Hot Topic #2: Glyphosate – science and scaremongering

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Glyphosate, the active ingredient in Roundup™, is the most widely used herbicide in the world. It affects a specific enzyme pathway in photosynthesis and disrupts the growth of organisms that can photosynthesise. Its action is systemic and so it is effective in killing the plants on which it is sprayed.

In New Zealand it is used to control weeds between growing crops on about 6% of our agricultural land (Hamish Marr, Canterbury Arable Farmer, Nuffield Report; 2019. https://ruralleaders.co.nz/is-roundup-our-friend-or-foe/). It enables no-till agriculture with a consequent saving in fossil fuel and gains in soil quality. In non-farming applications: home gardeners, councils and Waka Kotahi the NZ Transport Agency (NZTA; https://www.nzta.govt.nz/) use it. The Soil & Health Association of New Zealand (https://soilandhealth.org.nz/) has targeted NZTA; with a representative claiming in 2021, "New Zealand is drenched with glyphosate". Yet official data reveals that NZTA uses 30,000 litres a year. This volume is two standard Fonterra tankers full, or 1.2% of an Olympic swimming pool, and applied to our 11,000+ kilometres of state highway.

Concerns about glyphosate and human health have been raised in the media, and some local government bodies are choosing methods other than using glyphosate to kill weeds. Consequently, the New Zealand Environmental Protection Authority (EPA; https://www.epa.govt.nz/) has been urged to review its use in New Zealand and more research has been suggested. The evidence is however, that when used as recommend, glyphosate remains one of the safest ways to manage weed growth. This article discusses that evidence.

Some Facts

- No issues with human health were found by the United States Environmental Protection Agency (USEPA; https://www.epa.gov/) in a comprehensive review of open scientific literature about glyphosate in 2017, and where the studies had been conducted using sound scientific principles.
- Eighteen of nineteen government regulators around the world (including the New Zealand EPA), have indicated that there is no reason to ban glyphosate from use (Genetic Literacy Project, Sept 2021).
- All regulators advise that instructions for use should be followed, whatever substance is being used.

The root of the scaremongering

Concern about the use of glyphosate has escalated since 2015 when the International Association for Research on Cancer (IARC; https://www.iarc.who.int/) classified it as a 'probable human carcinogen'. The same year, the European Chemicals Agency (ECHA; https://echa.europa.eu/) Committee for Risk Assessment stated that 'on the available scientific evidence, there were no grounds to classify the controversial herbicide, glyphosate, as a carcinogen, as a mutagen or as toxic for reproduction'.

The IARC report was based on all published, peer-reviewed literature. The agency identifies hazards and does not consider the likelihood of exposure to the substance (i.e., the risk of exposure). The ECHA examined all the information that was available, including human evidence and 'the weight of the evidence of all the animal studies reviewed'.

The difference in the outcome of the two reports reflects the fact that IARC classifies chemicals according to hazard, whereas ECHA assesses 'risk' in its evaluation. The difference between hazard and risk is that the latter considers likelihood. For example, the sea is a hazard. People minimise risk by checking the weather forecast, swimming between the flags, and wearing life jackets when in boats. People are less likely to have a bad outcome in hazardous conditions if they take the precautions to minimise risk.

In respect of hazard, IARC has classified tobacco, UV radiation and ethanol in alcoholic beverages as CATEGORY GROUP 1 'known human carcinogen(s)' along with 118 other agents (https://monographs.iarc.who.int/agents-classified-by-the-iarc/). For these three hazards, the risk posed can be minimised by not smoking, wearing sunblock and limiting or stopping your intake of alcoholic drinks, but this does not appear to stop some people smoking, sunbathing or drinking.

In contrast, Glyphosate is classified as CATEGORY GROUP 2A 'Probably carcinogenic to humans' along with 89 other agents, including inhaling wood smoke, frying (food), eating red meat and doing shift work. It has been shown to be an order of magnitude less toxic than caffeine and even less toxic than table salt. It has also been shown to have a lower chronic toxicity than more than 100 other herbicides on the market, which suggests that banning it could increase the risk of illness (including cancer) due to exposure to the use of more-toxic herbicides (Kniss, 2016).

However, as the American Cancer Society (https://www.cancer.org/) explains, 'carcinogens do not cause cancer at all times, under all circumstances. Some may be carcinogenic only if a person ingests it, for example, as opposed to touching it; some may cause cancer only in people with a certain genetic makeup; some agents may lead to cancer after only a very small exposure, while others might require intense exposure over many years'. Any risk in the use of glyphosate is therefore minimised by diluting the chemical as instructed and using personal protective equipment (PPE) as advised. The guidelines for domestic use include wearing rubber gloves, a facemask and choosing a calm day for spraying.

The Court Case

Confusion about the use of glyphosate persists partly because of the high-profile court case in California in 2018. The judgement hinged on the fact that Bayer/Monsanto had to prove that glyphosate had not caused a school groundskeeper's cancer (non-Hodgkin's lymphoma); the groundsman did not have to prove that glyphosate had caused the cancer. It is impossible to prove anything is safe. A jury decided the verdict.

