Physicians and Scientists for Global Responsibility

New Zealand Charitable Trust

Glyphosate: N-(phosphonomethyl)glycine

An overview

Glyphosate, a broad-spectrum, post-emergence herbicide, was first registered for use by the United States Environmental Protection Agency (EPA) in 1974.

Glyphosate is the active ingredient in Monsanto's proprietary herbicide, Roundup®, and an ingredient in proprietary brands marketed by Bayer, Dow, Zeneca and others.[1] Patents continue to be filed for glyphosate and glyphosate-related applications, latterly in respect of genetically engineered glyphosate-resistant crops.[2] Monsanto's patent on glyphosate outside the US expired in 1991, and now most of it is manufactured in China. Within the US, the patent on isopropylamine salt, the most widely used salt form for glyphosate, continued until 2000.[3] The first-generation Roundup Ready® soybean trait patent expires in 2015.[4]

For decades, Monsanto was the largest US producer of glyphosate herbicides. The company introduced transgenic glyphosate-resistant commercial crops in the mid 1990s and by 2007 glyphosate was the most used herbicide in the US agricultural sector.[5] In 2012, the Asia Pacific market accounted for the largest share in terms of volume.[6]

US patent 7771736 B2 (pub. 2010) covers *in vivo* use for animals or humans of N-phosphonomethyl glycine, i.e. glyphosate, or a salt, ester or other derivative thereof, in combination with a dicarboxylic acid or a derivative thereof, as an antibiotic for the treatment of pathogenic infections, including infections of mammals by apicomplexan parasites.[7]

Regulatory bodies worldwide have approved many applications involving glyphosate, largely on the basis of decisions made by US regulatory authorities. Glyphosate is used in agriculture, horticulture, viticulture, silviculture and forestry, and in industrial and public sites, aquatic environments, gardens, and sports facilities.

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[1] http://en.wikipedia.org/wiki/Glyphosate.

[2] http://en.wikipedia.org/wiki/John_E._Franz. See early patent applications by scrolling down to Patents and/or see http://www.google.com/patents/US3799758. See also http://www.greenpeace.de/fileadmin/gpd/user_upload/themen/patente_auf_leben/greenpeace_patente_von_monsanto_englisch.pdf 'Monsanto's Patents: A List of seed monopolies'

[3] http://en.wikipedia.org/wiki/Monsanto and http://www.frost.com/prod/servlet/market-insight-print.pag?docid=JEVS-5N2CZG

[4] http://www.monsanto.com/newsviews/pages/roundup-ready-patent-expiration.aspx. For Monsanto Company patents see http://www.monsanto.com/products/pages/product-patents.aspx.

[5] Stephen O. Duke and Stephen B. Powles (2008) Glyphosate: a once-in-a-century herbicide: Mini-review. *Pest Management Science* Pest Manag Sci 64:319–325. http://en.wikipedia.org/wiki/Glyphosate. US EPA 2007 Pesticide Market Estimates, http://www.epa.gov/opp00001/pestsales/07pestsales/usage2007_2.htm#3_6 and http://www.epa.gov/opp00001/pestsales/07pestsales/usage2007_3.htm#3_7

[6] https://archive.org/details/GlyphosateMarketGlobalIndustryAnalysisSizeShareGrowthTrendsAndForecast2013-2019 and http://www.economist.com/node/14904184

[7] http://www.google.co.uk/patents/US7771736, Invented by William Abraham, Original Assignee Monsanto Technology Llc.

Despite being claimed as less toxic than other herbicides, concerns about its effects on human and environmental health continue to be raised[8] [9] and studies pursued to establish substantive evidence. Increasingly, countries are attempting to ban glyphosate: in Brazil, the Prosecutor General's office is pursuing a ban[10]; in Sri Lanka, President Mahinda Rajapaksa issued a directive to ban glyphosate[11]; and in 2013 El Salavador's National Assembly approved a decree to ban glyphosate[12].

1 - Glyphosate – how it works

Glyphosate is a non-selective herbicide, killing most plants when applied directly to foliage, including grasses, broadleaf, and woody plants. Pre-harvest glyphosate applications are used as a harvest management tool for dry down in addition to or in place of other chemicals for crop desiccation (siccation) to give the appearance of uniform crop maturity.[13] Used in smaller quantities, the sodium salt of glyphosate can act as a plant growth regulator and accelerate fruit ripening.

In actively growing plants, glyphosate-based herbicides are absorbed through foliage and translocated throughout a plant to concentrate in the meristem tissue, the plant tissue whose cells actively divide to form new tissues that cause the plant to grow. Glyphosate inhibits EPSP (5-enolpyruvylshikimate-3-phos-phate), an enzyme involved in the synthesis of the aromatic amino acids tyrosine, tryptophan and phenylalanine which are vital for protein synthesis and plant growth and development,[14] [15] and specific to plants and some micro-organisms. Exposure to glyphosate leads to stunted growth, loss of green colouration, leaf wrinkling or malformation, and tissue death takes from 4 to 20 days, all depending on the application dose.

Plants genetically engineered to be herbicide-resistant - such as Monsanto's Roundup Ready crops[16] - allow farmers to freely apply glyphosate as a post-emergence herbicide. This practice has seen application rates virtually double since the introduction of transgenic crops, and this over-application is seen as a main contributor in weed species becoming glyphosate-resistant.

2 - Glyphosate – the chemistry

Glyphosate is an aminophosphonic analogue of the natural amino acid glycine, and the name is a contraction of gly(cine) phos(phon)ate.[1] [17]

Glyphosate (N-phosphonomethylglycine) is classified as an organophosphorus herbicide.[18] It and its variants are detailed as herbicides or phytotoxicants. They are materials which control terrestrial and aquatic plants in a given location or selectively control the growth of one or more plant species in the presence of other plants, as with glyphosate-resistant plants.

