In wheat, studies show yield reductions by 8%-18%, which translates into a decline in production by up to 24 million metric tons. For the EU sector, this could result in up to EUR 10.5 billion in production costs. Grape wine production would decrease by up to 4.7 million metric tons, resulting in up to EUR 4.2 billion in production costs.[39] Impacts would also be seen on a wide range of other minor crops. This reduction in production of basic food commodities will also have implications for the EU's self-sufficiency. Furthermore, many existing production systems, practices and rotations would no longer be viable.

Glyphosate Use in Africa

Weed pressures are present in Africa year-round, especially in the tropical regions. If left uncontrolled during critical periods, crop yield losses can be staggering, sometimes reaching 90% of potential yields for some crops.[40] Urban migration has exacerbated the labor shortages during peak weeding periods. Effective and safe chemical weed-control tools, like glyphosate, therefore provide an important lifeline to African farmers, large or small. A recent review of pesticide use data for 14 African countries, based on market information from Demeter Dynamics, FAO data, and peer-reviewed literature, indicates that glyphosate makes up over 58% of the combined volumes of all herbicides used in these countries in 2020. In some of the countries reviewed, this was as high as 85%, used mostly on crops of strategic economic or food security importance.[41] Glyphosate is also one of the most widely used herbicides for conservation agriculture in Africa. Losing such a vital tool could have significant impact on food security and livelihoods in Africa, not to mention the likely impact on conservation farming in the face of worsening climate crises and the need to adopt climate-smart agriculture.

Transparency Commitments Made by Bayer

Bayer has expanded its transparency commitments to engage in more conversations about science and food production with internal and external stakeholders. We have formalized our continued dialogue by establishing a transparency-focused platform, which enables interested consumers and the scientific community to access summarized test results and evaluations on the human and environmental safety of active substances used in our crop protection products, like glyphosate. In the case of glyphosate, we have undertaken additional transparency efforts by participating in the Glyphosate Renewal Group (GRG), a collection of companies that sought the renewal of the EU authorization of the active substance glyphosate and joined resources and efforts to prepare a single dossier with all the scientific studies and information on the safety of glyphosate.[42] More information on our transparency efforts is available on pages 32-34.

Conclusion

As discussed above and throughout this report, glyphosate is a tool that farmers worldwide have relied on and realized benefits from for 50 years. We acknowledge that consumers, NGOs and others have questions about this technology, and we are committed to addressing them through scientific dialog and transparency. This report is another way of sharing information.

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1. The Role of Glyphosate in the Food Production System

By definition, agriculture alters the environment in order to cultivate food, and there will likely continue to be a trade-off between farming and sustainability, but it is a give-and-take that can be improved upon.[43] For example, thanks to the advancement of crop protection tools, today's farmers use less than one-third of the land they would have needed in 1961 to produce the same amount of food.[44] Producing more on less land protects the environment by reducing the need to expand agricultural production into natural habitats.[45]

Glyphosate plays a systemic role in modern agriculture and contributes to ensuring food security. For nearly 50 years, farmers around the world have used glyphosate to combat weeds in conjunction with conventional crops as well as glyphosate-tolerant GM crops. Without glyphosate, the production of certain staple crops, such as corn, soy and canola, would decrease by 23 million tons.[46] Glyphosate has also become an essential and cost-effective tool to manage weeds in non-agricultural settings, such as along roadways, in utility rights-of-way and in conservation areas, such as national parks.

The Need for Glyphosate

Weeds are one of the most persistent challenges farmers must tackle. Weeds compete with crops for resources, including soil nutrients, water, space and sunlight. They also can harbor insects and disease pests and interfere with harvesting, so it is no surprise that weeds cause the highest yield losses. The Food and Agriculture Organization (FAO) estimates that weeds account for 5%-10% of losses in the agriculture of developed countries and up to 20%-30% of losses in developing countries.[47] Without the use of herbicides, farmers would have to rely on more tilling or even manual weeding to protect their crops from being overtaken by weeds. According to the Weed Science Society of America, U.S. farmers would lose an average of 52% in corn and 49.5% in soybean yields if no herbicides were used.[48] In Africa, for example, yield losses caused by unweeded conditions reach 55%-90% in corn, 80% in cotton, 50%-80% in wheat and 90% in cassava.[49]

Since its introduction in 1974, glyphosate has become widely adopted by farmers, land managers and gardeners around the world. When sprayed on plant foliage, glyphosate is absorbed and translocated throughout the plant's tissues. In the plant, glyphosate inhibits an enzyme that is essential to plant growth but is not found in cells of humans or other animal. Inhibiting this enzyme prevents the plant from synthesizing certain essential amino acids and lignin that are needed for plant growth, so the plant dies. This gives glyphosate broad-spectrum capabilities that enable it to kill most broadleaf weeds and grasses.

Glyphosate is the active ingredient in the Bayer Roundup® brand, which is sold and used along with many generic glyphosate products around the world. Glyphosate's efficacy against a broad range of weeds along with its strong safety profile contributes to the stability and resilience of the global food supply system.

Use With GM Crops

Genetic modification is the process that allows plant scientists to take desirable genetic material from one organism found in nature, such as a bacterium, and transfer it to a plant they want to improve. Some examples of desirable characteristics or traits commonly transferred to crop plants include resistance to insects or disease and tolerance to herbicides, like glyphosate, that allow farmers to better control weeds. The use of glyphosate in conjunction with glyphosate-tolerant GM crops has resulted in:

- Simplified weed-control practices with reduced need to use multiple herbicides during the growing season[50]
- Broader adoption of conservation tillage[51]
- Increased yields and economic benefits for farmers[52]

// Reduction in manual labor on the farm[53]

Today, the overall amount of glyphosate used on glyphosate-tolerant crops makes up 20% of the total amount of glyphosate applied globally.[54] The primary glyphosate-tolerant crops – soybean, corn, cotton, canola, alfalfa and sugar beet – are grown primarily in North and South America and are exported all over the world.

Use With Non-GM Crops and Non-Agricultural Uses

Labelled uses of glyphosate include hundreds of crops beyond HT GM varieties. It is estimated that over 80% of glyphosate is used in agricultural systems where glyphosate-tolerant crops are not used and for non-agricultural uses.[55] In these situations, glyphosate simplifies weed management and reduces the need for mechanical tillage, particularly by ridding fields of weeds during the pre-planting phase.

Orchards and Vineyards

For orchards and vineyards, glyphosate is used to control weeds that compete with trees and vines for soil nutrients, water and sunlight, and act as hosts for a variety of pests.[56] Glyphosate is not taken up by roots, so it can be sprayed between vines and trees. USDA reported that 18% of apple acres and 29% of peach acres in the U.S. in 2021 were treated with glyphosate.[57] A study that compared three methods of weed control in almonds (two relied on herbicide programs that included glyphosate and the third was standard mowing) showed that the herbicide programs that included glyphosate resulted in lower weed density and greater percentage of bare ground than mowing alone.[58] The herbicide programs with glyphosate also resulted in lower labor requirements and fewer passes of machinery through the orchard that could compact soil around the tree roots.[59]

Wheat

Wheat ranks third among U.S. field crops in both planted acreage and gross farm receipts, behind corn and soybean. Based on trial data collected between 2007-2017, it is estimated that in the U.S., yield losses due to weeds could be as high as 25.6% for winter wheat and 33.2% for spring wheat.[60] Weeds can interfere with harvest and may result in dockage and lower quality grain, which impacts growers' return on investment. Glyphosate is very effective at killing jointed goatgrass and other grass weeds and is often used prior to planting wheat or after wheat is harvested to control unwanted growth in wheat stubble.[61] In addition to competing with the wheat crop, some weeds, such as Aristolochia and members of the aster family pose health risks to humans. Applying a preharvest application of glyphosate can prevent these weeds from reaching food supplies and causing acute or chronic health effects, including organ failure or cancer. Glyphosate also supports the practice of no-till and conservation tillage for reducing erosion in wheat. For example, the percentage of no-till acres in wheat has increased by over 15% in the last 26 years in the Great Plains region.[62]

Sugarcane

Glyphosate plays an important role in the cultivation and harvest of sugarcane, which accounts for about 45% of the total sugar produced domestically in the U.S., with Florida and Louisiana responsible for 90% of that amount.[63] Growing seasons in these states are short compared with most other locations where sugarcane is grown, but applying herbicides such as glyphosate encourages ripening, thus maximizing sugar content and minimizing yield losses. A study across 43 sugarcane varieties found 12%-15% increases in sugar content when glyphosate was applied early in the harvest season.[64] Glyphosate is also needed to control weeds during the fallow period of sugarcane production prior to planting or applied post emergence to weeds. In a study of a variety of weed-control options, a postemergence application of glyphosate more than doubled cane yields compared to an untreated control and provided similar weed control and yields as three rounds of manual control through hoeing.[65]

Cover Crops

Cover crops are unique in that most are planted for agronomic benefits and are not harvested for seed, fruit or forage. Their purpose is to cover the soil and, later, become incorporated into the soil as enrichment to benefit the primary crops grown in that field. Cover crops can provide numerous benefits, including reduced soil erosion, increased soil organic matter content, improved air and water filtration through soil, and reduced soil compaction.[66] Additionally, cover crops have the potential to reduce greenhouse gas emissions. Cover crops are subsequently killed before planting production crops so they

do not become weeds or slow soil drying and warming in spring. Glyphosate is the standard herbicide for cover crop elimination.[67]

Non-Agricultural Uses

Glyphosate has other applications outside of agriculture. For example, federal and state laws require weed control along transportation rights-of-way and mandate specific practices for the control of noxious and invasive weeds. In an economic analysis of highway median weed control, glyphosate was 275% less expensive than alternative methods that included multiple mowing passes and alternative herbicides.[68] In utility rights-of-way, glyphosate controls vegetation that can interfere with reliable delivery of electrical power. A study conducted for an Arkansas electric cooperative found that the long-term costs over a six-year cycle of right-of-way maintenance using herbicide were $50-$70 million lower than mowing alone.[69] Many rights-of-way also feature terrain where mowing is challenging, so herbicides like glyphosate are often preferred to control weeds, including roots.

