Roundup's not OK

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Dr Meriel Watts reminds us why we use natural forms of weed control in organic systems, rather than toxic, synthetic chemicals, as she systematically dispels the myth that Roundup is a relatively benign herbicide.

It's amazing how many organics people still think it's OK to just use a bit of Roundup on those weeds in the bush or the driveway, or …. of course, not on the food, but the bush, that's OK isn't it?

Well, no, actually it isn't, and here's why: Roundup and various other formulations of the active ingredient glyphosate, have the potential to cause serious health and environmental effects, and have caused some severe poisoning problems.

Thorough PR by the developer of Roundup, Monsanto, has resulted in the widespread belief that glyphosate is 'safe'. Registration processes have generally supported this attitude, and there are no national or international bans. However, independent scientifi c studies and widespread poisonings in Latin America resulting from aerial application are beginning to reveal the true effects of the world's most widely used herbicide.

Glyphosate is sprayed on numerous crops and plantations, including nearly 80% of genetically modifi ed (GM) crops (canola, corn, cotton, soybean, sugar beet), with relatively high levels permitted as residues in food and animal feed.

Poisonings and symptoms

Glyphosate herbicides have been frequently used in suicide attempts, resulting in many deaths, especially in Asia. There have also been many cases of unintentional poisonings amongst users and bystanders. Widespread poisonings have occurred in Latin America as a result of aerial spraying of GM soybean crops, and of coca crops in Colombia, effects being recorded as far as 10 km away from the supposed spray zone. The coca spraying has also resulted in widespread animal deaths and food crop losses.

Symptoms of poisoning commonly reported from unintentional exposure include vomiting, diarrhoea, abdominal pain, gastrointestinal infections, itchy or burning skin, skin rashes and infections (particularly prevalent in children), blisters, burning or weeping eyes, blurred vision, conjunctivitis, headaches, fever, rapid heartbeat, palpitations, raised blood pressure, dizziness, chest pains, numbness, insomnia, depression, debilitation, difficulty in breathing, respiratory infections, dry cough, sore throat, and unpleasant taste in the mouth.

Other effects reported include balance disorder; reduced cognitive capacity; seizures; impaired vision, smell, hearing and taste; drop in blood pressure; twitches and tics; muscle paralysis; peripheral neuropathy; loss of gross and fine motor skills; excessive sweating; and severe fatigue.

Acute toxicity

Glyphosate has a low toxicity rating (WHO Table 5) despite the substantial evidence of adverse health effects. Surfactants added to formulated glyphosate products may be more toxic: the surfactant POEA in Roundup is 2–3 times more toxic than the glyphosate itself. There are a number of other chemicals added to glyphosate formulations or contaminating them; some are known to be harmful, but many are regarded as trade secrets and it is unknown which might be contributing to the health effects.

Long-term toxicity

Recently scientists have found harmful effects on human cells at levels of glyphosate too low to have a herbicidal effect, some at levels similar to those found in food. These effects are amplified by the adjuvants in the Roundup formulation, which assist penetration of the cells by glyphosate. Several researchers have reported that glyphosate appears to accumulate in human cells.

Cancer, genotoxicity, endocrine disruption, reproduction

The International Programme on Chemical Safety (IPCS) and the United States Environmental Protection Agency (US EPA) have declared that glyphosate is not carcinogenic to humans. The US EPA originally classifi ed glyphosate as a Group C 'possible human carcinogen', then re-classifi ed it as Group D 'not classifi able as to human carcinogenicity', then as Group E 'evidence of noncarcinogenicity in humans', and then in 2006 rephrased this as 'Group E carcinogen with no evidence of human carcinogenicity'.

Yet there is substantial laboratory and some epidemiological evidence that points to the opposite conclusion. Some researchers have concluded that glyphosate and its formulations clearly present a risk of carcinogenic, mutagenic, and reproductive effects on human cells.