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[8] http://www.huffingtonpost.com/2011/06/24/roundup-scientists-birth-defects_n_883578.html
[9] http://www.huffingtonpost.com/2013/04/25/roundup-herbicide-health-issues-disease_n_3156575.html?utm_hp_ref=mostpopular
[10] http://news.agropages.com/News/NewsDetail---11886-e.htm
[11] http://www.dailymirror.lk/news/44366-glyphosate-to-be-banned-in-sri-lanka.html
[12] http://en.centralamericadata.com/en/article/home/El_Salvador_Use_of_53_Chemicals_Banned
[13] 'The agronomic benefits of glyphosate in Europe', Monsanto Europe SA. February 2010.
[14] http://www.purdue.edu/newsroom/releases/2014/Q1/plants-use-unusual-microbial-like-pathway-to-make-essential-amino-acid.html
[15] http://www.pnas.org/content/99/18/11567.full
[16] http://www.monsanto.com/products/Pages/monsanto-agricultural-seeds.aspx. Monsanto's transgenic Roundup Ready crops include alfalfa, canola, corn, cotton, sorghum, soybeans, sugar beets and wheat.
[17] http://npic.orst.edu/factsheets/glyphotech.pdf for detailed information on glyphosate. See http://npic.orst.edu/reg/state_agencies.html for a list of (US) products containing glyphosate and search by active ingredient.
[18] See Classification of Herbicides http://www.alanwood.net/pesticides/glyphosate.html. When glyphosate is used as an ester or salt, its identity should be stated: glyphosate-diammonium, glyphosate-dimethylammonium, glyphosate-isopropylammonium, glyphosate-monoammonium], glyphosate-potassium, glyphosate-sesquisodium, glyphosate-trimesium [81591-81-3].

Formulations of glyphosate include an acid, monoammonium salt, diammonium salt, isopropylamine salt, potassium salt, sodium salt, and trimethylsulfonium or trimesium salt.[19] Generally, references to glyphosate as a herbicide refer to the acid form. The variants can be solids or an amber-coloured liquid. Technical grade glyphosate is used in formulated products, as are the isopropylamine, sodium, and monoammonium salts. Of these, the isopropylamine salt is most commonly used in formulated products. This is an organic compound obtained, by various processes, from non-renewable fossil fuel resources such as petroleum or natural gas deposits, and to a lesser extent coal.

3 - Glyphosate – registration, additives, interactions and residue levels

To register pesticides in the US, the EPA requires laboratory testing for short-term (acute) and long-term (chronic) health effects. Its website says laboratory animals receive high doses to cause toxic effects to show how overexposure of these chemicals might affect humans, domestic animals, and wildlife. The majority of the tests are carried out by the corporation developing the product.

It is the active ingredient which is safety tested and not usually the other ingredients in a pesticide. These latter, named adjuvants, are often described by the developer as "inert". In a study published in December 2013, researchers give results from testing the toxicity of nine pesticides involving the active ingredient and in addition the added ingredients. Roundup was shown to be the most toxic of the pesticides tested. The researchers say their results "challenge the relevance of the Acceptable Daily Intake for pesticides because this norm is calculated from the toxicity of the active principle alone. . . . Chronic tests on pesticides may not reflect relevant environmental exposures if only one ingredient of these mixtures is tested alone."[20]

A study published in January 2014 confirmed the adjuvants, added to glyphosate formulations to increase their effectiveness, may be more toxic than glyphosate itself.[21] For example, studies show that the surfactant polyoxyethyleneamine or polyethoxylated tallow amine used in some glyphosate-based formulations is more toxic by the oral route to animals than glyphosate itself.[22] [23]

The primary purpose of adjuvants is to reduce surface tension and increase penetration. Adjuvants also help the mixing of two or more herbicides in a common spray solution, aid retardants used to decrease the potential for herbicide drift, aid mixing and suspending herbicide formulations in solution, and act as a buffer to change the spray solution acidity. Surfactants (surface active agents) are a type of adjuvant. Their primary purpose is to reduce the surface tension of the spray solution to allow more intimate contact between the spray droplet and the plant surface and thus improve absorption.[24] [25]

3.1 – Glyphosate and chelation

In the 1970s, glyphosate was identified as a chelator of minerals - a compound that combines with other minerals to make them available only under certain conditions. A chelator may be used to extract minerals from ores; e.g. fluoride is used to isolate uranium from the basic rock. Fluoride, found in phosphate fertilizers, chelates calcium and magnesium.

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[19] http://npic.orst.edu/factsheets/glyphotech.pdf. See also http://npic.orst.edu/reg/state_agencies.html for US products containing glyphosate (search 'active ingredient') and http://npic.orst.edu/factsheets/glyphotech.pdf for more on glyphosate.
[20] 'Major pesticides are more toxic to human cells than their declared active principles', Mesnage et al, http://www.hindawi.com/journals/bmri/aip/179691/
[21] 'Glyphosate commercial formulation causes cytotoxicity, oxidative effects, and apoptosis on human cells: differences with its active ingredient', Chaufan et al, Int J Toxicol. 2014, PMID: 24434723 http://www.ncbi.nlm.nih.gov/pubmed/24434723?dopt=Abstract
[22] http://www.panap.net/sites/default/files/monograph_glyphosate.pdf
[23] Mesnage R, Defarge N, Spiroux de Vendômois J, Séralini G-E. Major pesticides are more toxic to human cells than their declared active principles. Biomedical Research International, 2014. http://www.hindawi.com/journals/bmri/aip/179691/
[24] http://extension.psu.edu/pests/weeds/control/adjuvants-for-enhancing-herbicide-performance
[25] http://www.agroconsultasonline.com.ar/ticket.html/ucsu2062205591998internet.pdf?op=d&ticket_id=4874&evento_id=9969

Other recent studies indicate plant uptake systems are susceptible to the chelating effects of glyphosate. For example, short-term experiments showed root uptake and shoot translocation of manganese and iron were severely depressed by glyphosate applications.[26]

A 2014 study[27] hypothesizes that glyphosate, when mixed with hard water, forms a complex with heavy metals like arsenic and cadmium, resulting in the accumulation of the latter in the body. Such metals are naturally present in soil, or may be added through applications of fertilizers. Hard water can contain metals such as calcium, strontium and iron, as well as carbonate, bicarbonate, sulphate and chlorides. The study proposed a link under local conditions between chronic kidney disease and glyphosate. Chronic kidney disease of unknown origin (CKDu) is becoming increasingly common in poor farming communities in some areas of developing countries. The US Centre for Public Integrity found CKDu has killed more people in El Salvador and Nicaragua than diabetes, AIDS and leukaemia combined over the past five years on record. CKDu was identified in the mid-1990s and is now estimated to afflict 15% of working age people in northern Sri Lanka alone: 400,000 patients with an estimated death toll of 20,000.

Researchers have found copper adsorption decreases in general with increasing concentration of glyphosate in solution, that the concentration of free copper in solution is drastically reduced, and the adsorption of copper in their sample soil lower.[28] Glyphosate reduced seed and leaf concentrations of calcium, manganese, magnesium, and iron in non-glyphosate-resistant soybean.[29] Decreases in seed concentration of iron, manganese, calcium and magnesium by glyphosate were found to be specific and may affect seed quality.[30]

How such effects affect the nutritional content of a food plant are yet to be determined.

