Background

Phasing Out Glyphosate for the Benefit of Humanity and Biodiversity

Retrospect:
In 2002, a 10-year authorization for the use of glyphosate in the EU was granted, a decision which was based on data supplied by the industry itself. A reassessment of this decision was scheduled to take place in 2012, but was delayed until 2015. A very controversial public debate began in 2015, after the International Agency for Research on Cancer (IARC) classified glyphosate as "probably carcinogenic to humans". However, a conclusive report issued by the European Food Safety Authority (EFSA) in November 2015 declared that glyphosate was "probably not carcinogenic". At this point, the public began to strongly doubt the impartiality of the authorities responsible for this decision.

Monsanto, the first company to market the herbicide glyphosate, had been in close contact with the agencies responsible for regulating pesticide usage in the US for years. In the EU, the official assessments made by authorities (such as the German Federal Institute for Risk Assessment) adopted passages from the companies' application forms almost word for word, but without acknowledging the fact. In late November 2017, at the decision-making meeting of the EU Standing Committee on Food Safety, Germany's approval secured the majority necessary to grant a five-year extension of the authorization of glyphosate, which will be in force until the end of 2022.

Re-Authorization:
The EU-wide authorization of this non-selective or "total" herbicide expires on 15 December 2022. Currently, more and more people from France, the Netherlands, Sweden and Hungary are making the case that glyphosate fulfils all requirements necessary to be re-authorized in the EU. The national safety authorities of these four countries sent a report containing a joint assessment to the European Food Safety Authority (EFSA) and the European Chemicals Agency (ECHA). The report concludes that glyphosate is neither genotoxic nor carcinogenic.

After a public hearing in September, the EFSA and ECHA will submit their recommendations on extending the authorization to the EU Commission. The EU Commission will formulate a draft regulation based on these recommendations, which requires the approval of the EU Council of Ministers to go into effect.

Background:
Glyphosate is the most commonly used active ingredient in weedkillers worldwide. Total herbicides containing glyphosate kill all plants that have not been genetically engineered to be resistant to it. This process directly destroys plant communities in the fields and thereby the habitat and food source for insects and vertebrates alike.

Glyphosate accounts for 33% of herbicides in the EU.[1] In Germany, it is used on about 31% of arable land and 4% of grassland area,[2] with comparable amounts used in neighbouring countries. Glyphosate is most commonly known under the brand name "Roundup", a Bayer-Monsanto product. Glyphosate residues can now be found in many waterways

[1] Antier et al., "A survey on the uses of glyphosate in European countries", *INRAE*, 2020, https://doi.org/10.15454/A30K-D531
[2] https://www.lfl.bayern.de/ips/unkraut/190980/index.php

and soils.[3] Residues of glyphosate and its breakdown product amino methyl phosphonic acid (AMPA) are also increasingly being detected in food and other products for human consumption, such as beer[4] or bread.[5] Other criticisms of glyphosate include the fact that it is suspected of being carcinogenic to humans.

Glyphosate and other herbicides do more than just eliminate weeds that are undesirable to farmers; they also cause many wild herbs in the agricultural landscape to disappear. Market pressures force the agricultural industry to continually look for the cheapest means of increasing yields – and glyphosate is the ideal product for this end. In the short term, the use of total herbicides seems more economical than using machines to till the land. But the downside is that the use of herbicides has adverse effects on the agricultural landscape as a whole by depleting the food sources available not only to bees, but also to insects and animals such as butterflies, skylarks and partridges. In the medium to long term, this has a negative impact on agriculture.

Extent of glyphosate use:

- Glyphosate is the most commonly used pesticide worldwide.
- About 35,000 tonnes per year are used in Europe.[6]
- The majority of this amount is used in southern European countries in fruit and vegetable production.
- In Europe, the herbicide is mostly used in fruit and vegetable production and viticulture (totalling around 40% of the herbicide's usage), followed by grain cultivation at about 20%. Other arable crops such as rapeseed, sunflowers and soybeans account for about 5% of glyphosate usage.[7]

How does glyphosate work?