Glyphosate is also used to control noxious or invasive weeds, given that costs of manual or mechanical control can exceed the cost of using herbicides by 800%-1,500%.[70] National parks and other areas, such as reclaimed strip mines, rely on glyphosate to control invasive vegetation and restore native habitats. In aquatic settings, glyphosate replaces mechanical control of aquatic weeds to enable navigation and maintain wildlife habitat. In recreational environments that include managed turf grass, glyphosate applications to dormant turf, such as golf course fairways, control undesirable species of weeds and grasses without the need for total replacement. It is also used to manage weeds at sports fields, parks, picnic grounds, fairgrounds and shorelines. A study conducted at city parks in Northern California found that a 140-gallon mix of glyphosate and water costs $62 compared to the cost of two alternatives at $1,136 and $1,001.[71] The alternatives do not offer the same control benefits of glyphosate, which kills the roots; therefore, treatments need to be repeated to maintain desired weed control.

Additionally, glyphosate is used by conservation groups in the preparation of sites being converted into wildlife habitats or prairies. Repeated application of glyphosate is considered the most efficient and cost-effective method to clear out vegetation.[72] Glyphosate's ability to degrade rapidly and lack of soil residual allows for the planting of new prairie seed or other desired species the next day.

2. Controversies Over Glyphosate

Even though the leading health authorities around the world have thoroughly examined and affirmed the safe use of glyphosate for nearly 50 years, we recognize that glyphosate is surrounded by a degree of controversy, which we are committed to addressing through balanced and transparent communication and engagement. This section addresses these controversies and explains why the safety of glyphosate-based herbicides is supported by one of the most extensive bodies of research on human health and environmental effects ever compiled for a pesticide product. We hope that this report sparks productive dialog with our stakeholders.

Classification as a "Probable Carcinogen"

IARC Classification

An often misunderstood but widely debated issue involving glyphosate is whether exposure to glyphosate can cause cancer. The confusion about this matter was brought to the forefront by an isolated opinion issued in 2015 by the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO). IARC classified glyphosate as a "probable carcinogen" in 2015, claiming an association between glyphosate and non-Hodgkin's lymphoma.

IARC's classification of glyphosate as a "probable carcinogen" drew a significant amount of attention precisely because it is an outlier. IARC is one of four programs within WHO that has evaluated the safety of glyphosate and is the only one to find an association between glyphosate and carcinogenicity. It is important to note that IARC is not a regulatory body and did not conduct original scientific research. IARC used snippets of data and second-hand resources, and its opinion is wholly inconsistent with the conclusions of regulatory authorities and other experts around the world that have assessed not only the studies examined by IARC, but also many more. The comprehensive body of science – nearly 50 years of real-world experience and the continued science-based conclusions of regulators and international agencies around the world, including the U.S. Environmental Protection Agency (EPA), European Food Safety Authority (EFSA), European Chemicals Agency (ECHA), the Assessment Group on Glyphosate (including the competent authorities of Sweden, the Netherlands, France and Hungary), German BfR, and Australian, Canadian, Korean, New Zealand and Japanese regulatory authorities, as well as the Joint FAO/WHO Meeting on Pesticide Residues (JMPR)[73] – support that glyphosate-based products can be used safely and that glyphosate is not carcinogenic.

As additional context, note that IARC[74] places common, everyday substances, like red meat and hot beverages, in the same category as glyphosate; and its classification system does not reflect real-world exposure levels, which are essential to assess any human health risk.

Human Safety Studies and Regulatory Reviews

We recognize that the IARC classification and the accompanying media attention have raised questions about the safety of glyphosate. Claims about alleged harm caused by glyphosate, circulated through traditional and social media in recent years, often receive more attention than comprehensive safety assessments and conclusions of independent experts at regulatory authorities, particularly among consumers. We believe it is our responsibility to share fact-based information about glyphosate-based products to answer these concerns.

As one of the most widely used herbicides in the world, glyphosate has been extensively studied around the globe for both short- and long-term exposure effects to humans. These comprehensive studies have demonstrated many times over the strong human safety profile of glyphosate-based herbicides, which work by inhibiting an enzyme found only in plants and certain bacteria – not humans.

To secure registration by regulatory authorities, Bayer and other glyphosate manufacturers have conducted studies that thoroughly examined dietary exposure, metabolism in mammals, acute and repeated dose toxicity, genotoxicity, carcinogenicity, developmental and reproductive toxicity, effects on the endocrine system, and neurotoxicity. These studies were conducted following Good Laboratory

Practices (GPSs)[c]. (GLPs are firmly anchored in Bayer's binding group-wide "Bayer Societal Engagement (BASE) Principles," especially addressing transparency, including in publication and collaboration.) Based upon this data, independent experts and leading health authorities have conducted human health risk assessments and have repeatedly concluded that glyphosate herbicides exhibit low toxicity, do not disrupt endocrine systems, and are not mutagenic or carcinogenic. Furthermore, glyphosate's physiochemical properties, environmental fate and pharmacokinetics contribute to extremely low human exposures. This combination of low hazard and low exposure indicates that glyphosate presents minimal human health risk to farmers, pesticide applicators and consumers. This safety profile is a primary reason why glyphosate has continued to be approved by regulatory authorities around the world and has become one of the most widely used herbicides globally.

The largest and some of most recent epidemiology studies, which are most relevant for assessing exposure effects in the human population, found no association between glyphosate-based herbicides and non-Hodgkin's lymphoma (NHL) overall in real-world use, when adjusted for the use of other pesticides. (NHL is the type of cancer most frequently mentioned in relation to glyphosate.) These studies include:

// The Agricultural Health Study funded by the National Cancer Institute and the National Institute of Environmental Health Sciences in collaboration with the U.S. EPA[75]
// The Pooled Analysis from the International Consortium of Agricultural Cohort Studies (AGRICOH)[76]
// The North American Pooled Project[77]

In evaluations spanning nearly five decades, the overwhelming consensus of regulatory agencies, scientific bodies and independent scientists is that glyphosate, when used as directed, shall have no immediate or delayed harmful effects on human health or animal health, and no unacceptable effects on the environment. With seven separate regulatory data packages submitted to regulators by multiple registrants, glyphosate's safety is supported by one of the most comprehensive, worldwide human health, crop residue and environmental databases ever compiled on a pesticide product.

To be approved for use, pesticides undergo more than one hundred tests for safety and efficacy. Glyphosate-based products are registered in more than 120 countries throughout the world. Many countries have a governmental agency that is equivalent to the U.S. EPA that reviews data from required studies before a registration is granted. In low- and middle-income countries (LMICs) that do not have risk-based approaches to evaluate product safety, we raise the safety bar by following internal guidelines, while considering the unique needs of growers in those markets. In addition to meeting regulatory requirements in all countries where we register our products, we apply additional safety standards aligned with the FAO, WHO and the Organisation for Economic Co-operation and Development (OECD) standards.

The registration of a herbicide is not a one-time event; in fact, periodic reviews are required and each review may take years to complete. As an example, the reapproval of glyphosate was reviewed and recently approved for another 10 years in the European Union (EU). Most countries also require regulators to continually monitor and update registered pesticides for any new information concerning safety. Registrants are required to promptly report new evidence of adverse effects and to continually conduct studies to aid in risk assessments. If new information alleges adverse effects or incomplete data to support continued registration, regulatory authorities may conduct a special review to further assess the risk and benefit of continued use. Upon completion, regulators may choose to amend or cancel a product's registration.

Below are several examples outlining how regulatory bodies around the world have assessed the human safety of glyphosate:

// In September of 2016, the **U.S. EPA** re-affirmed its position that glyphosate is "not likely to be carcinogenic to humans" in its Glyphosate Issue Paper.[78] The EPA also released draft risk assessments for glyphosate in 2017 as part of the registration review that had been ongoing since 2009. The agency concluded that "Glyphosate exhibits low toxicity across species, durations, life

[c] Good Laboratory Practices (GPSs) are principles outlining how safety studies are planned, performed, monitored, recorded, reported and archived to maintain the quality and integrity of study data that supports regulated products.

stages, and routes of exposure."[79] In 2019, the EPA "… thoroughly assessed risks to humans from exposure to glyphosate from all uses and all routes of exposure and did not identify any risks of concern."[80] Both non-cancer and cancer effects were evaluated for glyphosate and its metabolites." Further, the EPA said that its, "… cancer evaluation is more robust than IARC's evaluation." EPA's conclusion is consistent with other countries and regulatory authorities.

- In November 2015, **EFSA** published a final conclusion of its peer review of the Renewal Assessment Report prepared for the member states, concluding that glyphosate should not be classified as carcinogenic. EFSA characterized the process as "… exhaustive (and) a full assessment that has taken into account a wealth of new studies and data."[81] In 2017, after comprehensive review of the endocrine data set on glyphosate, EFSA published its conclusion that glyphosate does not have estrogen, androgen, thyroid and steroidogenesis-mediated endocrine disrupting properties.[82] In July 2023, EFSA published the final conclusions of its peer reviewed Renewal Assessment Report and shared with the Commission. EFSA opined that "The assessment of the impact of glyphosate on the health of humans, animals and the environment did not identify critical areas of concern." It took EFSA 32 months to review 180,000 pages of dossier, 2,400 studies, and consultation with 27 national authorities to reach this conclusion. 90 experts were appointed by 27 EU member sates to review the data.
- After a rigorous and comprehensive assessment, the European Chemicals Agency´s **Risk Assessment Committee (ECHA RAC)** concluded in 2017 that, based on available scientific evidence, there should be no change to glyphosate's classification as non-carcinogenic, non-mutagenic, non-reprotoxic, non-genotoxic and without specific target organ toxicity.[83] The ECHA RAC undertook an additional review of glyphosate again in 2021/22, including input from industry and multiple NGO stakeholders, and reconfirmed the accuracy of its 2017 conclusions. In 2022, ECHA carried out a hazard assessment of glyphosate and concluded that it did not meet the scientific criteria to be classified as a carcinogenic, mutagenic or reprotoxic substance. EFSA used ECHA's hazard classification for the purposes of the EU risk assessment on glyphosate.
- On November 16, 2023, **The European Commission** re-approved glyphosate for use in the EU for 10 years (until the end of 2023) subject to several new conditions, amongst which: the prohibition for use as a desiccant (with the intention to control the time point of harvest or to optimize the threshing); the setting of maximum limits for 5 impurities in glyphosate (i.e., in the material manufactured); the requirement for Member States to pay particular attention to specific aspects when carrying out risk assessments (e.g., the protection of small herbivorous mammals, such as voles, and non-target plants, such as wildflowers) and to set risk mitigation measures to ensure that non-target organisms and the environment are protected; the setting of maximum application rates that shall not be exceeded unless the outcome of the risk assessment undertaken for the specific uses for which authorization is applied for demonstrates that a higher rate does not lead to any unacceptable effects on small herbivorous mammals; an obligation for the applicant to submit information on the possible indirect impacts on biodiversity within 3 years from the availability of an appropriate guidance document. The Commission based its decision on the comprehensive safety assessments carried out by EFSA and ECHA, together with EU Member States.[84]
- Following its comprehensive multi-year re-evaluation of glyphosate, the **Health Canada Pest Management Regulatory Agency** granted continued registration of glyphosate products in 2017. The agency assessed potential human health risk of glyphosate from drinking water, food, occupational and bystander exposure, as well as the environmental risk to non-target organisms. Both the active ingredient and formulated products were re-evaluated, and the agency concluded that "… products containing glyphosate do not present unacceptable risks to human health or the environment when used according to the revised product label directions."[85]
- Also in 2017, the **Korean Rural Development Administration** (RDA) publicly announced its completion of a safety re-evaluation of glyphosate and removed previously implemented sale restrictions based on the IARC classification. RDA concluded, based on animal studies and in alignment with large-scale epidemiological studies, there was no carcinogenic association between glyphosate and humans.[86]
- The **Australian Pesticides and Veterinary Medicines Authority** evaluated the IARC report and other contemporary scientific assessments of glyphosate in 2016 as part of its established chemical reconsideration nomination process. The agency concluded that glyphosate did not pose a carcinogenic risk to humans and that there were no grounds to place it under formal reconsideration.[87]
- In August 2016, the **New Zealand Environmental Protection Agency** commissioned a review of the evidence relating to glyphosate and carcinogenicity and concluded that "… glyphosate is unlikely to be

carcinogenic to humans or genotoxic (damaging to genetic material or DNA) and should not be classified as a mutagen or carcinogen."[88]