3.2 – Testing for glyphosate residues

In the US, the National Pesticide Information Centre Fact Sheet says glyphosate is not included in compounds tested by its Food and Drug Administration's Pesticide Residue Monitoring Programme. Neither is it in its Department of Agriculture's Pesticide Data Programme. A field test found lettuce, carrots and barley contained glyphosate residues up to one year after the soil was treated with 3.71 pounds of glyphosate per acre.[31] USDA data show that glyphosate-based herbicide use increased 6504% between 1991 and 2010. Following a request from Monsanto Company, acceptable tolerances for residues of glyphosate were recently raised again and posted in the US 'EPA Pesticide Tolerances: Glyphosate'[32] (effective 1 May 2013). These are applied to raw agricultural commodities and hay, oilseed crops, and vegetables, fruits and berries.[33]

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[26] 'Foliar-applied glyphosate substantially reduced uptake and transport of iron and manganese in sunflower (Helianthus annuus L.) plants', Eker et al, J Agric Food Chem. 2006 Dec 27;54(26):10019-25, http://www.ncbi.nlm.nih.gov/pubmed/17177536.'Relevance of glyphosate transfer to non-target plants via the rhizosphere[, Tesfamariam, Bott, Cakmak, Römheld, Neumann, Euro J Agro 31 (2009), http://wyofile.com/wp-content/uploads/2011/07/2009_Glyphosate_Rhizosphere_Waitingtimes_Bindingformsinsoils_Tesfamariamaetal.pdf

[27] 'Glyphosate, hard water and nephrotoxic metals: are they the culprits behind the epidemic of chronic kidney disease of unknown etiology in Sri Lanka?' Jayasumana C1, Gunatilake S2, Senanayake P3. Int J Environ Res Public Health. 2014 Feb 20;11(2):2125-47. doi: 10.3390/ijerph110202125. http://www.ncbi.nlm.nih.gov/pubmed/24562182

[28] 'The effect of dissolved glyposate upon the sorption of copper by three selected soils', Morillo et al, December 2001. Chemosphere, Volume 47, Issue 7, May 2002, Pages 747–752, http://dx.doi.org/10.1016/S0045-6535(01)00338-1. http://www.sciencedirect.com/science/article/pii/S0045653501003381.

[29] 'Glyphosate Interactions with Physiology, Nutrition, and Diseases of Plants: Threat to Agricultural Sustainability?' Cakmak et al, European Journal of Agronomy, Volume 31, Issue 3, October 2009, Pages 114–119, http://www.sciencedirect.com/science/article/pii/S1161030109000665

[30] 'Glyphosate reduced seed and leaf concentrations of calcium, manganese, magnesium and iron in non-glyphosate resistant soybean, Cakmak et al. http://research.sabanciuniv.edu/13147/1/2009_Glyphosate_reduced_seed_and_leaf_concentrations_of_calcium_etc.pdf

[31] National Pesticide Information Centre Technical Factsheet on: GLYPHOSATE http://npic.orst.edu/factsheets/glyphogen.pdf

[32] http://www.epa.gov/fedrgstr/EPA-PEST/1997/April/Day-11/p9231.htm

[33] Summary of Monsanto petition is on http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2012-0132-0009.

4 - Glyphosate in the soil and water

It is claimed that glyphosate residues are immobile and degraded by soil microbes to AMPA and carbon dioxide,[34] and that glyphosate and AMPA (aminomethylphosphonate) are unlikely to move to ground water due to their strong adsorptive characteristics. In fact, glyphosate adsorbs to soil and can potentially contaminate surface waters because it adsorbs to soil particles suspended in runoff.

If glyphosate reaches surface water it is not broken down readily by water or sunlight[35] and glyphosate contamination of surface water is often attributable to urban use.[36] Glyphosate and AMPA were found in marine sediment in the Waitemata Harbour and Hauraki Gulf in New Zealand, believed to have come largely from urban roadside spraying of weeds. The maximum glyphosate concentration detected was 1 ppm, while AMPA had a maximum level of 0.37 ppm.[37]

Glyphosate and the metabolite AMPA were found in up to 100% of samples of rain and air in agricultural areas in the US. About 0.7% of glyphosate applied in agricultural areas is removed from the air by rain. In Belgium, glyphosate was one of the most frequently detected pesticides in rainwater in 2001 and was measured in rain in Canada, at all sites and throughout the "growing season", at a maximum concentration of 1.51 ug/m2/day.[38]

The median half-life of glyphosate in soil ranges from 2 to 197 days, its persistence affected by soil and climate conditions, and can range up to 1699 days under anaerobic conditions in laboratory studies. In water, its median half-life varies from a few days to 91 days.[39] The glyphosate metabolite, aminomethylphosphonic acid, has been shown to have a median-half life of 240-958 days in some soils[40] and persist up to two years in Swedish forest soils.[41]

The French Supreme Court upheld judgements by two previous courts that "Monsanto falsely advertised its herbicide as 'biodegradable' and falsely claimed it 'left the soil clean.'" The French parliament has adopted a law to prohibit private or public non-agricultural use of pesticides in green areas, forests or public space from 1 January 2020.[42] From 1 January 2022, it will be prohibited to place pesticides for non-professional use on the market, to be sold, used or in the possession of someone. This includes glyphosate-based herbicides. Denmark has banned autumn spraying of glyphosate on sites where leaching is extensive because of heavy rain. Research showed glyphosate had contaminated groundwater from which Denmark obtains drinking water at a rate of five times more than the allowed level for drinking water.[43]

Manuel Tejada (2009) studied the degradation and the effects on biological properties in two soils after the addition of glyphosate, diflufenican and glyphosate+diflufenican and found the application of glyphosate+diflufenican mixture to soil increased the toxic effects of both herbicides in the soil biological activity and the individual soil persistence of each herbicide.[44]

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[34] http://maps.thefullwiki.org/Glyphosate

[35] "Registration Decision Fact Sheet for Glyphosate (EPA-738-F-93-011)" United States Environmental Protection Agency. 1993.