- Glyphosate is a broad-spectrum herbicide that is absorbed through leaves. It acts "systemically", which means it is transported from the leaves to all parts of the plant including the shoots, seeds and roots. Glyphosate cannot be washed off and is not broken down by heating or freezing.
- It enters the soil directly when sprayed or via plant roots, and remains there for a period of time ranging from several weeks to a year after application, depending on the soil type and temperature.[8]
- Glyphosate blocks the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) in plants, which plays a central role in the synthesis of aromatic amino acids and other important elements via a metabolic pathway known as the shikimate pathway. If these amino acids and ingredients are missing, the plants die. Only plants that have been genetically modified to be resistant to glyphosate can survive, such as glyphosate-resistant soy. Microorganisms also possess a shikimate pathway. Glyphosate therefore also inhibits microorganisms whose EPSPS can be disrupted by glyphosate. This affects microorganisms in the soil as well as in the intestines of

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[3] Silva et al., "Pesticide residues in European agricultural soils – A hidden reality unfolded", 2019, https://www.sciencedirect.com/science/article/pii/S0048969718343420?via%3Dihub.

[4] https://www.oekotest.de/essen-trinken/Bier-Test-Glyphosat-Reste-in-jedem-dritten-Pils_111655_1.html.

[5] https://www.deutschlandfunk.de/glyphosat-rueckstaende-in-mehl-broetchen-und-haferflocken.697.de.html?dram:article_id=218620.

[6] https://www.lfl.bayern.de/ips/unkraut/192703/index.php.

[7] https://www.lfl.bayern.de/ips/unkraut/192703/index.php.

[8] Laitinen et al., "Glyphosate and phosphorus leaching and residues in boreal sandy soil", *Plant Soil* no. 323, pp. 267–283, https://doi.org/10.1007/s11104-009-9935-y.

animals, as a new study on the microbiome of rats shows.[9] In this way, glyphosate also enters the food chain at large.

- Similar adverse effects causing the alteration of the microbiome of bees have also been proven. The impact glyphosate has on bees marks an important difference between controlling weeds using glyphosate and doing so via tilling the land with machines, since the latter only removes weeds and not microorganisms. Glyphosate therefore damages biodiversity far beyond its intended range of effects.

Effects:

- Glyphosate residues can persist in food and feed for at least two years, and up to four years in products with a high starch content.[10]
- Glyphosate affects all leafy plants, destroying habitats and food sources for many animals and insects. Glyphosate therefore destroys biodiversity not only in plants, but also in animals and microorganisms.
- According to the German Environment Agency, the intensive use of highly effective broad-spectrum herbicides such as glyphosate inevitably leads to the impoverishment of plant life. Many bird species, such as skylarks, yellow buntings, or partridges, but also mammal and other animal species in the agricultural landscape, are significantly deprived of their basic source of nutrition.[11]

Glyphosate in the soil damages microorganisms and weakens trace mineral intake

- The entry of glyphosate into the soil affects the **soil microflora**. Microorganisms have two different forms of the EPSPS enzyme, one sensitive to glyphosate and one that is tolerant to it. Therefore, depending on which form they possess, microorganisms react insensitively or sensitively to glyphosate. The application of glyphosate alters the activity and composition of microbial communities.[12]
- If glyphosate has a negative impact on microorganisms, this can have an impact on the **breakdown processes** in the soil, the nitrogen balance or the provision of micronutrients. For example, rhizobiaceaea, which are crucial for the fixation of nitrogen in papilionaceous plants (legumes), are sensitive to glyphosate. Glyphosate is also suspected of promoting **resistance** to antibiotics in bacteria.[13]
- **Fungi** also react differently to glyphosate. Negative effects have been observed in species that support plant health, such as mycorrhizal fungi.[14] There is also increasing evidence that glyphosate promotes fusarium (a type of fungal mould) infestation in crops. Various studies suggest that the widespread use of glyphosate to control weeds is responsible for the increase in bacterial and fungal diseases.[15]

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[9] Mesnage et al., "Use of shotgun metagenomics and metabolomics to evaluate the impact of glyphosate or Roundup MON52276 on the gut microbiota and serum metabolome of Sprague-Dawley rats", 2021, https://ehp.niehs.nih.gov/doi/10.1289/EHP6990.