- A joint **UN FAO and WHO** Meeting on Pesticide Residues in 2016 re-evaluated glyphosate and concluded "… in view of the absence of carcinogenic potential in rodents at human-relevant doses and the absence of genotoxicity by the oral route in mammals, and considering the epidemiological evidence from occupational exposures … glyphosate is unlikely to pose a carcinogenic risk to humans from exposure through the diet."[89]
- Also in 2016, the **Japan Food Safety Commission** reviewed glyphosate acceptable daily intake and did not observe any neurotoxicity, carcinogenicity, reproductive effect, teratogenicity or genotoxicity. Five distinct assessment data sets were submitted from each manufacturer, and toxicological profiles among the data sets were found to be largely consistent after individual verification.[90]
- Critics of glyphosate have been pressuring regulators across the globe to reconsider their approvals of glyphosate-based herbicides, claiming that Monsanto (prior to being acquired by Bayer) improperly influenced regulators' scientific reviews and that IARC's categorization of glyphosate warrants reconsideration. In response, regulators investigating those claims have not found any cause to alter their original assessments that glyphosate-based herbicides are safe when used as directed.
- The EU conducted the first inquiry into allegations of improper industry influence over the approval of glyphosate. In 2017, **EFSA** asserted that: "Following this investigation, EFSA can confirm: that there are no grounds to suggest that industry improperly influenced the EU assessment of glyphosate; and that the role of industry and of other actors in the process was carried out according to standard procedures." Further, the Authority stated that it was "… satisfied that the evidence EU experts had access to was sufficient to allow for a thorough, independent evaluation of the toxicity of the substance and of the possible risks regarding intended uses."[91] The **European Chemicals Agency** also issued a statement confirming that industry influence "did not have any impact on the overall hazard assessment as presented in the Opinion on the proposed harmonized classification and labelling of glyphosate that was discussed and adopted by the Committee for Risk Assessment in March 2017."[92]
- **Health Canada** investigated allegations that its re-evaluation of glyphosate had been improperly influenced by industry. In 2019, the agency stated: "After a thorough scientific review, we have concluded that the concerns raised by the objectors could not be scientifically supported when considering the entire body of relevant data. The objections raised did not create doubt or concern regarding the scientific basis for the 2017 re-evaluation decision for glyphosate. Therefore, the Department's final decision will stand"[93]
- The **Australian Senate Rural and Regional Affairs and Transport References Committee** was called upon to investigate the scientific independence of the Australian Pesticides and Veterinary Medicines Authority (APVMA). In particular, the committee looked at the APVMA's response and review of glyphosate following IARC's 2015 classification of glyphosate as a "probable carcinogen." The committee reported in 2019 that it determined: "…APVMA's scientific processes to be robust, noting that all 264 of the studies referenced in the IARC report were independently evaluated by the Office of Chemical Safety, in addition to other studies and data"[94]
- The **German Federal Institute for Risk Assessment (BfR)** was alleged to have copied portions of a 2015 report assessing the health impact of glyphosate from industry submissions. The Institute affirmed its independent review in this statement: "The BfR did not in any way adopt the applicant's conclusions without first assessing their validity. In accordance with its statutory mandate, the BfR reviews the originals of all reported studies. Critical remarks from the BfR are contained within the Renewal Assessment Report. The sole criterion for the consideration of study results is the scientific quality and evidence of the studies themselves"[95]

Several publications have attempted to correlate glyphosate use and the incidence of various disorders and diseases over time. Some of the more widely circulated claims include allegations that glyphosate-based herbicides cause autism spectrum disorder, Alzheimer's disease, obesity, anorexia nervosa, liver disease, reproductive and developmental disorders and cancer.[96] Rather than providing experimental evidence that describes a causal association, these publications rely on correlation, which is not evidence of causation.

Some concerns have been raised as to whether glyphosate is an endocrine disruptor (a chemical that may mimic or interfere with the body's hormones). No regulatory agency in the world has found glyphosate to be an endocrine disruptor. A case in point is the EPA: As part of requirements set forth in

the 1996 Food Quality Protection Act, EPA issues lists of chemicals to be tested as part of its endocrine disruptor screening program. Glyphosate was included in the first round of testing, during which EPA reviewed ten EPA-mandated studies as well as data from the scientific literature.[97] In 2015, EPA concluded that "glyphosate demonstrates no convincing evidence of potential interaction with the estrogen, androgen or thyroid pathways in mammals or wildlife."[98] Like the EPA, no other regulators have concluded that glyphosate is an endocrine disruptor.

As mentioned earlier, glyphosate inhibits an enzyme, EPSP synthase, that is present in cells of plants and some microorganisms but not human or other animal cells. Some have speculated that because this enzyme is in certain bacteria, glyphosate residues can inhibit their growth in the gut of animals. There are also some reports that indicate that growth of pure strains of certain bacteria are inhibited when grown in batch culture systems in vitro. However, these studies are not representative of conditions in the gastrointestinal tract, where mixed bacteria grow at relatively high growth rates due to continuous flows. Systems that replicate these conditions have not been shown to negatively affect the bacteria or the host animal.[99] It is important to recognize that toxicity studies mandated by regulatory authorities use animals that have active microbial fermentation in their digestive tract.

Others have suggested that glyphosate could chelate minerals in the gastrointestinal tract and prevent their absorption, resulting in mineral deficiencies; however, other more potent chelators, such as certain amino acids, are ubiquitous in the digestive tract and are part of a healthy diet. Regulatory testing identifies potential hazards, but risks of these hazards need to be evaluated in the context of realistic exposures and conditions. Conclusions about safety should be based on empirical results within the limitations of model systems or experimental design.

Litigation

The IARC report spurred a wave of tort litigation in the U.S. that received significant media attention. We have great sympathy for anyone who suffers from disease, and we understand their search for answers. At the same time, the extensive body of science – referenced above – continues to show that glyphosate is not responsible for cancers alleged in this litigation. It is exactly this discrepancy between some of the trial verdicts and the assessments by regulatory authorities that has kept the topic of glyphosate safety in the public domain. In May 2021, Bayer announced a five-point plan that provides a path to closure of the U.S. litigation.[100] This plan does not include any admission of liability or wrongdoing. Bayer has a winning record at trial in this litigation and overall has resolved the majority of cases filed in this litigation.

Glyphosate Residues

Some groups have raised concerns about the fact that residues of glyphosate can be detected in foods we eat or in the human body.[101] When questions about residues are raised, it is important to consider that strict rules are in place to limit the amount of any pesticide that may remain on harvested crops. In the EU, EFSA sets daily exposure limits at least 100 times below levels shown to have no negative effect in safety studies. Regulators then monitor food and feed for pesticide residues to ensure that residues are not at unexpected concentrations. When concentrations are greater than expected, this could suggest that farms are not following the product label. The residues sometimes found in food are not even remotely close to regulatory limits. These trace amounts are typically present at parts per billion (ppb) and are not detectable without complex and precise analytical methods.

The mere presence of a chemical in urine or food does not constitute a health concern; rather, it is the amount of exposure compared to a human health standard that matters for human health. Specific to this question, EPA examined exposures to glyphosate through diet, drinking water and home uses, and reported that it is unlikely uses of glyphosate pose a risk to human health.[102]

One media report that received considerable attention only reported residues in beer. That report failed to indicate that even the highest levels of glyphosate detected in beer in 2016 (30 micrograms per liter) were so low that the intake for an adult calculated on this basis would be more than 1,000 times lower than the currently estimated amount that can be ingested daily over a lifetime without appreciable health risk.[103] There is no reliable scientific evidence that glyphosate use results in residue levels that pose health problems for consumers.