The evidence against the likelihood of glyphosate causing the cancer is considerable.

Dr Andrew Kniss, Professor of Weed Science at University of Wyoming, has calculated that 97% of people with non-Hodgkin's lymphoma have had no exposure to glyphosate. This indicates that removal of glyphosate would not mean elimination of non-Hodgkin's lymphoma. Further, a 70-fold increase in glyphosate use from its registration in 1974 to the year 2000, has not been associated with an increase in non-Hodgkin's lymphoma. In fact, the incidence of non-Hodgkin's lymphoma in America peaked, and then declined.

Yet more reassurance is provided by a large research project in the US involving almost 55,000 people, 83% of whom had used glyphosate. In 2017, the project reported that 'glyphosate was not statistically significantly associated with cancer at any site' (Andreotti et al., 2018). The authors did note an increased, but statistically non-significant, risk of acute myeloid leukaemia (AML) in the study in the highest exposure quartile compared with those who had never used glyphosate. It is also notable that AML can arise during non-Hodgkin's lymphoma treatment.

A further point, not often mentioned in the media, is that in its report in 2015, IARC alerted the world to potential carcinogen issues related to glyphosate (https://www.iarc.who.int/featured-news/media-centre-iarc-news-glyphosate/), but stated that evidence of a link to non-Hodgkin's lymphoma was limited.

Reassurance

Chemical companies spend time and money evaluating new products to ensure that they work on the target while having no impact on human health and the environment. Phillips McDougall reported in 2016 that only one in 160,000 chemicals achieved registration between 2010 and 2014. The cost was up to NZ$300 million to research, develop and register a new crop protection product, and the average time for the process was estimated at over 11 years.

In the European Union, the introduction of plant protection products is very strictly regulated and involves a long procedure, including a science-based risk assessment (European Parliament Research Service (EPRS), 2019). Toxic effects on humans and other organism are evaluated within the assessment. The EPRS has stated that modern plant protection products, when applied according to regulations and guidelines, are safer than in the past. In addition, there are strict controls on residues, with a safety factor of 100 mandated. Improvements in application technology meant that environmental impacts and risks for operators have also decreased. Risk assessment costs for the crop protection industry per active substance have increased from US$41 million in 1995 to US$71 (EPRS, 2019).

In addition to tests in the country of development, new products for New Zealand must comply with laws here. These are the Hazardous Substances and New Organisms Act 1996 (https://www.legislation.govt.nz/act/public/1996/0030/latest/DLM381222.html administered by the EPA) and the Agricultural Compounds and Veterinary Medicines Act 1997 (https://www.legislation.govt.nz/act/public/1997/0087/latest/DLM414577.html administered by the Ministry for Primary Industries (MPI). Three years of testing and trials must be completed locally over multiple seasons and in different regions of the country. In 2015,

costs for the introduction of a new product were estimated by AGCARM (http://agcarm.co.nz/), an industry association of companies that manufacture, distribute and sell products, to be at least $250,000, but often around $750,000. These trials must prove the efficacy of the product, and measure residues as well as generating health and safety data. The data from the trials are submitted to the EPA and the MPI to support an application. Approval is required from regulators before the product can be marketed.

Net benefit

Chemical regulators such as the New Zealand EPA take a net-benefit approach to any application for chemical approval. The organisation also reviews licences on a regular basis, particularly if there are concerns or new research evidence about a product. Calculating net benefit rests on two key principles:

1. Being able to work out how much better off we are with an item than without it, and
2. Making the correspondence between willingness to pay and well-being comparable across different social groups.

It is notable, that in developing countries, people seeking better health status and food production are more likely to accept the use of synthetic chemicals in medicines, fertilisers and pesticides. In contrast, in developed countries, people seeking a synthetic chemical-free existence weight avoidance highly and are prepared to pay more for food. Their decisions can be more complicated, because there are for example few so-called 'natural' alternatives as efficacious as modern antibiotics, no matter how much a person is prepared to pay. The parallel is that nothing has been found that is as efficacious and safe (when used as prescribed) as glyphosate.

Economics

A ban of glyphosate in Europe has been estimated to reduce crop yields by 20-40% (Oxford Economics, The Anderson Centre, 2017). Glyphosate is widely used in the UK (2.2 million ha of farmland annually) and in any given year, 34% of land for wheat and 33% of land for oilseed rape is treated. The available cereal growing area has been estimated to reduce by 15% on average if glyphosate is removed from use, with wheat area decreasing 20% and oilseed rape decreasing by 37%. In addition, wheat yield per ha is expected to decrease by 12% and oilseed rape yield by 14%.