[10] EFSA, "Conclusion on the peer review of the pesticide risk assessment of the active substance glyphosate" *EFSA,* journal 13, no.11: 4302, 2015, https://doi.org/10.2903/j.efsa.2015.4302.

[11] https://www.umweltbundesamt.de/themen/boden-landwirtschaft/umweltbelastungen-der-landwirtschaft/pflanzenschutzmittel-in-der-landwirtschaft.

[12] Van Bruggen et al., "Environmental and health effects of the herbicide glyphosate", 2018, https://www.sciencedirect.com/science/article/abs/pii/S0048969717330279?via%3Dihub; Kremer, 2020, https://www.researchgate.net/publication/348159632_Impacts_of_Genetically_Engineered_Crops_on_the_Soil_Microbiome_Biological_Processes_and_Ecosystem_Services.

[13] Van Bruggen et al., "Environmental and health effects of the herbicide glyphosate", 2018, https://www.sciencedirect.com/science/article/abs/pii/S0048969717330279?via%3Dihub.

[14] Zaller et al., "Herbicides in vineyards reduce grapevine root mycorrhization and alter soil microorganisms and the nutrient composition in grapevine roots, leaves, xylem sap and grape juice", *Env Sci Poll Res,* 2018, https://doi.org/10.1007/s11356-018-2422-3.

[15] Martinez et al., "Impacts of glyphosate-based herbicides on disease resistance and health of crops: a review", 2018, https://link.springer.com/article/10.1186/s12302-018-0131-7.

- Studies also show effects of glyphosate application on the composition and activity of individual **bacterial species**. For example, the species *pseudomonas fluorescens* – which plays an important role in protecting the soil against fungal pathogens – is disturbed by glyphosate. Essentially, glyphosate seems to disrupt the food web in the soil between bacteria, fungi and microorganisms, thereby promoting the growth of harmful fungi.[16]

Residues in waterways

- **Glyphosate residues** can now be detected in **waterways**. Quite frequently the level of substances such as glyphosate and AMPA in bodies of water exceeds the guidelines set by the European water suppliers (0.1 µg/l). In Germany, up to 60% of the monitoring sites examined exceeded this level.[17]
- Pesticide findings in waterways contradict the goals of the **European Water Framework Directive** (WFD). Its aim is to manage bodies of water and implement measures to maintain or achieve "good water conditions". For pesticide residues, the ratio of 1µg/l must not be exceeded.

Danger to amphibians and earthworms

- Glyphosate is harmful to water-based organisms. Comparatively high levels of glyphosate can occur in small, shallow bodies of water in the agricultural landscape that are important for amphibian development. Amphibians absorb the active ingredients through their skin. Fully matured animals can also be affected.
- Earthworm populations can also be depleted by glyphosate. Laboratory tests proved that glyphosate can impair the reproductive activity of earthworms by up to 60%. This was confirmed by a study conducted by the Soil Science Working Group at the University of Vienna in 2015.[18] The study showed that the activity of deep-burrowing earthworms was dramatically reduced after the herbicide was applied. In horizontal-burrowing earthworms, the number of offspring had halved compared to specimens in soils where herbicide had not been applied.

Danger for insects

Insects can also be affected. For example, reduced growth and behavioural changes were observed in dragonfly eggs and larvae which live in water contaminated with glyphosate.[19] In general, insects in the larval stage are particularly at risk. Glyphosate or the herbicide product which contains it is often not directly lethal, but nonetheless shows detrimental effects on the development, fertility, lifespan and behaviour of these species.

Danger for honey bees

Glyphosate causes considerable damage to honey bees, for example by negatively affecting the bacteria in the bees' gut.[20] Disturbances in the intestinal flora can lead to increased susceptibility to pathogens and thus weaken the bee colony.

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[16] Kremer & Means, "Glyphosate and glyphosate-resistant crop interactions with rhizosphere microorganisms", 2009, https://pubag.nal.usda.gov/download/35795/PDF.