Recent statements from regulatory authorities reinforce the point that glyphosate residues pose no concern:

- In 2016, JMPR concluded that glyphosate is unlikely to pose a risk to humans from exposure "through the diet."[104]
- In 2020, EFSA stated the following about pesticide residues overall: "The findings suggest that the assessed levels for the food commodities analysed are unlikely to pose concern for consumer health."[105]
- Also in 2020, the U.S. EPA stated the following about glyphosate residues: "Due to its widespread use, trace amounts of glyphosate residues may be found in various fresh fruits, vegetables, cereals, and other food and beverage commodities. However, these trace amounts are not of concern for the consumer. EPA conducted a highly conservative dietary risk assessment for glyphosate that evaluated all populations, including infants, children, and women of child-bearing age. EPA assumed that 100 percent of all registered crops were treated with glyphosate, that residues were at the tolerance level for each crop, and that residues in drinking water were from direct application of glyphosate to water. These assumptions would lead to much higher estimated levels of exposure than would be expected to occur with actual use. The resulting conservative estimates of dietary exposure were not of concern."[106]

Other considerations when analyzing claims about glyphosate residues include whether glyphosate was measured using a reliable method, whether the samples were handled and stored correctly and whether the measured amounts were compared to a health standard. These considerations are relevant when considering some allegations that were made that glyphosate was present in human milk.[107] The original reports were posted on a website that did not supply basic information about the validation of the assay or how samples were collected and handled. The assay used to measure glyphosate was a kit that was only validated for qualitative analysis of water samples. Milk, however, is a complex matrix that would require a separate method of validation to avoid inaccurate results, and by nature of the assay, matrix effects of food can result in false positives. EPA and Germany's BfR have questioned the biological plausibility of glyphosate appearing in milk, and all subsequent studies that used validated assays did not detect glyphosate in human or cows' milk.[108] In one study, dairy cows were fed rations containing feedstuffs that had measurable residues of glyphosate for 26 days. Glyphosate was not detectable in their milk at concentrations greater than the limit of quantitation (3 µg/kg [ppb]).[109]

Claims about adverse effects on digestive system microorganisms[110] were considered as part of a scientific review of glyphosate in the EU. After reviewing the available data, EFSA concluded that there were no effects at realistic doses.[111]

Environmental Impact

The use of pesticides in general has always been associated with questions about their environmental safety, and glyphosate is no exception. Questions have been raised about the impact of glyphosate on biodiversity, non-target species, and soil and water. While we acknowledge these questions, our confidence in the environmental safety of glyphosate is backed by hundreds of peer-reviewed scientific studies and regulatory reviews. Glyphosate has a favorable environmental profile because it binds tightly to the soil, which limits movement; it degrades over time; it does not bioaccumulate; and it has been proven nontoxic to wild mammals, birds, fish, and aquatic and terrestrial invertebrates at environmentally realistic exposure levels.

Environmental Safety Studies and Regulatory Reviews

Environmental safety assessments for our crop protection products are conducted by groups of experts trained in the field of ecotoxicology, which combines knowledge and techniques from both ecology and toxicology along with an understanding of the environmental fate of substances after they are applied for crop protection. Since crop protection products exist to eliminate certain pests, our goal is to protect the organisms that are not targeted by the crop protection product. The groups of non-target organisms that are tested are selected based on the ecosystem functions they provide. Since it is impossible to test the universe of species, non-target organisms that represent key ecological services are tested (e.g., pollination services, biological control of pests, soil services). Representative non-target organisms from

the terrestrial environment that are tested include avian species, wild mammals, bees, beneficial insects, soil organisms and plants. Representative non-target organisms from the aquatic environment that are tested include different organisms that comprise an aquatic food web, such as primary producers (e.g., algae and plants), primary consumers (invertebrates), and secondary consumers (e.g., fish).

To protect avian populations, the potential for acute and reproductive effects are evaluated. To protect potential effects to wild mammals, data is drawn from the extensive battery of toxicology studies that have been designed to assess effects on survival, growth, development and reproduction. To protect the biological functions and biodiversity of non-target arthropods (insects), beneficial insects such as green lacewings, beetles and parasitic wasps that are important for biological control of pest species are tested for potential effects on survival and reproduction. To protect non-target plant communities and the organisms that depend on them, studies are conducted on a diverse group of plant species to assess potential effects on seedling emergence and growth of emerged plants. To protect non-target soil macro-organism populations and the services they provide (e.g., detritivory, nutrient cycling) acute and reproduction studies are conducted on representative soil organisms (e.g., earthworm) and for potential functional effects on carbon and nitrogen cycling. To protect aquatic communities, acute and chronic effects on all levels of the aquatic food web are tested (e.g., algae, plants, invertebrates and fish). Further, a study is performed to understand the potential for a substance to bioaccumulate in organisms and through the food web.

In addition, an extensive battery of environmental fate studies is performed to help characterize exposure to the active ingredient and its relevant environmental metabolite(s) in aquatic and terrestrial environments. Mathematical models are used to perform exposure calculations that consider a range of soil and weather conditions that are representative for agricultural areas, combined with information on application rate, application timing, application method (e.g., ground vs. aerial), number of applications, and the crop to which a product will be applied. This allows us to predict environmental concentrations of the active substance and its metabolites in soil after the compound is applied on the field and in water and sediment after exposure via spray drift, drainage or run-off. The parameters that are used for environmental exposure modeling provide predictions of realistic worst-case concentrations, which will generally not be exceeded under real-world conditions, and are therefore protective of non-target organisms. In some cases, measurements from real-world monitoring programs are collected to further our understanding of the range of environmentally realistic exposures to non-target organisms. If the predicted concentrations show a potential risk, mitigation measures are required to reduce exposure and achieve acceptable risk. There is a wide range of such mitigation measures, for all routes of environmental exposure and for all environmental risk assessments. For example, a simple but efficient mitigation measure to eliminate the exposure to bees is a restriction that the compound must not be sprayed while the crop is flowering. We confirm the efficiency of such measures with experimental studies and modeling, which allows authorities to evaluate their appropriateness during the registration process.

Giesy et al. (2000) summarized the body of environmental fate and effect studies conducted with glyphosate as well as a representative glyphosate-containing product to conduct an ecotoxicological risk assessment.[112] Acute and chronic hazard quotients confirmed minimal risk of adverse effects. This assessment indicates that application of glyphosate in terrestrial sites, including agriculture, forestry, residential, rights-of-way and habitat restoration, poses minimal risk to non-target species when used according to the label.[113] Additionally, Von Merey et al. (2016) evaluated chronic risks from exposure to glyphosate against a battery of representative soil macroorganisms and microorganisms under controlled laboratory conditions.[114]

Roundup formulations are not registered for overwater use, so the toxicity of the formulated product is not relevant for overwater use. Rather, for aquatic applications, glyphosate is mixed with a surfactant that has low aquatic toxicity and will not pose a risk to aquatic communities. Although drift from sprays with Roundup might contaminate water, these exposure concentrations are a small percentage compared to overwater applications and pose minimal risk to aquatic communities.[115] Results from the studies demonstrate that the potential impact is low for beneficial soil macroorganisms and nutrient cycling soil microorganisms under environmentally relevant exposure scenarios.

In most countries and world regions, it is mandatory for each crop protection product to have a label that explains how the product may and may not be used by the farmer. In countries and world regions with these requirements, the product label is prescribed by the regulatory authority as part of the product authorization and

is based on their evaluation of all available data, including the outcome of the environmental safety assessments. Further, the label states how the product and the container should be disposed of correctly. Thus, if applied accordingly, the potential impact on the environment and non-target organisms will be below acceptable levels.

Our products meet environmental regulatory requirements in all countries where they are registered, and we apply additional safety standards aligned with the FAO, WHO and OECD standards. We also closely follow scientific approaches and risk evaluation models from mature regulatory systems around the world, including the U.S., Canada, Brazil, EU, Australia, New Zealand, Japan and China. In LMICs that do not have risk-based approaches to evaluate product safety, we raise the safety bar by following our internal guidelines, while considering the unique needs of growers in those markets. In addition to human safety, regulatory agencies examine the environmental safety of products such as glyphosate.

After conducting a routine registration review of glyphosate in February 2020, EPA published an Interim Registration Review Decision (ID), which did not identify any human risks of concern from exposure to glyphosate but identified potential ecological risks and recommended interim risk mitigation measures in the form of label changes to manage spray drift and herbicide resistance. Nevertheless, the ID concluded that the benefits of glyphosate outweighed the potential ecological risks when the product is used in accordance with label instructions. In March 2020, the glyphosate ID was challenged in the U.S. Court of Appeals for the Ninth Circuit by petitioners who claimed that the EPA's interim decision and mitigation measures violated the Endangered Species Act (ESA). Unable to meet the court-imposed October 1, 2022, deadline to reconsider the review of the ecological portion of the ID, EPA withdrew its glyphosate ID on September 23, 2022, and initiated consultations and a review of its decision.[116] EPA's withdrawal of its interim registration review decision has no effect on the registration of glyphosate or Roundup products, nor does it change the conclusions the EPA has repeatedly reached regarding the safety of these products. In a press release on this matter, the EPA emphasized that, "Pesticide products containing glyphosate continue to remain on the market and be used according to the product label and are unaffected by this action." We remain confident, based on the extensive science supporting its safety, that the agency will again conclude that glyphosate is safe for use, consistent with the findings of other expert regulators worldwide.

The reauthorization of glyphosate in the EU includes an analysis of environmental risk mitigation. Following comprehensive scientific review, EFSA concluded in July 2023 that glyphosate fulfills all required approval criteria according to the EU Plant Protection Regulation.

In July 2023, EFSA published the final conclusions of its peer reviewed Renewal Assessment Report and shared with the Commission. EFSA so opined that "The assessment of the impact of glyphosate on the health of humans, animals and the environment did not identify critical areas of concern." A concern is defined as critical when it affects all proposed uses of the active substance under evaluation (e.g., pre-sowing uses, post-harvest uses, etc.), thus preventing its approval or renewal. It took EFSA 32 months to review 180,000 pages of dossier, 2,400 studies, and consultation with 27 national authorities to reach this conclusion. 90 experts were appointed by 27 EU member states to review the data. EFSA's assessment relied on ECHA's 2022 hazard classification that concluded that glyphosate did not meet the criteria to be classified as carcinogenic, mutagenic or reprotoxic. On biodiversity, the experts recognized that the risks associated with the representative uses of glyphosate are complex and depend on multiple factors and that the available information does not allow firm conclusions to be drawn on this aspect of the risk assessment.[117]

Biodiversity

We acknowledge that agriculture is responsible for significant land use change, which is one of several drivers – in addition to direct exploitation, climate change, pollution and invasive species – that has an impact on biodiversity, and we believe that the diversity of ecosystems, species and crop varieties is inherently valuable and needs to be protected.[118] What we strive for is a balance between the need to protect biodiversity and meeting the social, environmental and economic needs of a global population that is growing in numbers and wealth. We can achieve that by continuously optimizing agricultural production systems so we can use existing farmland more efficiently to maintain yields. Glyphosate is a

tool that enables farmers to achieve high yields without expanding farmland, and Bayer advises customers to use glyphosate in a responsible way to protect native biodiversity.

Pollinators

Adverse effects from herbicides on monarch butterfly populations in North America is a common topic of discourse. Over the past 20 years, this insect has faced a number of challenges: losses of breeding and foraging habitats, weather, predators, pathogens, parasites, and declining overwintering habitats in Mexico. One of these challenges – the loss of breeding and foraging habitats along migration routes – is related to intensive agriculture. Milkweed plants are essential to the monarchs' survival; they lay their eggs on the leaves of the plant, and the butterfly caterpillars eat it as a sole source of nutrition. Milkweed, however, is also a weed that constitutes a problem for farmers in North America. In order to maximize crop yields, farmers strive to keep their fields weed-free. Glyphosate is highly effective in helping farmers control milkweed in their fields – a positive development for food production and an unintended consequence for monarch populations. Bayer recognizes that intensive agriculture has had an impact on monarch butterflies through changes in milkweed abundance and distribution and, since 2014, has been actively involved in developing compensatory measures to restore their natural habitats. This is, in fact, a perfect example of how intensive agriculture and conservation efforts can exist side by side.