Numerous laboratory studies have shown that glyphosate and the Roundup formulation can be genotoxic and endocrine disrupting. One study summarises these effects occurring at doses substantially lower than those used in agriculture, or permitted as residues: at 0.5 mg/kg (40 times lower than levels permitted in soybeans in the US) they were anti-androgenic; at 1 mg/kg they disrupted the enzyme aromatase; at 2 mg/kg they were anti-oestrogenic; at 5 mg/kg they damaged DNA, and at 10 mg/kg there were cytotoxic. These effects can result in crucial outcomes for sexual and other cell differentiation, bone metabolism, liver metabolism, reproduction, development and behaviour, and hormone dependent diseases such as breast and prostate cancer.

Studies have demonstrated that glyphosate and/or Roundup cause genetic damage in human lymphocytes and liver cells; bovine lymphocytes; mouse bone marrow, liver, and kidney cells; fish gill cells and erythrocytes; caiman erythrocytes; tadpoles; sea urchin embryos; fruit flies; root-tip cells of onions; and in *Salmonella* bacteria. Other studies have shown that it causes oxidative stress, cell-cycle dysfunction, and disruption to RNA transcription, all of which can contribute to carcinogenicity.

Laboratory studies have shown that very low levels of glyphosate, Roundup, POEA, and the metabolite AMPA all kill human umbilical, embryonic and placental cells. Roundup can reduce sperm numbers, increase abnormal sperm, retard skeletal development, and cause deformities in amphibian embryos.

Exposure to glyphosate-based herbicides, even at very low doses may result in reproductive and hormonal problems, miscarriages, low birth weights, birth defects, and various cancers, especially haematological cancers such as non-Hodgkin's lymphoma and hormonal cancers such as breast cancer.

Several epidemiological studies have linked exposure to glyphosate with non-Hodgkin's lymphoma, hairy cell leukaemia, multiple myeloma, DNA damage; and one study with spontaneous abortions and pre-term deliveries.

Neurological and other effects

Glyphosate is assumed by regulators to have no neurological effects – the US EPA did not require neurotoxicity studies to be carried out for the registration of Roundup. However there is emerging evidence that glyphosate can affect the nervous system, and in particular areas of the brain associated with Parkinson's disease. In one case study glyphosate exposure was linked to 'symmetrical parkinsonian syndrome'. An epidemiological study of children identified a link with Attention Hyperactivity Deficit Disorder (ADHD).

Glyphosate damages liver cells and interferes with a number of enzymes important in metabolism.

Photo: Elsa Nivia, RAPAL Colombia

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Photo: Steffan Browning

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Left: A boy in Colombia suffering from skin damage on his face as a result of exposure to to Roundup Ultra

Top: Aerial spraying of Roundup Ultra to eradicate coca in Colombia has also resulted in the killing or damaging of other crops

Middle and Bottom: The 'dead' look that typically results from Roundup spraying

Environmental effects: Water

The environmental effects of glyphosate of greatest concern are those that occur at a subtle level, and can result in significant disruption of aquatic and terrestrial ecosystems, including the agroecosystem.

Glyphosate is water soluble and increasingly found in the environment at levels that have caused signifi cant effects on species that underpin the entire aquatic food chain.

Glyphosate and/or Roundup can alter the composition of natural aquatic communities, potentially tipping the ecological balance and giving rise to harmful algal blooms. It can have profound impacts on microorganisms, plankton, algae and amphibia at low concentrations: one study showed a 70% reduction in tadpole species and a 40% increase in algae.

Insects, crustaceans, molluscs, sea urchins, reptiles, tadpoles, and fi sh can all be affected, with vulnerability within each group varying dramatically between species. Effects include reproductive abnormalities, developmental abnormalities and malformations, DNA damage, immune effects, oxidative stress, modified enzyme activity, decreased capacity to cope with stress and maintain homeostasis, altered behaviour, and impaired olfaction that can threaten their survival. Amphibians are particularly vulnerable. Roundup is generally more toxic than glyphosate, especially to fish.