[36] Botta F, Lavison G, Couturier G, Alliot F, Moreau-Guigon E, Fauchon N, Guery B, Chevreuil M, Blanchoud H (September 2009). "Transfer of glyphosate and its degradate AMPA to surface waters through urban sewerage systems". Chemosphere 77 (1): 133–9. doi:10.1016/j.chemosphere.2009.05.008. PMID 19482331. http://www.sciencedirect.com/science/article/pii/S0045653509005852

[37] Page 33 http://www.aucklandcity.govt.nz/council/documents/technicalpublications/TR2009_021%20-%20Field%20Analysis%20of%20Chemicals%20of%20Emerging%20Environmental%20Concern%20in%20Auckland.pdf

[38] Quaghebeur et al 2004; Humphries et al 2005; Chang et al 2011

[39] http://npic.orst.edu/factsheets/glyphotech.html

[40] US EPA 1993

[41] Ecotoxicology and Environmental Safety, Volume 18, Issue 2, October 1989, Pages 230–239 'Influence of climatic and edaphic factors on persistence of glyphosate and 2,4-D in forest soils' Torstensson et al, www.sciencedirect.com/science/article/pii/0147651389900845

[42] http://www.env-health.org/news/latest-news/article/new-french-law-will-ban-non

[43] 'Denmark Bans Glyphosates, The Active Ingredient In Roundup', Politiken. http://organic.com.au/news/2003.09.15

[44] 'Evolution of soil biological properties after addition of glyphosate, diflufenican and glyphosate+diflufenican herbicides', Manuel Tejada

Zabaloya et al (2008) looked at the impacts of post-emergence herbicides on soil microbial communities sampled from agricultural fields with a history of herbicide application in the Argentine Pampas. The herbicides focussed on in the study were glyphosate, metsulfuron-methyl and 2,4-D (2,4-dicholorophenoxyacetic acid). Soil microcosms were treated with one herbicide at a time at a dose 10 times higher than the recommended field application rates causing changes to soil microbial activity, bacterial density and functional richness with the effects of glyphosate most pronounced.[45]

Researchers looking at soil fertility examined the effects of glyphosate with its by-products on growth and viability of microbial models. They found "evidence that Roundup has an inhibitory effect on microbial growth and a micro-biocide effect at lower concentrations than those recommended in agriculture." Also "these results should be considered in the understanding of the loss of micro-biodiversity and microbial concentration observed in raw milk for many years."[46]

Researchers recently quantified the biodegradation of glyphosate using standard "simulation" flask tests with native bacterial populations and coastal seawater from the Great Barrier Reef. The half-life for glyphosate at 25°C in low-light was 47 days, extending to 267 days in the dark at 25°C and 315 days in the dark at 31°C. The adjuvant AMPA was detected under all conditions. The conclusion was that "glyphosate is moderately persistent in the marine water under low light conditions and is highly persistent in the dark."[47]

5 – Glyphosate-resistant transgenes in the environment

On the environmental effects of glyphosate, Pesticide Action Network Asia and the Pacific (PANAP) says: ". . . of greatest concern are those that occur at a subtle level, and can result in significant disruption of aquatic and terrestrial eco-systems, including the agro-ecosystem."[48]

Today the loss of genetic diversity in commercially important crops is acknowledged. Despite crops being bred for superior resistance, genetic uniformity and monoculture practices increase the possibility of pests and diseases evolving to overcome the host plants' resistance.

Developers claim transgenic crops will help overcome such problems, but scientists cannot easily quantify the exact effect/s novel organisms will have when released into the environment; each may differ to the next. Genes move naturally within a species, by seed dispersal and pollination. This movement is a basic biological principle of plant evolution and is facilitated by insects, wind, animals, humans and other factors. The ecological risks tied to the release of transgenic plants include non-target effects of the crop and the escape of transgenic DNA into wild populations.[49]

Sufficient knowledge existed prior to release of transgenic organisms to demand applying the precautionary principle and early post-release effects warranted cessation. As early as 1998, a researcher at the US Department of Agriculture (USDA) found a resistance gene transferred by pollen from imidazolinone-resistant wheat to jointed goat grass (Aegilops cylindrica).[50]

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http://www.sciencedirect.com/science/article/pii/S0045653509003567

[45] 'An integrated approach to evaluate the impacts of the herbicides glyphosate, 2,4-D and metsulfuron-methyl on soil microbial communities in the Pampas region, Argentina' Zabaloya et al (2008) http://www.sciencedirect.com/science/article/pii/S092913930800036X

[46] 'Effects of Roundup(®) and glyphosate on three food microorganisms: Geotrichum candidum, Lactococcus lactis subsp. cremoris and Lactobacillus delbrueckii subsp. bulgaricus', Clair et al, Curr Microbiol. 2012 May;64(5):486-91. doi: 10.1007/s00284-012-0098-3. 2012. http://www.ncbi.nlm.nih.gov/pubmed/22362186

[47] 'Glyphosate persistence in seawater', 'Mercurio et al. WeedsNews4779, http://weedsnetwork.com/traction/permalink/WeedsNews4779

[48] Watts MA. 2009. Glyphosate Monograph. Pesticide Action Network Asia and the Pacific, Penang. http://www.panap.net/sites/default/files/monograph_glyphosate.pdf,

[49] 'Ecological effects of transgenic crops and the escape of transgenes into wild populations', Pilson et al, Annu. Rev. Ecol. Evol. Syst. 2004. 35:149–74 http://fbae.org/2009/FBAE/website/images/PDF%20files/Imporatant%20Publication/ecological%20effects%20of%20transgenes.pdf

[50] http://www.ianrpubs.unl.edu/epublic/live/g1484/build/

A Canadian study identified pollen transfer as the main means for the development of canola (*Brassica napus*) with naturally occurring, multiple-resistance to the herbicides glyphosate, glufosinate, and imazethapyr. Study results have indicated that, "the pedigreed canola seed production system in western Canada is cross-contaminated with various herbicide resistance traits at a high level."[51] Cross pollination events are well documented.

A large proportion of the transgenic crop plants developed include glyphosate-resistance: alfalfa, canola/rapeseed, corn/maize, cottonseed, rice, soybeans, sugar beet and wheat. In many locations, transgenic crops have become the dominant crop grown, and pose potential problems as volunteer crops. Glyphosate-resistance and other transgenes have transferred to weeds, and to non-transgenic crops. Called introgression, this is the infiltration of genes from one species into the gene pool of another.

5.1 – Glyphosate-resistant transgenes in weed species

Dr Charles Benbrook, in 'Genetically Engineered Crops and Pesticide Use in the United States: The First Nine Years' (2004)[52] said:

"Resistance to glyphosate has emerged as a serious concern across most of the intensively farmed regions of the US. The number of resistant weeds and their rate of spread is not surprising given the degree of selection pressure imposed on weed populations by farmers applying glyphosate herbicides multiple times per year, and sometimes year in and year out on the same field. Resistant weeds typically emerge first on just a few isolated fields, but their pollen, genes, and seeds can travel widely and spread quickly, especially if glyphosate continues to be relied on as heavily has it has been in recent years."

Farmers use Roundup containing glyphosate on Roundup Ready crops, applying it liberally, and have consequently neglected other weed control measures.[53] [54] Historically, farmers used multiple herbicides, which slowed the development of resistance, and they tilled growing land. Roundup Ready crops have reduced those practices and increased the use of glyphosate dramatically.