Bayer agrees with many other organizations, including the U.S. Fish and Wildlife Service,[119] that the most impactful solution is expanding the monarch butterfly's habitats in North America by planting more milkweed.[120] We collaborate with conservation groups, academic experts, farmers and government agencies to create additional habitats that help the monarch population to thrive and has contributed over $10 million to many organizations that support the revival of the monarch population. For instance, our partnership with the National Fish and Wildlife Foundation (NFWF) to date has supported 98 projects that have generated more than 301,000 acres of habitat restoration.[121]

Similarly, herbicides like glyphosate reduce the amount of weeds that make up habitats for honeybees and other pollinators. The impact of glyphosate on honeybees has been thoroughly evaluated. A study published in 2014 examined what happens to honeybee brood when exposed to both realistic and worst-case doses of glyphosate. There were no significant effects from glyphosate observed in brood survival, development and pupal weight. Additionally, no biologically significant levels of adult mortality were observed.[122]

As with any herbicides, to mitigate the potential impact of glyphosate, farmers should consult the product labels, which indicate recommended application rates and restrictions on the timing and the number of applications. Spray drift reduction equipment and field buffers are additional measures for ensuring that herbicides and insecticides do not migrate to natural habitats that serve as refuges for biodiversity.

Potential Overreliance on Glyphosate and Weed Resistance Development

Reliance on a single weed-control method can lead to weed resistance. When glyphosate was introduced, it became popular among farmers as a simple method to combat weeds in the fields, particularly with GM crops, leading to instances of resistance. For example, Palmer amaranth, commonly known as pigweed, was first identified resistant in Georgia, followed by Alabama, Arkansas, Florida, Louisiana, Mississippi, North Carolina, South Carolina and Tennessee. Another closely related dioecious amaranth, known as waterhemp has also developed resistance to glyphosate in Illinois, Iowa, Minnesota and Missouri.[123] For sustainable weed management, multiple modes of action are needed. Integrated Weed Management (IWM) is a strategy for weed control that considers the use of all available weed-control techniques. Bayer offers sustainable IWM programs with less environmental impact to help guide farmers through science-based best practices for crop protection and herbicide stewardship, as well as to prevent resistance. Our customized agronomic solutions show farmers the benefits of a holistic approach to weed management, including the use of crop rotation, cover crop planting, utilizing multiple modes of action, and other cultural and mechanical practices such as harvest weed seed control. We support this by adding the mode of action of the product to the label.

Worldwide, 416 herbicide-resistant weed biotypes have been reported to be resistant to 21 different herbicide modes of action. For reference, over almost 50 years of use, less than 10% of important weeds across different crops have developed resistance to glyphosate.[124] Scientists have examined various ways of addressing weed resistance, such as limiting the use of glyphosate to alternate years or rotating

herbicides with different modes of action year after year only to conclude that they would be counterproductive and deprive growers of the many benefits enabled by glyphosate (e.g., conservation tillage, reduction in manual labor, increased farm income, etc.). Instead, the use of multiple modes of action has been shown to be the most advantageous and effective at preventing resistance.[125]

Growers can manage resistant weeds by following best management practices (BMPs), which most regulatory agencies mandate as part of the product registration process. Label requirements for resistance management also are intended to educate growers to avoid resistance issues. Bayer has developed BMPs that can slow the development of weed resistance. This includes the Roundup Ready PLUS Crop Management Solutions program, which provides soybean, corn and cotton farmers with weed management options and economic incentives when incorporating additional mechanisms of action into their weed-control strategy. Our stewardship commitments include developing resistance management tools, collaborating with other stakeholders to better understand resistance dynamics and training growers in BMPs.

In North America, particularly in the U.S., farmers continue to see benefits from using glyphosate-based herbicides even as resistance in certain weeds has developed. [126] Farmers have adopted integrated weed management strategies incorporating a mix of herbicides, other herbicide tolerant (HT) crops, and cultural weed-control measures. Corn and soybean growers are scouting for resistant weeds, rotating with other crops and incorporating additional herbicidal mechanisms of action.[127] Cotton growers are relying on more diverse weed management systems that include chemical, cultural and mechanical controls, while still including glyphosate as part of those systems.[128] Beginning in 2018, farmers, notably in North America, have the option of using glyphosate-tolerant seed plus other active ingredients, such as dicamba, glufosinate and 2,4-D.

In both North America and globally, GM HT crop adoption levels have remained steady in recent years, indicating that farmers continue to derive important economic benefits from using the technology.[129] In 2021, cotton and corn farmers used glyphosate on 83%[130]and 41%[131] of their acres, respectively, while in 2020, soybean farmers used glyphosate on 78% of their acres.[132] Through industry initiatives, such as the Take Action platform, Bayer provides farmers the resources they need to adopt weed management practices.[133]

In other regions, Bayer partners with industry organizations to promote IWM strategies. For example, in Australia, Bayer works with CropLife Australia to train farmers on how to manage weed resistance. Australia experienced glyphosate resistance in horticultural (vines, tree crops and vegetables) and non-cropping situations (e.g., airstrips, railways, firebreaks, fence lines, roadsides, driveways, irrigation ditches and around sheds).[134]

Responsible Business Conduct

Product Stewardship at Bayer

Bayer has adopted a life cycle approach that addresses all major aspects of responsible product management. Bayer Product Stewardship activities include: investing in safety and quality testing of our products and services; understanding and maintaining compliance with regulatory requirements; facilitating trade and commodity; marketing; continually improving development, manufacturing, distribution, and crop production techniques; promoting responsible product use; and implementing initiatives against production, import, trade and use of counterfeit and illegal products and services.

As part of its life cycle approach, Bayer created a Product Stewardship Commitment, Principles and Key Requirements regulation. The regulation addresses the product life cycle for all our agricultural products and services worldwide, including all seeds and traits, biologics and crop protection products, such as glyphosate, as well as services in the Bayer portfolio. Below are some of the specific requirements Bayer upholds related to crop protection products:[135]

- Residue trials for crop protection products will be conducted in accordance with national and regional regulatory requirements prior to marketing. These tests must – at the minimum – be in accordance with Codex Alimentarius and FAO guidelines on good analytical practice and crop residue data in order to provide a basis for establishing appropriate maximum residue limits.

- In countries where there are no specific requirements for labelling, crop protection products will be labelled in accordance with the Global Harmonized Systems Codes (GHS) and the FAO Guideline on Good Labelling Practice of Plant Protection Products.
- Containers for crop protection products that can be easily opened by children or are likely to attract the curiosity of children will not be used.
- Containers for products intended for or supplied to the general public will not have a presentation or a design similar to that used for foodstuffs, animal feed, or medicinal or cosmetic products, which could confuse consumers.
- Statements on intrinsic product safety for crop protection products will generally not be made in advertising or promotion.
- Marketing of crop protection products adheres to applicable global, regional and local industry codes, and materials are designed to be understandable, clear and consistent to avoid creating misunderstandings by buyers or users.

3. Glyphosate's Contribution to Sustainability

Environmental Benefits

As discussed earlier, agriculture alters the environment to produce food. And, while it might sound counterintuitive that a crop protection product provides environmental benefits, this is the case with glyphosate. Two of the most important environmental benefits enabled by glyphosate are its role in facilitating conservation tillage and its ability to control invasive species.

Conservation Tillage

In the last 150 years, 50% of the Earth's topsoil has been lost due to erosion. Plowing (tilling) – a common weed control practice – disturbs the top layer of the soil, which is essential for growing plants, causing its erosion. Glyphosate facilitates the adoption of conservation tillage practices, which protect and enrich the topsoil, when used with conventional as well as with GM crops. Instead of (or, in some cases, in addition to) plowing, glyphosate is used to kill weeds or cover crops, leaving the plant residue on the ground as a protective layer.

In Europe, where GM crops are not cultivated, conservation tillage is practiced with conventional crops. Spain, France, Italy, Germany, Slovakia, Romania, Poland, and the UK have more than 250,000 hectares of cropland managed under conservation tillage, with most countries in Europe also practicing conservation tillage in orchards and vineyards. Spain, for example, has approximately 1.3 million hectares of orchards and vineyards managed under conservation tillage.[136]

The cultivation of GM crops has greatly facilitated the adoption of conservation tillage practices. The association between conservation tillage and HT crop adoption is strongest for soybean, cotton and sugar beet. An analysis of the relationship between conservation tillage and glyphosate-tolerant soybean adoption found that adoption of glyphosate-tolerant soybeans has a direct positive influence on the adoption of conservation tillage practices. A 2012 USDA Agricultural Resource Management Survey found that approximately 97% of soybeans grown in the U.S. were herbicide tolerant and 70% of U.S. soybean growers practiced conservation tillage.[137]

Conservation tillage provides many well-documented benefits to farmers, the public and the environment overall, from savings in fuel and labor costs to reduced soil erosion, increased wildlife habitat, and improved water and air quality.[138]

Soil Health

Conservation tillage is key in preserving soil health. Glyphosate enables low-till and no-till farming practices that minimize the disruption to the soil. In turn, the reduced level of soil disturbance enhances biological activity within the soil and reduces the potential for erosion. Glyphosate also makes it easier for farmers to use cover crops, which not only sequester carbon, but also preserve soil health and fertility, and reduce erosion and compaction. The utilization of crop residues in no-till farming drastically increases water infiltration and retention by the soil, meaning there is less runoff and more soil moisture available for the crop.[139] Tillage also causes widespread soil disturbance that can lead to erosion and topsoil loss, impacting the sedimentation and turbidity of streams. In fact, the U.S. EPA has identified sediment as the second most important cause of impairments of assessed rivers and streams. Gianesi and Reigner estimated that reverting to tillage practices commonly used prior to the introduction of glyphosate-tolerant crops would release 356 billion pounds of sediments into streams and rivers, and result in an estimated $1.4 billion in downstream damage associated with water treatment costs and possible dredging.[140]

The use of conservation tillage practices, in tandem with glyphosate and glyphosate-resistant crops, also reduces soil erosion from wind and water. For example, the heavily farmed Upper Mississippi River basin

in the U.S. has experienced reductions in wind erosion by 64% and water erosion by 61% since the widespread use of glyphosate-resistant crops and conservation tillage.[141] Additionally, the adoption of no-till practices has enabled U.S. wheat farmers to conserve soil moisture to make possible a rotation with more profitable crops. Crop residue shields the soil surface from erosion caused by heavy rains and allows more water to soak into the soil. The conserved soil moisture can be used to produce a more lucrative second crop, such as corn. No-till planting of wheat reduced erosion by 90%-95%.[142] Glyphosate can be used in sustainable farming practices that are promoted in the EU Soil Strategy for 2023, such as cover cropping, crop rotation, reduced tillage and even reduced chemical inputs through a targeted use.