Environmental effects: Soil and plant health

As with the aquatic environment, it is the subtle effects causing disruption of the ecosystem that are of greatest concern, particularly effects on the agroecosystem. Glyphosate is toxic to some but not all soil microorganisms, altering microbial community dynamics in ways that are harmful to plants and to ecological balance. It increases microorganisms capable of metabolising the chemical.

It can reduce some beneficial organisms such as saprophytic fungi that decompose dead plant material and are important for soil fertility. Numerous studies have shown that glyphosate stimulates the growth of a number of fungal pathogens that cause diseases in many crops.

The upsurge in use of glyphosate in no-till agriculture has brought about a resurgence of some diseases. Glyphosate binds micronutrients in the soil and causes micronutrient deficiencies in plants that increase their susceptibility to disease, decrease their vigour, and produce micronutrient-deficient food crops. It can reduce the plant's production of lignin and phenolic compounds, which are also important for disease resistance. It can reduce nitrogen fixation in legumes such as soybean.

Glyphosate can alter the nutritional composition of foods, for example the protein and fatty acid content of soybeans. It can cause iron deficiency in soybeans, which is a concern for human health as human iron defi ciency is widespread.

Effects on earthworms and beneficial insects

Glyphosate has adverse effects on some earthworms; a number of beneficial insects useful in biological control, particularly predatory mites, carabid beetles, ladybugs, green lacewings; as well as other insects that play an important part in ecological balance such as springtails, woodlice (such as slaters), and field spiders.

Lifeless strips of brown earth following Roundup use in a New Zealand lavender farm

Photo: Philippa Jamieson

Residues in soil

Glyphosate is relatively persistent in soil, with residues still found up to three years later in cold climates. It is less persistent in warmer climates, with a half-life between four and 180 days. It is bound onto soil particles, and this was once thought to mean that glyphosate is not biologically active within soil, nor will it leach to groundwater. However it is now known that it can easily become unbound again, be taken up by plants or leach out, indicating a greater risk of groundwater contamination. It can reduce nitrogen and phosphate fertility of soils.

Residues in water

Glyphosate is soluble in water, and slowly dissipates from water into sediment or suspended particles. Although it does break down by photolysis and microbial degradation, it can be persistent for some time in the aquatic environment, with a half-life up to nearly five months, and still present in the sediment of a pond after one year.

Residues of glyphosate have been found in a wide range of drains, streams, rivers, and lakes, in many countries including Canada, China, France, Netherlands, Norway, USA, and UK. Urban use on roadsides and rail corridors is contributing significantly to this contamination, with residues being found in sewage sludge and wastewater treatment plants. Contamination of 'vernal pools', pools that are shallow and disappear in dry weather, are a concern for amphibia, for which these water sources are critical.

Residues have also been found in groundwater in Canada, Denmark, the Netherlands, and USA. They have been detected in the marine environment off the Atlantic coast of France; and in the rain in Belgium and Canada.

Resistance

Fourteen weeds in 14 countries have developed resistance to glyphosate. Most of this resistance is has been caused by the repeated use of glyphosate in GM crops and no-till agriculture. Some has resulted from a gradual evolution of exposed weed species, some from gene flow from GM crops to weed relatives. The later has been observed with sugar beet in France, canola in Canada, creeping bentgrass in USA, and also with corn and soybean. Now even Monsanto is recommending the use of other herbicides in addition to glyphosate in Roundup-Ready crops to slow the onset of resistance in weeds.

Climate change effects

A number of glyphosate's adverse effects can be expected to increase with climate change: higher temperatures enhance glyphosate's reduction of chlorophyll and carotenoids in freshwater green algae, increase toxicity to fish, and increase susceptibility to *Fusarium* head scab in cereals.

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This article is based on a recently completed monograph which is available on the PAN AP website www.panap.net

To see the complete monograph and all references, please see:
http://www.pananz.net/resources/Div_Loaded_Files/Documents/Glyphosate/Glyphosate%20monograph%20PANANZ.pdf

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