As early as 2000, in Alberta, Canada, chemical and DNA tests found canola volunteers resistant to three herbicides: Monsanto's Roundup (glyphosate), Liberty (glufosinate ammonium) produced by Bayer CropScience and BASF's Pursuit (ammonium salt of imazethapyr). The industry suggested adding the more toxic 2,4-D or similar to a chemical mix to kill these wayward plants.[55]

The more toxic replacement herbicides suggested[58] include 2,4-D and HPPD-inhibiting herbicides such as Laudis, Impact and Callisto. Callisto's active ingredient is mesotrione[56] and it has an adjuvant, ethylene glycol. The data sheet of the manufacturer, Syngenta, states Callisto inhibits an enzyme which in turn inhibits carotenoid biosynthesis, that carotenoid pigments protect chlorophyll from decomposition by sunlight and consequently there are restrictions on planting following Callisto applications, from six to 18 months depending on the crop, and a withholding period of 70 days from the last application.

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[51] The IR Evidence of Contamination of Pedigreed Canola (Brassica Napus) Seedlots in Western Canada with GE HR Traits, Friesen et al, Canadian Food Inspection Agency, 1995a, 1995b. http://www.kurt-schweizer.ch/home/gentech/RapsKanadaVanAcker.pdf

[52] http://www.nlpwessex.org/docs/Benbrook2004.pdf Genetically Engineered Crops and Pesticide Use in the United States: The First Nine Years, Charles M. Benbrook, BioTech InfoNet, Technical Paper Number 7, October 2004. http://www.nlpwessex.org/docs/benbrook.htm for other reports by Dr Charles Benbrook

[53] http://www.nlpwessex.org/docs/Benbrook2004.pdf

[54] 'The Rise of Superweeds—and What to Do About It' Union of Concerned Scientists USA http://www.ucsusa.org/food_and_agriculture/our-failing-food-system/industrial-agriculture/the-rise-of-superweeds.html

[55] www.gene.ch/genet/2000/Feb/msg00053.html

[56] http://css.cals.cornell.edu/extension/cropping-up-archive/wcu_vol12n06-2002a1mesotrione.pdf

Scientists in Nebraska have already found water hemp resistant to 2,4-D[57] and scientists at the University of Illinois have found water hemp resistant to HPPD-inhibiting herbicides.[58] Historically, water hemp is a problematic weed in the US 'Corn Belt' because it is aggressive, fast growing and out-competes corn for light, water and nutrients.

In 2005, the Herbicide Resistance Action Committee identified 13 weeds as glyphosate-resistant and common across the Corn Belt states. There is glyphosate-resistant water hemp in Missouri; ragweed in Arkansas; lambs quarters, horseweed and ragweed in Ohio; horseweed in Kansas.[59] Each year, the list of resistant weeds grows. The International Survey of Herbicide Resistant Weeds[60] lists weeds resistant to EPSP synthase inhibitors (G/9) – i.e. glyphosate - and to other herbicides. Traditionally, Palmer amaranth, known as pigweed and wild spinach, is used as a medicinal plant and cooked or used as a salad vegetable. Reports say pigweed contamination is turning fields of transgenic crops into "weed battlefields". A pigweed plant produces around 10,000 seeds at a time, is drought-resistant, and has very diverse genetics. It grows as high as three metres and smothers young cotton plants.[61]

A 2010 report from the Third World Network, says, "The rapid spread of glyphosate-resistant Palmer pigweed constitutes a major agronomic failure of genetically engineered Roundup Ready seeds. This failure was foreseen by critics but dismissed by Monsanto. The critics were right. The failure is prompting US farmers to revert to agricultural practices used in the 1980s and earlier, such as hand weeding and increased tillage."[62] It continued: "Stricken by a lack of foresight across the conventional agricultural sector, farmers have little choice but to increase use of herbicides, including older chemicals banned in many countries due to their toxicity. These include paraquat and 2,4-D."

A January 2014 Dow AgroSciences Press Release[63] stated new data "indicate an astonishing 86 percent of corn, soybean and cotton growers in the South have herbicide-resistant or hard-to-control weeds on their farms. The number of farmers impacted by tough weeds in the Midwest . . . now tops 61 percent. Growers need new tools now to address this challenge." The "new tools" are their transgenic crops and associated agricultural proprietary chemicals.

Glyphosate-resistant weeds have now been found in 18 countries worldwide, with significant impacts in the US, Brazil, Australia, Argentina and Paraguay.[64] Despite the fact that New Zealand does not grow commercial transgenic crops, glyphosate-resistance has been identified in several locations, the cause given as "over application" of the herbicide.[65]

A study by David Mortensen, a plant ecologist at Pennsylvania State University, and his team, predicts total herbicide use in the US will rise from around 1.5 kilograms/hectare in 2013 to over 3.5 kilograms/hectare in 2025 as a direct result of growing transgenic crops, and that the new transgenic technologies will also lose their effectiveness.[66]

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[57] http://cropwatch.unl.edu/web/cropwatch/archive?articleID=4669108

[58] 'Resistance to HPPD-inhibiting herbicides in a population of waterhemp (*Amarathus tuberculatus*) from Illinois, United States', Hausman NE et al, *Pest Manag Sci.* March 2011;67(3): 258-61, epub Jan 262011, www.ncbi.nlm.nih.gov/pubmed/21308951

[59] http://cornandsoybeandigest.com/ag-issues/glyphosate-resistance-rising-0201.

[60] http://www.weedscience.org/summary/home.aspx,http://www.weedscience.org/summary/MOA.aspx?MOAID=12,

[61] 'Explosion Threatens Monsanto Heartlands France,' 2 May 2009, www.scoop.co.nz/stories/WO0905/S00064.htm; "'Superweed' explosion threatens Monsanto heartlands," 9 April 2009, www.france24.com/en/20090418-superweed-explosion-threatens-monsanto-heartlands-genetically-modified-US-crops, http://tiny.cc/vTMid; 'Monsanto's GM crops spawning superweed epidemic in US.' www.organicconsumers.org/articles.

[62] Genetically Engineered Backslide: The Impact of Glyphosate-Resistant Palmer Pigweed on Agriculture in the United States, © Edward Hammond 2010, http://www.twnside.org.sg/title2/biosafety/pdf/bio12.pdf

[63] http://www.agriculture-xprt.com/news/dow-agrosciences-statement-about-usda-announcement-regarding-draft-environmental-impact-statement-fo-409452

[64] International Survey of Herbicide Resistant Weeds www.weedscience.org/graphs/soagraph.aspx (2013).

[65] http://www.far.org.nz/index.php/media/entry/glyphosate-resistance-confirmed-in-new-zealand.