Carbon Sequestration and Reduction

The organic crop residue left in the soil as a result of conservation tillage increases the amount of organic carbon stored, or sequestered, in the soil and reduces CO2 emissions into the environment.[143] Aggregate estimates of soil carbon sequestration levels between 1996 and 2020 suggest that the amount of soil carbon sequestered since 1996 has been equivalent to 93,745 million kg of carbon or 344,044 million kg of carbon dioxide that has not been released into the global atmosphere, equivalent to taking about 228 million cars off the road over this period.[144]

Conservation tillage also reduces carbon emissions on the farm. Traditional tillage practices require sometimes as many as five passes over the land with a plow; however, no-till requires just a single pass (to plant seeds). A Purdue University report calculated that a farmer planting GM crops and implementing conservation tillage can save 225 hours of labor per year for a 500-acre farm; the equivalent of four 60-hour work weeks saved in a year.[145] The fuel savings arise from making fewer insecticide applications with the use of GM insect resistant (GM IR) crop technology in maize, cotton and soybeans (in countries where farmers previously used mechanical forms of application) and the switch from conventional tillage to reduced tillage or no tillage systems facilitated by GM HT crops. These have delivered permanent savings in carbon dioxide emissions. In 2020, the fuel related savings were 2,330 million kg of carbon dioxide, arising from reduced fuel use of 948 million litres. These savings are equivalent to taking 1.68 million cars off the road for one year. [146] Over the period 1996 to 2020, the cumulative permanent reduction in fuel use has been about 39,147 million kg of carbon dioxide, arising from reduced fuel use of 14,662 million litres. This is equivalent to taking 25.9 million cars off the road for a year. [147]

The estimates described above assume that no-till or reduced till practices were in continuous use of the course of 25 years that the data spans. Based on this assumption, aggregating these soil carbon savings with the fuel related savings referred to earlier puts the cumulative carbon dioxide savings for the period 1996-2020 to be between 107,959 million kg and 314,372 million kg, or equal to removing between 72 million and 209 million cars off the road for a year.[148]

Biodiversity

Crop residue in conservation tillage systems increases wildlife cover. The general rule is that the greater the amount of crop residue a tillage practice leaves on the surface, the better the practice is for birds and small mammals.[149] In addition to providing essential habitats and resources to other non-target species, it leads to increased biodiversity during post-harvest periods. Fields that are not tilled have a greater diversity and a higher density of birds and nests than reduced-till or conventionally tilled fields.[150] Conservation tillage reduces disturbance enough to have a positive influence on nesting birds, because of the low frequency of disturbance.[151]

Invasive Species Management

Non-native invasive plants are responsible for destroying natural habitats for native plants and wildlife and reducing biodiversity. They multiply quickly, spreading over extensive areas, and are difficult to control. They are also expensive to manage. For instance, in Florida's conservation lands alone, the cost of managing invasive plants was approximately $45 million in 2009-2014, according to research conducted by scientists at University of Florida, The Nature Conservancy and The Environmental Defense Fund.[152] Glyphosate is an indispensable option for land managers who need to control invasive weeds in water and on land and is an aid in restoring native habitats, due to its efficacy, low potential for adverse impacts and ability to reduce labor requirements.[153]

Alternative control methods can't provide the same level of control as glyphosate. The Ojai Valley Land Conservancy (OVLC) in California is tasked with controlling Arundo (*Arundo donax),* an invasive species

widespread in the Ventura River watershed, which provides clean water to residents and farms. Arundo poses a threat to the Ventura River watershed by consuming excessive amounts of water, posing a major fire hazard, clogging flood control channels and destroying native habitat.[154] Arundo biomass also is frequently washed off on coastal beaches, where public agencies spend an estimated $197,000 per year on removal.[155] OVLC tried other methods to control Arundo, such as goats, hand removal and solarization (placing thick black plastic over plant stumps), but they are not practical due to low effectiveness and negative side effects, including erosion, destabilizing stream banks, removing native vegetation, and further infestation.[156] Glyphosate is the only effective method for controlling Arundo.

In another study at Medicine Lake National Wildlife Area in Montana, targeted glyphosate applications effectively controlled Canada thistle while allowing biomass of shrubs, forbs and other desired plant species to increase and expand waterfowl habitat.[157]

Glyphosate is often the herbicide of choice when dealing with invasive species such as kudzu, poison ivy and poison oak, purple loosestrife, pampas grass and many aquatic weeds. For example, in Australia's Northern Territory, glyphosate plays a key role in fighting gamba grass (Andropogon gayanus), one of the most aggressive invasive weeds in the Australian tropics. Gamba is an African pasture grass that was imported as feed for cows because it grows taller than native species. But if the Gamba goes uneaten and wildfires occur, it fuels much hotter fires. Research has shown that the season of severe fire weather increased by six weeks while fire management costs were nine times higher, in part due to the presence of overgrown gamba.[158] The only herbicide able to control gamba is glyphosate. In fact, the Northern Territory has given landowners free glyphosate for 10 years to help with mitigation efforts.[159]

Sustainability Commitment: Crop Protection Environmental Impact Reduction

Being intentional about crop protection's role in creating a more sustainable agricultural system is an important step in driving improvements. As part of our commitment to significantly reduce the environmental impact of our crop protection portfolio, Bayer has set a target to reduce the environmental impact of our global crop protection portfolio per hectare by 30% by 2030 against a 2014-2018 average baseline.

To estimate the environmental impact of crop protection products, Bayer adopted a methodology for crop protection environmental impact reduction (CP EIR) that factors in the potency of the substances used and the emissions released into the environment through their use.[160] Applying CP EIR allows Bayer to go beyond looking at volumes per hectare by also taking into account other variables, such as the environmental profile of the crop protection product and the emissions into the environment. One indication of this is that, while the total global volume of crop protection sold has steadily increased, the average amount of active ingredients applied per hectare has decreased. This overall volume increase is due to greater food demand, stemming from a growing world population, whereas the decreased volume applied per hectare is the result of innovations to improve the efficacy and reliability of crop protection products. These innovations have led to the ability to use less product for the same level of control and, in many cases, the use of active ingredients with better environmental profiles, such as glyphosate.

Using the CP EIR methodology, assessments show that, despite our strong global market position, Bayer products only account for 2% of the environmental impact from crop protection in 2021.[161] While this measurement is encouraging for our business, it only makes us more determined to further reduce our portfolio's impact and lead the change in transforming the level of impact for the entire industry.

Based on the data collected between 2018 to 2022, Bayer has reduced the treated-area-weighted environmental impact per hectare of our global crop protection portfolio by 12% against the 2014 – 2018 baseline. The reduction was mainly the result of changes in our crop protection product portfolio in recent years. For the reporting period 2017 to 2021, we must restate our progress as 11% as opposed to the previously reported 14%, due to model enhancements and newly identified data corrections.[162] The use of glyphosate, next to other products in our portfolio, has been a key contributor to this reduction based on its favorable profile and the environmental benefits its use enables, such as conservation tillage and soil health, mentioned previously.

We are proud to be the only company within our industry to make such a measurable commitment across the entire crop protection portfolio with publicly available models. More information about the CP EIR methodology and impacts is available in our Crop Science Sustainability Progress Report.

Glyphosate's Systemic Role in Preserving Food Security

Due to its widespread adoption, glyphosate plays a systemic role in today's food system. Limiting the availability of glyphosate-based products would result in significant impacts on food production and, as a result, on food availability and affordability.

At the EU level, phasing out glyphosate in wheat production would translate into an increase of costs for the sector of up to EUR 10.5 billion, resulting from both reduced agricultural output (and therefore revenue) and higher production costs.[163]

In 2021, HT GM crops were planted in 27 countries,[164] up from three countries in 1996.[165] A study published in 2017 estimated the impacts that would arise if restrictions on glyphosate resulted in the world no longer planting glyphosate-tolerant GM crops. The countries with the largest cultivated areas are in North and South America. Farmers who grow GM crops see increased yields and reduced production costs. In South America, the adoption of GM crops has shortened the cropping time of soybeans, making it possible to grow a second crop (such as soybeans after wheat) in the same season. Globally, farmers would be the first to notice the impact of a ban on glyphosate, with a projected $6.76 billion annual loss of farm income gains.[166] In addition, the increases in global production of three key commodities – soybeans, corn and canola – achieved through the cultivation of GM crops, would be lost by significant amounts. Argentina would be expected to see 55% of annual production losses in soybeans; Brazil would see the greatest losses in corn; and Canada in canola.[167]

The global production of soybeans, corn and canola would be estimated to fall by 3.7%, 0.6% and 0.7%, respectively. World prices of all grains, oilseeds and sugar would be expected to rise, especially soybeans (+5.4%) and canola (+2%).[168]. The global production of coarse grains (mainly corn) would be expected to drop by 0.6%. In the U.S., corn production would be expected to drop by 2.3%, in Brazil by 0.8% and the rest of South America by 1.6%.[169] Drops in production would be expected to result in crop price increases. Globally, the price of soybeans would be expected to increase more than other crops by 5.4%[170]. Global prices of canola, palm, other oil seeds and coarse grains would increase by 2%, 0.9%, 1.1% and 1.4%, respectively. The global prices of rice, wheat, sugar crops and other crops would increase by 0.5%.[171] Price increases would be highest in the U.S., Canada, Brazil and other South American countries.