In Germany, an economics study (Fairclough et al., 2017) revealed that the largest absolute loss in contribution margin from a ban on glyphosate use would occur in viticulture (grape growing; losses of up to 220 €/ha) and apple production (losses of up to 186 €/ha). The contribution margin refers to the influence of one product or unit on the overall profit generated by a company. The losses were explained by the fact that the management of these permanent crops is very labour-intensive, in the absence of glyphosate for weed control. Since the overall contribution margin of these crops is quite high, the relative impact to the overall profitability is however only of marginal significance.

The crops that would be most affected by a glyphosate ban are barley and silage maize (Fairclough et al., 2017). Their contribution margin would shrink by 40 to 70% and might even become negative when farmers also suffer yield losses. This could have far-reaching impacts on the structure of the agriculture industry's structure. Where the cultivation of certain crops is no longer profitable, their production would either need to be subsidised, or farmers would need to switch to the cultivation of other crops.

The environmental impact of increased soil cultivation, increased fossil fuel use and increased soil compaction, and decreased soil structure leading to increased erosion, are also factors to consider when glyphosate is not used. In addition, increased labour for weed control decreases the financial viability of a crop. Fairclough et al. (2017) concluded that: the "agriculture industry, which does in fact take into account the three pillars of sustainability, is hardly realistic without the use of glyphosate". (The three pillars are economic viability, environmental protection and social equity.)

In this context, statements about dozens of countries and states banning the use of glyphosate need further examination. These bans are usually limited to an urban area, or where it appears to be generic, there have been exceptions for agriculture. The exceptions recognise that without glyphosate, yields will decrease significantly and cost of the product to the consumer will increase.

Environmental impact

Guidelines for use of glyphosate cover concentration and conditions such as wind, to avoid spray drift and impact on non-target species. Depending on the conditions, glyphosate and its metabolites can persist in soil, water and plant tissues. Its main metabolite AMPA (aminomethylphosphonic acid) has been found in 45% of EU agricultural topsoils (Silva et al., 2018). The survey involved 11 countries and six crop production systems. It is therefore possible that transfer will occur to non-target areas through processes

such as leaching and surface runoff. It is also evident that glyphosate applied to cropping systems has the potential to reach unintended areas through processes like off-target herbicide movement, spray drift, and root uptake (Kanissery et al., 2019).

Although some concerns have been raised about a negative effect on soil biota (Damgaard et al., 2016) the results can generally be explained by the removal of the above ground food source (that is, through the herbicide action of the glyphosate). The loss of ground cover also affects food sources for insects and birds, and thus can create a shift in populations. In addition, where cropping has replaced wooded areas or native grassland, habitat and nesting sites can be removed along with food sources. However, as the biggest impact on biodiversity is the expansion of agriculture (Sanchez-Bayo & Wyckhus, 2019); it would seem that using all the tools available, including glyphosate, to optimise yields on current agricultural land might be better for biodiversity than expanding into virgin territory.

Alternatives

Glyphosate herbicide is approved for use in New Zealand because its benefits are known, and when guidelines on use are followed, no link to cancer has been shown. Despite this, there are some ratepayers who would rather have their rates increase than allow the council to use glyphosate. Similar decisions have been made overseas.

Suggestions that vinegar or other organic acids can be used instead of glyphosate for weed control have been investigated. Pelargonic acid (or citric, oxalic or acetic acid) must be very concentrated (e.g., 20% versus the 5% of acetic acid in household vinegar) to be able to burn vegetation, and these concentrated acids require special equipment and full PPE in their use.

These acids can be effective on young seedlings that have few reserves for regrowth, but on older plants, the above ground parts might experience a temporary setback, but the lack of systemic activity (no movement to the roots) means that the plants are likely to regrow. In 2017, Bristol City Council reported that using acetic acid was 3.6 times more expensive and far less effective (weeds reappeared within a month instead of five to six months) than using glyphosate. In addition, contractors were reluctant to use vinegar as they were 'afraid of complaints about the smell'. Hot foam was 6.5 times more expensive, and contractors refused to respond to a request for a quotation for weed control the following season, because they did not believe the alternatives to glyphosate were viable options.

Mechanical weeding can be effective, but involves more tractor time and hence fuel consumption (and greenhouse gas production), than the use of glyphosate. Research in Australia comparing thermal weed control (flaming and hot water application), with glyphosate showed that flaming was not successful, except on very young weeds. Two applications 3-4 weeks apart of hot water were equally effective as a single dose of glyphosate, but hot water required special equipment (and water), creates its own health and safety problems, and the repeated control measures increased the time and fuel consumption involved in weed control.

Conclusions

Since its discovery, considerable research has been published in various forms on the use of glyphosate. The consensus is that it is an important tool in food production, and when used as the guidelines mandate, no health or environmental impacts have yet been found. The emphasis is on using the chemical appropriately to avoid 'drenching' and unintended spray drift.

However, as science advances, it is possible that an even more targeted and effective chemical is developed, and that it meets all the criteria associated with providing net benefit.

New Zealanders can be reassured that regulations about the use of chemicals are the responsibility of the NZ EPA and MPI, and there are regular checks of chemical residues in food to ensure that producers are using chemicals responsibly.

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