[66] Mortensen et al, BioScience 62, 75–84 (2012).
http://www.jstor.org/discover/10.1525/bio.2012.62.1.12?uid=3738776&uid=2129&uid=2&uid=70&uid=4&sid=21103352335931

As stated, to overcome herbicide-resistant weeds Monsanto has suggested applying glyphosate with more toxic chemicals like 2,4-D. 2,4-D is a member of the phenoxy family of herbicides manufactured from chloroacetic acid and from 2,4-dichlorophenol produced by chlorination of phenol. The process creates contaminants; e.g. isomers, dioxins,[67] monochlorophenol, and other polychlorophenols and their acids.

Developers are now aiming to release transgenic crops resistant to those more toxic herbicides, for example, 2,4-D and dicamba which belong to a chemical class associated with increased rates of diseases, including non-Hodgkin lymphoma. They are highly toxic to broadleaf crops, including many common fruit and vegetable crops, and more prone to air dispersal than glyphosate. Increased use is likely to harm neighbouring farms and uncultivated areas and inevitably result in wider use of these problematic herbicides.

2,4-D is banned in Sweden, Denmark and Norway because it is linked to cancer, reproductive harm and mental impairment. It was an ingredient in Agent Orange, along with 2,4,5-T, the herbicide used in chemical warfare in the Vietnam War. Increased usage will mean increased residues on crops.

In 2013, the USDA's Animal and Plant Health Inspection Service (APHIS) released a Draft Environmental Impact Statement[68] as part of determining whether to deregulate transgenic corn and soybean plants resistant to several herbicides, including 2,4-D: currently Dow AgriSciences' Enlist™ corn, Enlist soybean and Enlist E3™ soybean traits.[69] At the same time, the US EPA has to conduct a review of the related herbicides.

In a 2012 report, Dr Charles Benbrook said: "Contrary to often-repeated claims that today's genetically-engineered crops have and are reducing pesticide use, the spread of glyphosate-resistant weeds in herbicide-resistant weed management systems has brought about substantial increases in the number and volume of herbicides applied." Approval of transgenic corn and soybeans tolerant to 2,4-D could mean the usage volume of 2,4-D could rise "by another approximate 50%".[70]

5.2 – Glyphosate-resistant transgenes and the dangers to commercial crops

Gene movement does not always stay within a species. It can occur between species that are closely related within the same botanical family. In 2003, Britain's advisory committee on releases to the environment (ACRE) identified wild turnip, hoary mustard, wild radish, brown mustard, and wild cabbage as species from which hybrids could be formed with transgenic canola/oilseed rape. In one field trial plot of transgenic oilseed rape/canola, researchers found 46% of seeds in a wild turnip plant were contaminated with novel DNA.[71] The commercialisation of transgenic rice raises potential for gene flow to wild and weedy rice relatives[72] and to traditional commercial varieties.[73]

Other crops with a high risk of contaminating their weedy relatives include sorghum with shatter cane and Johnson grass, canola with mustards, wheat with jointed goat grass and quack grass, rice with red rice,sunflower with wild sunflower.

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[67] http://www.abc.net.au/news/2013-07-22/four-corners-dangerous-dioxins/4833848

[68] http://www.regulations.gov/#!docketDetail;D=APHIS-2013-0042

[69] http://www.aphis.usda.gov/wps/portal/aphis/newsroom/news?1dmy&urile=wcm%3apath%3a%2FAPHIS_Content_Library%2FSA_Newsroom%2FSA_News%2FSA_By_Date%2FSA_2014%2FSA_01%2FCT_eis_ge_products

[70] 'Impacts of genetically engineered crops on pesticide use in the US - the first sixteen years', Dr Charles M Benbrook, Centre for Sustaining Agriculture and Natural Resources, 2012, 24:24 doi:10.1186/2190-4715-24-24. http://www.enveurope.com/content/24/1/24

[71] www.guardian.co.uk/science/2003/jul/10/gm.sciencenews

[72] Lu & Snow, 2005

[73] Day-Rubinstein et al, 'Crop Genetic Resources:An Economic Appraisal', Economic Information Bulletin, Economic Research Service, USDA, May 2005) www.ers.usda.gov/publications/eib2/eib2.pdf

Wild radish, wild turnip, wild cabbage and other wild *Brassica* species grow in New Zealand. Sorghum is grown in warmer areas for summer feed and although rare Johnson grass has been found growing. For details of weed species check with Key to Weed Species of New Zealand[74], Massey University Weed Species Data Base[75], the Foundation for Arable Research[76] and The Foragers Year[77].

Brassica crops related to canola are grown in Australia. Volunteer populations of transgenic herbicide-resistant canola have implications for gene flow into weeds species and vegetable crops, and roadside volunteers have the potential to contaminate adjacent crops. Out-crossing rates can result in a substantial number of out-crossed seed per hectare.[78]

Based on studies elsewhere of gene flow into weed species, we can assume interspecific hybridization will occur in certain species combinations.[79] Introgression of herbicide resistant genes or other transgenic traits from *Brassica napus* to the cultivated species *B. rapa* and *B. juncea* is possible if the species are in physical proximity.[80] [81] [82]

Since its commercial introduction in the mid 1990s, herbicide-resistant canola has been widely grown by Canadian farmers, principally Liberty Link varieties with glufosinate ammonium as its active ingredient and Roundup varieties containing glyphosate. A Greenpeace report in 2005[83] stated that by that time it had become virtually impossible for Canadian farmers to grow canola that was not genetically engineered. Evidence of seed contamination is also given in the Union of Concerned Scientists' Report, 'Gone to Seed - Transgenic Contaminants in the Traditional Seed Supply'.[84]

5.3 – Containment of glyphosate-resistant transgenes

Using genetic engineering technology to change one gene does not necessarily change only one function. A variety of changes in transgene expression can occur in a created organism, and each novel DNA sequence is different. The potential for problems starts there.

Glyphosate-resistant and other transgenic crops had been grown commercially for a decade when a Committee under the auspices of the US National Research Council examined the potential consequences of what effect/s transgenes might have on natural or managed ecosystems and human health. In its report, 'Biological Confinement of Genetically Engineered Organisms' (2004), it states, "It is unlikely that 100% confinement will be achieved by a single method."[85] Studies and reports on transgene transfer are numerous.