The study estimates that the loss of HT GM technology would negatively impact welfare by raising crop production costs, reducing crop yields in almost all regions, and influencing trade. Global welfare would be expected to fall by $7,408 million per year, with the largest losses in the U.S., South America and Brazil.[172] The countries with highest welfare losses would be China, the U.S., the EU, South America and Japan, with welfare losses of $2,143 million, $1,870 million, $933 million, $768 million and $651 million, respectively, per year.[173]. Among these regions, China, the EU and Japan would lose welfare because the terms of trade would change against them (due to their high reliance on imports that would become more expensive). The U.S. and South America would gain due to changes in the terms of trade (higher world prices) but would experience total welfare losses because of losses in the efficiency caused by shifting away from HT GM technology to conventional production technology.[174]

Socioeconomic Benefits for Farmers

In addition to its agricultural and environmental benefits, glyphosate is enabling positive socio-economic benefits for farmers around the world. These include reduced labor costs, higher yields and improved return on investment. In developing regions of Africa and Asia, glyphosate use supports the advancement of agriculture and improved quality of life, providing considerable labor savings compared to mechanical weed-control methods. For regions of North and South America that adopted glyphosate-tolerant crops, glyphosate replaced several other herbicides, lowered the cost of weed management, reduced the amount of labor needed to manage weeds in these crops, and increased off-farm household income.[175] In Europe, glyphosate is used with a wide range of crops, including with no-till farming.

Glyphosate Use in North and South America

Farmers in both North and South America adopted glyphosate-tolerant crops because they reduced farm household labor requirements and enabled an increase in off-farm income. Farm incomes for those using the technology have increased by $261.3 billion between 1996-2020. Of these increases in income, 72% have come from yield and production gains and the remaining 28% from cost savings. In terms of investment, for each extra dollar invested in GM crop seeds versus conventional seed, farmers gained an average $3.76 in extra income in 2022. Also, in 2020, if conventional production systems were used instead for the four main GM crops, an additional 23.4 million hectare of land would need to be planted to these crops.[176]

Since the introduction of HT corn, this technology has contributed $20.2 billion cumulatively to farm incomes.[177] In 2020, HT corn delivered $1.55 billion to farm income. HT soybeans in 2020 accounted for $4.1 billion of farm income. Since the introduction of HT soybeans in 1996, this technology has accounted for $57 billion in cumulative farm income. HT cotton varieties produced $134.8 million in farm income for 2020 and $2.53 billion in cumulative farm income since their introduction. HT sugar beet produced $77.3 million in farm income in 2020 and has produced $755.3 million since its introduction in 2008. At the country level, U.S. farmers have been the largest beneficiaries of higher incomes, realizing $11 billion in extra income between 1996 and 2020.[178]

Glyphosate use has been associated with improved profitability for farmers. For example, the average soybean farmer with 517 acres reduced their labor requirements by 14.5% by adopting herbicide tolerant soybeans.[179] This reduction resulted in a total reduction of 94.5 hours of labor per growing season, allowing the extra time to be devoted elsewhere, including off-farm employment.

It is worth noting that the onset of tort litigation in the U.S. did not raise concerns among growers regarding the safety of the product. In 2018, Bayer surveyed 704 U.S. growers and learned that the majority (75%) had positive perceptions of the Roundup Brand, 22% were neutral and only 3% had negative perceptions. Of those with negative perceptions, only one respondent had safety concerns about glyphosate causing skin irritation.

In South America, growers benefited from an increase in income of $7.64 billion in five years since the adoption in 2013-2014 of GM and insect-resistant soybeans.[180] For every extra $1 spent on GM seed relative to conventional seed, farmers gained $3.88 in extra income. These income gains resulted from a combination of higher yields and lower costs of weed and pest control.[181] In the 2020-2021 crop year, HT biotech crops accounted for 99.8% of soybeans in Argentina and 98% of soybeans in Brazil.[182] In addition, the technology has helped South American farmers adopt reduced-till and no-till production systems. These have shortened the time between planting and harvesting, allowing them to produce an additional soybean crop after wheat in the same growing season.

In addition to the positive impacts when used with GM crops, it should be noted that North and South American growers of non-GM crops also have seen benefits from using glyphosate in orchards and vineyards, and with wheat and sugarcane.

Glyphosate Use in Asia-Pacific

Glyphosate is one of the most widely used herbicides in Asia-Pacific to prepare fields for planting as well as to control weeds. While some farms in Asia-Pacific countries still rely on hand and mechanical weeding to a significant extent, rural regions are experiencing a depleted agricultural workforce as populations migrate to more urban areas. Having access to effective herbicides like glyphosate is critical to offset labor shortages and still produce enough food.

Herbicides dominate weed-control practices in all crops in China, Thailand and Vietnam, but are less prevalent in India, Indonesia and the Philippines, where mechanical weeding is still practiced. In these latter countries, herbicides tend to be used more widely in commercial crops and less in subsistence crops. For example, herbicides are used on about 30% of the total corn crop in the Philippines, where only about one-third of the crop is commercial.[183] In countries where herbicides are used for weed control, glyphosate is one of the most important and widely used active ingredients.

As some countries in Asia take steps towards restricting the use of glyphosate or mandating that glyphosate only be applied by licensed operators, growers are expected to face higher weed-control

costs and likely lower yields. Data indicates that restricting glyphosate use in these countries would lead to increased use of alternative herbicides and additional manual and mechanical weed-control methods that would cost farms between $22-$30 per hectare and increase weed-control costs by $1.4 billion to $1.9 billion per year.[184] Indian rice and tea farmers, for example, would see a 17%-19% increase in weed management costs as well as an 18%-19% decrease in yields if they had to switch to other herbicides.[185]

If the use of glyphosate were to be prohibited in land preparation in Asia-Pacific, the following are likely to occur in several crops:

- Land preparation for sowing and planting of crops is expected to be poorer, as glyphosate is a key input for delivering prime conditions for sowing and planting of seeds in a weed-free environment, and it is more effective at controlling a broader range of weeds than some alternatives (e.g., paraquat, where this is permitted for use).
- Land preparation costs are expected to increase because the main alternatives to glyphosate (herbicides and/or mechanical or hand weeding) are commonly more expensive.
- The length of time for which effective weed control is maintained may decrease, requiring additional weed-control activities (e.g., additional applications of other herbicides, such as paraquat or glufosinate, cultural practices, hand weeding, mechanical weeding, and additional burning, notably in Indonesia and Philippines).
- Yields may decrease as a result of poorer levels of weed control (e.g., higher levels of pests and diseases vectored by aphids and nematodes harbored in summer fallow weeds).
- Some of the benefits associated with reduced-till and no-till systems may be lost. As previously discussed, glyphosate is widely considered to be a key component to the successful adoption and maintenance of reduced-till and no-till systems, which have enabled many farmers in grain growing regions and in places where GM HT crop technology has been adopted to reduce their fuel and labor costs at seeding time, improve soil conservation (less erosion) and better manage soil moisture levels.
- For the immature and mature phases of production of important Asian crops, like tropical fruit, vines, sugarcane, rubber, palm oil, tea and coffee, the expected impacts of restrictions on glyphosate use are similar to those of the land preparation phase, with increased cost of weed control, reduced effectiveness of weed-control measures, lower yields and more pest and disease problems.

These effects have already been observed in parts of Asia. For example, the Sri Lankan government's decision to ban chemical fertilizers and pesticides in 2015 led to a drastic decline in rice harvest. As a result, Sri Lanka was no longer self-sufficient in its most important staple food and was forced to spend $450 million on rice imports. The decline in tea production alone, by far Sri Lanka's most important export crop, is estimated to have caused economic losses of $425 million. The livelihoods of those employed in agriculture (about 30% of the population) were severely affected by the ban, in the absence of a suitable alternative to glyphosate. Smallholder farmers saw the biggest impact: Over 94% of smallholder corn farmers reported a reduction in family income and 40% reported a reduction in corn yields. Similarly, 40% of tea farmers reported a reduction in family income and an 11% decline in tea production in 2016, just one year after the ban on glyphosate as well as a ban on synthetic fertilizers was introduced.[186] In light of the negative impacts on the nation's economy, the Sri Lankan government reversed the ban in 2018.

Glyphosate Use in Europe

In Europe, glyphosate-based products have been used safely for nearly 40 years. They still play a critical role in both IWM and sustainable agriculture, helping farmers implement effective and environmentally friendly practices, such as reduced-till and no-till farming. Glyphosate is being used in a broad range of crops: wheat, barley, sugar beet, corn, grape wine, olives, and fruits and vegetables. A ban of glyphosate in the EU would have a significant impact. In wheat, studies show yield reductions by 8%-18%, which translates into a decline in production by up to 24 million metric tons. For the EU sector, this could result in up to EUR 10.5 billion in production costs.[187] Grape production would decrease by up to 4.7 million metric tons, resulting in up to EUR 4,2 billion in production costs.[188] A survey conducted among Italian farmers in 2017 forecasts a 20% yield reduction for corn, corresponding to a loss of revenues of EUR 494 per hectare.[189] With approximately 660,000 hectares for corn in 2017, the loss would be of about EUR 326 million. For durum wheat, the loss would be of 33% yield and corresponding revenue decrease of EUR 399 per hectare. With approximately 1.27 million hectares for durum wheat in 2017, the loss would be of about EUR 506 million.[190] It is estimated that without glyphosate, production of potatoes in the EU could decline by up to 10.4 million tons. At the EU level, phasing out glyphosate in potato production would translate into an increase of costs for the sector of up to EUR 2 billion, resulting from both reduced agricultural output (and therefore revenue) and higher production costs.[191]

This reduction in production of basic food commodities would also have implications for the EU's self-sufficiency.[192] Without glyphosate, many existing production systems, practices and rotations would no longer be viable. Increased tillage practices required to replace glyphosate would increase fuel consumption per hectare, resulting in an increase in greenhouse gas emissions.[193]

Glyphosate Use in Africa

Africa experiences weed challenges year-round, especially in tropical regions, where weeds grow more vigorously and regenerate more quickly because of the heat and higher light intensity. If left uncontrolled during critical periods, crop yield losses can be staggering, sometimes reaching 90% of potential yields for some crops.[194] Smallholder farms in Africa still rely heavily on hand weeding, typically spending 50%-70% of their labor time pulling, slashing and hoeing. [195] Women contribute more than 90% of the hand-weeding labor for most crops, and children are often forced to miss school during the peak weeding period to assist.[196] As populations migrate from rural to more urban areas, these smallholder farms have faced added labor shortages.

Effective and safe chemical weed-control tools like glyphosate provide an important lifeline to small and large African farms. A recent review of pesticide use data for 14 African countries indicates that glyphosate makes up over 58% of the combined volumes of all herbicides used in these countries in 2020; in some countries, this can be as high as 85%, used mostly on crops of strategic economic or food security importance.[197] Corn farmers are by far the biggest users, with almost half of all glyphosate sold in South Africa in 2012 applied in corn fields. Wheat farmers were in second place with 13% of total glyphosate use, and soybean farmers in fourth place with 6%, behind industrial glyphosate use (8%).[198]

The majority of South African farmers using HT technology indicated the main benefit of using an HT crop in combination with a broad-spectrum systemic herbicide (such as glyphosate) is the ease of weed control and management. To a large extent, this was also indicated by farmers using glyphosate on conventional or transgenic crops. Farmers indicated that because pre-plant burn-down can be done efficiently, they are able to plant at the right time, resulting in higher yields. For post-emergence weed control, HT-crop farmers also indicated that weed control could be done at the right time and more effectively, without worry about weed control in wetlands or application of several selective herbicides throughout the rainy season.