[17] LAWA Bund/Länder-Arbeitsgemeinschaft Wasser, "Bericht zu Mikroschadstoffen in Gewässern", pp. 7, 17/18 March 2016, www.lawa.de/documents/Uml24-2016_20160126_LAWA_Bericht_Mikroschadstoffe_in_Gewaessern_final_207.pdf.

[18] Gaupp-Berghausen et al., "Glyphosate-based herbicides reduce the activity and reproduction of earthworms and lead to increased soil nutrient concentrations", 2015, https://www.nature.com/articles/srep12886.

[19] Janssens & Stocks, "Stronger effects of Roundup than its active ingredient glyphosate in damselfly larvae", *Aq Toxicol* vol. 193: pp. 210-216, 2017, https://www.sciencedirect.com/science/article/abs/pii/S0166445X17303156?via%3Dihub.

[20] Motta et al., "Glyphosate perturbs the gut microbiota of honey bees", 2018, https://www.pnas.org/content/115/41/10305.

Glyphosate also has a negative impact on the bees' development[21] and sense of direction, and can alter their learning and memory.[22]

Glyphosate is not beneficial to soil, nor does it contribute to climate change mitigation[23]

Since the early 1990s, farmers have often been told to work without ploughs so as to prevent erosion. However, anyone who attempts to pursue conventional methods of farming without using ploughs will soon enough run into the problem that the weeds quickly get out of hand. This is why the use of total herbicides, especially glyphosate, is increasing, especially in no-till farming.[24]

Total herbicides have become an integral part of the system in conventional no-till farming. In recent years, the European Agriculture Conservation Federation (ECAF) has been a leading advocate of the claim that no-till farming is good for the soil and the environment, and that it even protects soil organisms. The ECAF has been working closely with Monsanto, the inventor of glyphosate, for years. Other proponents of glyphosate also repeatedly point out that only mulch or no-till farming can build up humus. But what matters most is how much and what kind of organic material is put into the soil, not whether it is ploughed into the ground or not.

Contrary to frequently repeated claims, refraining from ploughing alone does not lead to a significant build-up of humus. This has been confirmed by a study comparing 69 different locations worldwide.[25] Studies that claimed to show carbon enrichment had only measured to a maximum depth of 15 cm.

Nevertheless, many recommendations for climate protection measures at the EU level and in some agricultural policy support programmes still erroneously claim evidence of carbon sequestration. In terms of its impact on the climate, however, no-till farming is actually counterproductive, since it increases nitrous oxide emissions. The formation of nitrous oxide is facilitated by the fact that soils that are not ploughed are more densely compacted.[26]

Glyphosate and human health

Herbicide residues in food and feed can affect human and animal health. For example, since glyphosate is concentrated in seeds, harvested products can contain high levels of toxic residue. In the EU, soybeans are permitted to have a residue level of 20 mg/kg. Only a few other products in the EU, such as barley, oats or sunflower seeds are allowed to have such a high glyphosate level. For wheat, linseed or rapeseed, the level is 10 mg/kg, but for most foods the level is 0.1 mg/kg.[27] In some cases, glyphosate-resistant soybeans in the USA reach almost 20 mg/kg of glyphosate

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[21] Odemer et al., "Chronic High Glyphosate Exposure Delays Individual Worker Bee (Apis mellifera L.)" *Development under Field Conditions Insects* 11:664, 2020, doi:10.3390/insects11100664.

[22] Farina et al., "Effects of the Herbicide Glyphosate on Honey Bee Sensory and Cognitive Abilities: Individual Impairments with Implications for the Hive Insects", 10, 354, 2019, doi:10.3390/insects10100354.

[23] Beste, A., "BUND Factsheet Glyphosat ist weder Boden- noch Klimaschutzmittel!", 2019, https://www.bund.net/service/publikationen/detail/publication/glyphosat-ist-weder-boden-noch-klimaschutzmittel/.

[24] Minor interpellation by the Greens "Risikobewertung und Zulassung des Herbizidwirkstoffs Glyphosat" (Bundestags-Drucksache 17/6858, Answer of the German Federal Government: 17/7168); http://dipbt.bundestag.de/dip21/btd/17/071/1707168.pdf.

[25] Luo et al., "Can no-tillage stimulate carbon sequestration in agricultural soils? A meta-analysis of paired experiments", 2010, https://www.sciencedirect.com/science/article/abs/pii/S0167880910002094.