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74 http://www.landcareresearch.co.nz/resources/identification/plants/weeds-key

75 http://www.massey.ac.nz/massey/learning/colleges/college-of-sciences/clinics-and-services/weeds-database/weeds-database_home.cfm

76 http://www.far.org.nz/index.php/

77 http://foragersyear.wordpress.com/

78 'Gene flow study: Implications for the release of genetically modified crops in Australia', Glover et al, http://data.daff.gov.au/brs/brsShop/data/12860_gene_flow_report.pdf

79 'Outcrossing Potential for Brassica Species and Implications for Vegetable Crucifer Seed Crops of Growing Oilseed Brassicas in the Willamette Valley', James R Myers Oregon State University Extension Service Special Report 1064 January 2006 http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/6304/SR%20no.%201064_OCR.pdf

80 http://abe.dynamicweb.dk/images/files/Gene%20flow%20to%20other%20Brassiceae%20species%20report%20-%20April%2002.pdf Gene flow between brassica napus and other brassicaceae species, Dr Phil Salisbury Institute of Land and Food Resources, University of Melbourne, Report: PAS0201 April 2002

81 'Weeds, Resistance and Gene Flow', Christopher Preston, School of Agriculture, Food & Wine, University of Adelaide, Out crossing between canola and wild radish http://www.australianoilseeds.com/__data/assets/pdf_file/0019/7363/Weeds,_Resistance_and_Gene_Flow_Chris_Preston_Canola_Workshop_20_March_09.pdf

82 'Risk assessment of outcrossing of transgenic Brassica, with focus on B. Rapa and B. Napus', R.K. Downey, AAFC Saskatoon Research Centre, Canada, http://www.regional.org.au/au/gcirc/4/61.htm

83 http://www.greenpeace.org/international/Global/international/planet-2/report/2005/5/canola-report.pdf

84 http://www.ucsusa.org/assets/documents/food_and_agriculture/seedreport_fullreport.pdf

85 http://www.nap.edu/openbook.php?record_id=10880

5.4 – Glyphosate-resistant transgenes in landraces

Of particular concern is introgression with species known as landraces in areas referred to as 'centres of origin'. A landrace is a local variety of a plant species which has developed over millennia by adaptation to the natural and cultural environment in which it grows. Landraces are the storehouses of humanity's basic stock heirloom varieties.

Such natural genetic diversity and crossbreeding has led to gains in agricultural productivity and quality. For example, following the disastrous Southern Corn Leaf Blight in 1970,[86] new hybrids were bred from Mexico's corn/maize landraces, saving the Southern US states from further significant crop and livelihood losses.

Mexico is the centre of origin of maize/corn[87] and because of potential risks to its landraces cultivation of transgenic corn was banned there from 1998. Despite this precaution, transgenic material has been found in landraces in Mexico's remote regions, with higher concentrations near major transport arteries. Under the North American Free Trade Agreement, Mexico has moved from exporting to importing corn, corn largely trucked from the US, without being milled, along main highways. Many blame seed spillage from this mode of transport for the landrace contamination.[88] In 2013, a judge threw out the appeals of Monsanto and Mexico's Environment and Natural Resources Ministry to overturn a court ruling that continued the ban on planting transgenic maize in Mexico.[89] [90] [91]

5.5 – Glyphosate-resistant transgenes in human gut bacteria

Gene flow has even been recorded in the human gut. Transgenic soy represents 77% of soy production globally. The list on http://www.soyconnection.com/soyfoods/product_overview.php demonstrates how easily most consumers could ingest multiple helpings of soy transgenes via food daily. The single study commissioned by the UK Food Standards Agency on human volunteers and carried out at the University of Newcastle demonstrated that transgenic DNA from soybeans in the form of a burger and a milkshake found its way into the gut bacteria of the human volunteers.[92]

6 – Glyphosate – what farmers face

In 2012, the USDA indicated 88 percent of corn/maize grown in the country was transgenic. When a study found glyphosate enhances the growth of aflatoxin-producing fungi, lending an explanation for the substantial increase in fungal toxins now found in corn grown in the US,[93] the potential for large areas to be affected is plain.

Canadian Percy Schmeiser farms in Bruno, Saskatchewan, breeding and growing canola. In 1997, he found Roundup Ready canola plants growing near his farm. To prove this, he sprayed his nearby field with Roundup and found much of the crop was glyphosate-resistant. He saved this harvest separately, and intentionally planted it in 1998. Monsanto approached him to pay a license fee for using their

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[86] http://www2.nau.edu/~bio372-c/class/sex/cornbl.htm

[87] http://aboutbiodiversity.org/agbdx/cornblight.html. See FAQ Country of Origin www.psgr.org.nz.

[88] David Quist,'Vertical Trans(gene) Flow:Implications for Crop Diversity and Wild Relatives', Third World Network, 2010, www.twnside.org.sg/title2/biosafety/pdf/bio11.pdf

[89] 'Mexican Judge Throws out Monsanto Appeal to Confirm GM Maize Ban', 30 December 2013, Sustainable Pulse http://sustainablepulse.com/2013/12/30/mexican-judge-throws-monsanto-appeal-confirm-gm-maize-ban/

[90] Piñeyro-Nelson, A. et al. Mol. Ecol. 18, 750–761 (2009).

[91] Mercer, K. L. & Wainwright, J. D. Agric. Ecosyst. Environ. 123, 109–115 (2008).

[92] Netherwood, T. et al. (2004). Assessing the survival of transgenic plant DNA in the human gastrointestinal tract. Nature Biotech. 22, 204-209. doi:10.1038/nbt934 http://www.nature.com/nbt/journal/v22/n2/full/nbt934.html

[93] 'Influence of herbicide glyphosate on growth and aflatoxin B1 production by Aspergillus section Flavi strains isolated from soil on in vitro assay', Barberis et al, J Environ Sci Health B. 2013; 48(12): 1070-9. doi: 10.1080/03601234.2013.824223; http://www.ncbi.nlm.nih.gov/pubmed/24007484.

patented technology without a licence. Schmeiser refused, claiming that the actual seed was his because it had grown on his land. Monsanto sued Schmeiser for patent infringement. The case went through the Canadian courts over several years until a Supreme Court 5-4 ruling found in favour of Monsanto. In 1999, Schmeiser filed a separate lawsuit against Monsanto for ten million dollars for "libel, trespass, and contamination of his fields with Roundup Ready Canola."[94]

Many conventional farmers, on finding transgenic contamination in their fields, have been fined by Monsanto Company, some even losing their livelihood because of financial hardship created by fines and court costs. In Bowman v. Monsanto Company, a US Supreme Court also found in favour of Monsanto[95] and a Reuters article in January 2014 reported that the Supreme Court upheld Monsanto's case against the Organic Seed Growers and Trade Association, organic and conventional family farmers, seed companies and public advocacy interests, who had collectively sought a legal standing to prohibit the company from suing farmers whose fields became inadvertently contaminated with its transgenic crops.[96]

In August 2012, conventional farmer, Bob Mackley, spoke in New Zealand about transgenic crops and their effects in his native Australia. He reported that many Australian farmers have suffered significant losses as a result of transgene contamination of their conventional crops, and that legislation favours seed companies, not farmers. Legally without the means to protect his livelihood, Mackley has been forced to time his plantings to avoid contamination from transgenic crops grown by a neighbour. His is a critical balance between profit or contamination and loss.