A study assessed potential yield losses in corn, wheat and soybeans, should glyphosate be removed or reduced in the South African agricultural system. In total for these three main crops, the value of glyphosate in the 2012-2013 production season was estimated to be between R796 million and R3.381 billion (i.e., between 1.9 and 8.2 times the value of the glyphosate used in the production of these crops).[199] This assessment only focused on the direct farm-level impacts (yield and cost of production practice changes) and did not take into consideration the impact of decreased crop production on the rest of the economy. For instance, a decrease in corn production due to a lower yield would have led to decreased foreign currency earnings from decreased exports, as South Africa is a surplus corn producer.

Decreased wheat and soybean production would have led to foreign currency outflows, as South Africa would need to import more of these products to meet their needs. The economic impact of the potential foreign currency loss, taking into consideration the direct and indirect economic multiplier effects, would be considerable. Under a "no glyphosate" scenario with yield loss assumption of 5%, consumers would have lost R45 million and under a possible 15% yield loss, R189 million.

Studying smallholder farmers in northern KwaZulu-Natal, researchers found that farmers who plant HT maize seed and use a no-till practice, while controlling weeds with a post-emergent glyphosate application, enjoyed a yield increase due to more effective weed control and saved considerably on weeding labor.[200]

HT maize was particularly popular in households headed by female farmers. Over a three-season period, farmers planting conventional and Bt maize and controlling weeds by hand and hoe spent 19, 17 and 21 days (7-hour days) per hectare on weed control. On average, 59% of this manual weeding was done by female household members and 9% was done by children younger than 16. In contrast, most HT adopters did not do any manual weeding. By using HT maize and applying glyphosate post-emergent, smallholder farmers in KwaZulu-Natal were able to save substantially on weeding labor, with female farmers and other female household members benefitting the most. On average, in HT maize-adopting households, females were able to spend 11 fewer days per hectare on weeding than their conventional and Bt maize planting counterparts; males saved six days and children saved two days.[201]

Male farmers and male household members planting glyphosate-tolerant maize were able to spend more time tending to cattle and goats, or on off-farm income-generating activities, like building, woodwork, "piece jobs," hunting or pursuing permanent employment. Female farmers and female household members in HT-adopting households spent most of their extra time doing housework and working in their own, or a community, vegetable garden – a possible food security impact if they had to reallocate those hours to the farm. Children spent more time relaxing and doing school homework or chores.[202]

In a study in Ghana, 40% of farmers indicated herbicides permitted large areas of land to be cleared with 37% of labor and time savings, hence being less costly.[203]

Losing glyphosate as a vital tool for agriculture could have significant impacts on food security and livelihoods in Africa, not to mention the likely impact on conservation farming in the face of worsening climate crises and the need to adopt climate-smart agriculture.

4. Commitment to Transparency at Bayer

Bayer has made a commitment to enhancing our corporate transparency efforts with our stakeholders. Some of these efforts include: supplying detailed disclosures on materials, project expenses, research activities, regulatory study reports and collaborations; establishing advisory bodies; and engaging in dialogue with customers and stakeholders. We rely on these regular, constructive and transparent engagements to recognize important trends and developments in society and our markets at an early stage and take this information into account in how we conduct business.

Trust and Transparency

Science and innovation have transformed health and nutrition around the world. In our work, science has allowed us to develop products that can support farmers as they seek to provide enough food for the world. While the science behind modern agriculture is held to rigorous standards, information about how companies test and develop new products has not typically been accessible to the public.

As such, Bayer has made a commitment to continually enhance our corporate transparency efforts throughout many facets of our business, including: [204]

- We have made study summaries concerning the human and environmental safety of many of our active substances that have been evaluated by the European Food and Safety Authority (EFSA).[205]
- Full study reports are available upon request.
- The full 2020 glyphosate dossier is accessible via the website of the Glyphosate Renewal Group (GRG).[206]
- We increase transparency and visibility of our innovative research activities within the external scientific community through our Science in Spotlight platform, listing peer-reviewed scientific publications authored by Bayer employees.
- To generate more transparency around our scientific collaborations, we launched the Bayer Science Collaboration Explorer in 2021. In this publicly accessible database, we disclose information on new contract-based scientific collaborations with universities, public institutions and individuals. Data on collaborations in Germany and the U.S. is currently available. Additional countries will follow.
- We make detailed disclosures on material and project expenses and headcount of the essential political liaison offices in the transparency registers of the European institutions and the U.S. Congress. We also report data for countries in which there is no legal disclosure obligation.

Innovation is at the core of our purpose: "Science for a better life." Emerging life science technologies are advancing rapidly and deliver the opportunity for disruptive positive impact on society, people and the environment. Bayer is committed to using emerging technologies in an ethically responsible way within our business and research and development activities. We seek to actively take part in the development of bioethical standards, to engage with society and relevant stakeholders, and to address potential concerns.

Advisory Bodies

In the spirit of improved two-way communication, Bayer seeks guidance and perspective on our R&D and sustainability efforts from these advisory bodies:

- We have established an external advisory body – the Bioethics Council – to ensure a broad independent perspective and guidance on complex ethical questions related to emerging life science and crop science technologies. The Bioethics Council will consist of a diverse group of leading experts in the field of bioethics who will engage in regular dialogue with Bayer executives.
- We have established an independent external Sustainability Council[207] that advises the Board of Management and performs other functions on sustainability initiatives, provides guidance on the

contribution that Bayer can make with its research and development, and independently examines the progress made by Bayer in the implementation of its sustainability targets.[208]
// Additionally, our Supervisory Board, the highest internal governance board of the company, has established a dedicated ESG (Environmental, Social and Corporate Governance) Committee,[209] which focuses on corporate social responsibility and the environmental, social and corporate governance elements of the company's business activities.

Transparency with Regulators

To encourage and welcome a science-based discussion with the international research community, consumers and other interested parties, hundreds of glyphosate safety study summaries and reports that were submitted to EFSA as part of the EU re-approval process are now accessible online. This effort was led by the GRG, a collection of companies, including Bayer, that have joined efforts to prepare a single dossier to support the renewal of the EU approval of glyphosate.[210]

The GRG website makes the following information available to the public:
// The minutes of the meetings with regulatory bodies involved in the re-assessment of glyphosate (i.e., EFSA, and the Assessment Group on Glyphosate (AGG): The Assessment Group consists of the regulatory authorities of four European Member States: ANSES (France), Nebih (Hungary), CTGB (the Netherlands) and KEMI (Sweden)).
// The application for the glyphosate renewal, including the list of new studies to fulfil current regulatory requirements as well as the feedback correspondence on the application from the AGG.
// The public part (i.e., except confidential business information) of the re-approval dossier submitted in 2012.
// Full study reports, submitted at the time, and where the GRG has access and disclosure rights, are accessible via a simple online ordering procedure (with the minor exception of documents containing confidential, production-related information that is not safety-relevant).
// The entire public part of the 2020 glyphosate dossier, including new study reports (with the minor exception of those documents containing certain production information that is not safety-relevant)

Many of these and other similar studies were submitted to and evaluated by the U.S. EPA during its most recent risk assessment of glyphosate. Links to scientific safety studies on our glyphosate products may be found online.[211] The site also includes a compilation of the EPA's conclusions and analyses of the scientific evidence relevant to glyphosate safety as well as the agency's discussion of the conclusions reached by other foreign and international regulatory agencies.

Engagement with Stakeholders

We seek common ground with critical stakeholders and listen carefully to diverse points of view and engage in thoughtful dialogue. This requires that all engagements and communications be truthful and transparent. We respect the independence of journalists and media representatives. Our interactions with media are governed by the Bayer Societal Engagement (BASE) principles, set out in a publicly available Board of Management-approved group regulation, which establishes how we interact worldwide, not just with our employees, but also with patients, customers, consumers, business partners, political stakeholders, scientists, critics and our stockholders. In this way, we want to live up to our social responsibility as a sustainably acting and transparent company that is respected for its contribution to progress in healthcare and agriculture. We want to listen, understand, take concerns seriously and engage in respectful dialogue – especially where this is difficult or uncomfortable. This means that we engage openly and transparently with media and provide accurate information. Sometimes a scientific article makes claims or provides new information that merits a response or further enquiries, or it may be the origin of a media report where journalists approach Bayer for comment. They have often raised their concerns about crop protection products and have questions about the impacts on the environment, farmers and consumers. Some critics continue to repeat broad claims without additional substantiation. Although we cannot provide comprehensive responses to all unsubstantiated claims, we try to engage in a scientific and constructive dialogue whenever we can. Our scientists assess new studies and reports and their methodologies thoroughly on their scientific merit, and we aim to provide science-based answers to the questions they raise.

Ongoing dialogue with our farmer customers and related value chain stakeholders is vitally important to us. After all, their needs, expectations and viewpoints affect our credibility, reputation and public acceptance and thus our commercial success. Dialogue that is regular, constructive and transparent helps us to recognize important trends and developments in society and our markets at an early stage and take this information into account when shaping our business. In strategic decision-making processes that demonstrate our commitment to governance, stewardship, and responsible use practices, Bayer proactively approaches our customers and key social and political players right from the start of a new project. Such open dialogue modeled on industry leadership and transparency enables us to identify opportunities and address any perceived risks early on. This process is in line with our Stakeholder Engagement Guidelines and is supplemented by an internal information platform.

Conclusion

This report is intended to improve transparency on the topic of glyphosate and to provide a holistic overview of questions surrounding glyphosate through a sustainability lens. Glyphosate plays a critical role in modern agriculture, making it possible to safely, sustainably and reliably feed a growing global population. Farmers around the world have experienced significant socio-economic benefits with the use of glyphosate. And, while every agricultural technology has some impact on the environment, glyphosate is known for its favorable safety profile and has the potential to make agriculture more sustainable. Regulatory agencies around the world also have determined repeatedly that there are no risks to human health from the current registered uses of glyphosate.

Bayer recognizes the power of transparency in addressing controversial topics and we are committed to ongoing dialogue and transparency. We hope that this report has answered our stakeholders' need for a balanced review of the topic.

Endnotes

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