[26] Gensior et al., "Landwirtschaftliche Bodennutzung. Eine Bestandsaufnahme aus Sicht der Klimaberichterstattung", *Bodenschutz*, 12/3/2016, https://www.openagrar.de/receive/timport_mods_00015244; Catch-C, "Compatibility of Agricultural Management Practices and Types of Farming in the EU to enhance Climate Change Mitigation and Soil Health", 2014.

[27] https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/mrls/?event=search.pr.

residue,[28] and this level is even exceeded in some countries, such as Argentina.[29] Since glyphosate breaks down to AMPA in soy plants, AMPA must also be taken into account.

The residue levels ruled to be permissible are often arbitrary and do not offer sufficient safety. As a rule, the higher the amount of glyphosate sprayed, the higher the permissible maximum residue levels are. For example, the permissible level for soybeans was increased 200-fold from 0.1 mg/kg to 20 mg/kg in 1996 when glyphosate-resistant GM soybeans were approved for cultivation in the USA and for import to the EU. These so-called RoundupReady soybeans are now grown on huge stretches of land in North and South America, and millions of tonnes are imported to the EU for use as animal feed. Residue levels safeguard agricultural and business models that rely on the large-scale use of synthetic chemical pesticides.
The acceptable daily intake (ADI) of glyphosate for humans used to be 0.3 milligrams per kilogram of body weight. In 2015, EFSA proposed to increase this value to 0.5 mg/kg. Glyphosate is found in human urine: "In a random sample of around 400 urine samples over a period of 15 years, it was found that the proportion of samples in which glyphosate was detected had increased over the years. In 2001, the substance was detected in the urine of only 10% of the student participants, in 2013 it was found in almost 60% of the test group, and most recently, in 2015, this figure was at 40%".[30]
The chronic toxicity of glyphosate and Roundup is a major topic of ongoing debate. Scientists report that glyphosate and Roundup have toxic and tumour-promoting effects on animal and human cells, as well as embryotoxic effects on laboratory animals.[31]

In regions of Latin America where glyphosate-resistant plants are cultivated on a large scale and where glyphosate is used extensively as a herbicide, there is an increased rate of miscarriages, malformations of new-born babies, and cancer. However, this correlation has not yet been studied in depth.[32] An increased risk of neurodegenerative diseases such as Alzheimer's and Parkinson's is also being investigated.[33] The use of glyphosate can also lead to cross-resistance to antibiotics.

In March 2015, the World Health Organisation's (WHO) International Agency for Research on Cancer (IARC) classified glyphosate as "probably carcinogenic to humans", which corresponds to the second highest level of risk, Group 2A.[34]

Court ruling on compensation claims for cancer caused by glyphosate:
In the USA, many class action lawsuits are currently underway, brought by people suffering from cancer who are suing Monsanto, or its current owner Bayer, for damages.[35] In August 2018, a jury in San Francisco awarded a caretaker who had frequently used glyphosate at his job and developed lymphoma a compensation payment of 289 million dollars, which was initially reduced to 79 and later to 20 million dollars. The ruling declared that Monsanto had

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[28] http://www.whatsonmyfood.org/food.jsp?food=SY.

[29] https://www.testbiotech.org/node/927.

[30] https://www.umweltbundesamt.de/themen/neue-uba-untersuchung-zu-glyphosat.html.

[31] See for example Van Bruggen et al., "Environmental and health effects of the herbicide glyphosate", *Science Total Environ* 616–617: 255–268; Mesnage et al., "Multiomics reveal non-alcoholic fatty liver disease in rats following chronic exposure to an ultra-low dose of Roundup herbicide", *Sci Rep 7*, 39328., 2016, https://doi.org/10.1038/srep39328.

[32] Antoniou et al., "Roundup and birth defects; Is the public being kept in the dark?", 2011 https://de.scribd.com/doc/57277946/RoundupandBirthDefectsv5.

[33] Samsel & Seneff, "Glyphosate, pathways to modern diseases III: manganese, neurological diseases, and associated pathologies" *Surg Neurol Int* 6(1):45. https://doi.org/10.4103/2152-7806.153876.

[34] https://www.iarc.who.int/wp-content/uploads/2018/07/MonographVolume112-1.pdf.

[35] Kurenbach et al., "Sublethal exposure to commercial formulations of the herbicides dicamba, 2,4-dichlorophenoxyacetic acid, and glyphosate cause changes in antibiotic susceptibility in Escherichia coli and Salmonella enterica serovar Typhimurium", *mBio* 6 (2), e00009- 15, 2015, https://doi.org/10.1128/mBio.00009-15.

concealed the cancer risk of the substance. In March 2021, Bayer accepted the court ruling. Bayer offered a settlement to the more than 10,000 other plaintiffs, which is expected to cost around 10 billion dollars. Lawsuits which have not yet been filed are expected to be settled for another 2 billion dollars.[36]

A phase-out is possible

It is indeed possible to move away from farming systems that rely heavily on the use of glyphosate. Herbicides containing glyphosate are used in arable farming primarily for the removal of weeds and other undesirable plants, either after the harvest of the preceding crop or before sowing the following crop. In principle, it is therefore possible to dispense with glyphosate and to replace the use of these herbicides with agronomic measures such as **mechanical weed control**.[37]

In addition to mechanical weed control, **crop rotation** is another essential method for reducing the use of glyphosate. In view of the climate-friendly effects of mulch and no-till methods, soil-loosening and soil-sweeping techniques are the best methods for use in arable farming. However, those who wish to use direct-sowing and mulch-tillage techniques because of the risk of erosion or to conserve soil moisture can also take advantage of the expanding field of research and testing being done on such techniques without the use of total herbicides. Research and testing are also taking place in organic farming, for example.[38]

New developments in digitalisation can open up paths to environmentally friendly weed control

Taking cues from the knowledge of successful methods of arable farming and mechanical techniques that have been developed for decades, a number of high-tech methods which facilitate a gentle and non-chemical method of weed control are currently being developed. These methods use spectroscopic or imaging technologies to distinguish the crop plants from the weeds. This allows weed control to be carried out mechanically (via computer-controlled hoes), by hot steam, or by laser. These methods do not use any herbicides. Moreover, only the weeds that compete with the crop for nutrients are killed. In this way the crop, as well as desirable weeds that promote biodiversity and arable fertility, can all be preserved. This new, environmentally friendly method of weed control can be used in both conventional and organic agriculture. Corresponding methods are already available on the market, and can be expected to have a major impact on the industry in the near future.

In the roll-out of these high-tech methods it is important to ensure both the availability of the technology, as well as that farmers are able to maintain control over the data generated by these systems. What's more, the prices of these technologies must be made feasible for smaller farms, so as not to further drive the shift towards large-scale farming.[39]

Examples of these methods are the sensor-controlled cross hoe,[40] the "sensor array" for weed control,[41] and digital plant protection,[42] which uses lasers instead of chemicals. Information related to these developments can be found in

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[36] https://taz.de/Prozess-um-Glyphosat-in-den-USA/!5757088/.

[37] Zwerger, "Handlungsempfehlung der Bund-Länder-Expertengruppe zur Anwendung von Glyphosat im Ackerbau und in der Grünlandbewirtschaftun", 2017, https://doi.org/10.5073/berjki.2017.187.000.

[38] https://www.kbd-sachsen.de/Glyphosatverzicht.php; https://www.oekolandbau.de/landwirtschaft/pflanze/spezieller-pflanzenbau/koernerleguminosen/ackerbohnen/anbau-von-ackerbohnen-und-erbsen/.

[39] See the BUND working group on agriculture's discussion paper on digitalisation: https://www.bund.net/fileadmin/user_upload_bund/publikationen/landwirtschaft/bak_landwirtschaft_diskussionspapier_digitalisierung.pdf.

[40] https://www.dbu.de/123artikel1936_html.

[41] https://www.dbu.de/123artikel38249_2430.html.

[42] https://www.dbu.de/123artikel37941_2442.html.

the German Federal Environmental Foundation's programme "Vermeidung und Verminderung von Pestiziden in der Umwelt".[43]

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