Australian, Steve Marsh, an organic farmer, sought AUD$85,000 compensation from a neighbour who grows transgenic crops, claiming the neighbour's crop contaminated 70 percent of his property. His action was dismissed and all issues as to costs reserved.[97]

Over millennia, farmers learned from experience. Like Percy Schmeiser, who spent his farming life developing his canola seed crop, they selected the best seed for next year's crop to improve yields and quality. Crops were varied and rotated on small acreages, with some land left fallow each year. This method largely solved the potential problems that affect monoculture practices today.

7 - Glyphosate and its effects on human health

With pharmaceuticals a risk benefit judgment needs to be made by a medical professional before any initiation of their use. Pharmaceuticals are clearly distinct and identifiable single agents, whereas food derived using genetic engineering technology contains transgenes, possibly from multiple sources, with unpredictable changes in plant chemistry and often higher levels of accompanying chemical residues. These are multiple, complex and poorly defined alterations compared with those from a food sourced from non-genetically engineered sources.

'Informed consent' is a basic of patient-physician and subject-researcher relationship. It involves making the participant aware of and verifying understanding of the risks, benefits, facts, and the future implications of the procedure or test to which they are going to be subjected.[98]

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[94] Percy Schmeiser Wikipedia various

[95] http://en.wikipedia.org/wiki/Bowman_v._Monsanto_Co.

[96] 'Monsanto critics denied U.S. Supreme Court hearing on seed patents' Washington, 13 January 2014 http://www.reuters.com/article/2014/01/13/us-usa-court-monsanto-idUSBREA0C10H20140113

[97] http://news.sciencemag.org/people-events/2014/02/organic-farmer-sues-gm-farming-neighbor. Court Transcripts http://www.supremecourt.wa.gov.au/T/transcripts.aspx. http://decisions.justice.wa.gov.au/supreme/supdcsn.nsf/PDFJudgments-WebVw/2014WASC0187/%24FILE/2014WASC0187.pdf

[98] 'The World's Largest Human Experiment, Monsanto Glyphosate-based Roundup Herbicide', by Madison Ruppert, Part One, GMOs, Roundup and The Monsanto Monstrosity, 10 July 2011 http://www.bibliotecapleyades.net/ciencia/ciencia_monsanto62.htm

The definition of informed consent used by US Food and Drug Administration (FDA) is complicated, a virtual "get out of jail free" card. After public outcry, US regulators adopted voluntary labelling of products with transgenic ingredients.[100] In contrast, guidelines approved by the Codex Alimentarius Commission allows countries to label transgenic foods and foods containing transgenic ingredients without breaching international free trade laws.[100]

What is fact is that consumers – particularly citizens in the US where some 40 percent of transgenic crops are grown – have been guinea pigs for close to two decades, given little choice but to ingest multiple unlabelled transgenic foods or food ingredients on a daily basis, day in day out, year round. With about 94% of US soybean farmers and 72% of corn farmers using Roundup Ready crops, common ingredients in a substantial range of food products, a large majority of foods come from glyphosate-resistant crops to some extent. In addition, animals fed glyphosate-resistant crops will bio-accumulate glyphosate and/or glyphosate metabolites, adding to the human end-user's intake.[99]

The safety of glyphosate use on herbicide-resistant crops has not been substantiated by rigorous, independent scientific research. Studies used to legitimize approvals are generally industry studies, often neither published nor peer-reviewed, and taken over a too-short timeframe. Guidelines issued recently by the European Food Safety Authority call for two-year whole food feeding studies to assess the risks of long-term toxicity.[100] This is an improvement on current practices.

7.1 - Glyphosate – exposure for humans

Commonly, people applying glyphosate-based herbicides do not use personal protective equipment and take few other precautions to protect themselves or their families.

Proponents say glyphosate does not easily pass through human skin, that when taken in through the skin or by mouth it is eliminated in less than one day, leaving the body via urine and faeces without changing into another chemical. However, studies with rats showed about one-third of a dose of glyphosate was absorbed by the rats' intestines, and half found in their stomachs and intestines six hours later. All traces were gone within one week.[27]

Glyphosate residues are found in the Western diet, particularly associated with transgenic food sources. It is estimated 90 percent of transgenic crops grown worldwide are glyphosate resistant[101] and the four main crops are commonly used as food or food ingredients for the human food chain: soy, corn/maize, cottonseed and canola/oilseed rape. They also commonly appear in animal feed.

Pure glyphosate is claimed as low in toxicity, but there is evidence of numerous adverse effects. Additionally, it is formulated with various adjuvants (agents) added to assist efficacy, sold under many trade names[102], and these adjuvants, while often labelled 'inert', can confer additional toxicity.[103]

Negative impacts on the body may manifest slowly over time by damaging cellular systems, and causing oxidative stress and endocrine disruption, all general mechanisms of harm that result in insidious effects.

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[99] http://extoxnet.orst.edu/tibs/bioaccum.htm, http://www.saferchemicals.org/resources/chemicals/pbts.html

[100] EFSA Journal 2013;11(7):3347 [18 pp.]. doi:10.2903/j.efsa.2013.3347, European Food Safety Authority, Scientific Report of EFSA On request from: European Commission Question number: EFSA-Q-2013-00316 Pub 31 July 2013, Affiliation: European Food Safety Authority (EFSA) Parma Italy, http://www.efsa.europa.eu/en/efsajournal/pub/3347.htm.

[101] Powles (2008) Glyphosate: a once-in-a-century herbicide, Pest Manag Sci 64: 319-325 http://onlinelibrary.wiley.com/doi/10.1002/ps.1518/abstract

[102] See http://en.wikipedia.org/wiki/Glyphosate for trade names. Those other ingredients can make the product more toxic.

[103] National Pesticide Information Centre, General Fact Sheet, Glyphosate http://npic.orst.edu/factsheets/glyphogen.pdf

In 2002, Chemical Research in Toxicology, a publication of the American Chemical Society, published a paper about the effect on cell cycle regulation of glyphosate-containing Roundup. It concluded: ". . . our results question the safety of glyphosate and Roundup on human health."[104]

Researchers in one study concluded, "the direct effect of glyphosate on early mechanisms of morphogenesis in vertebrate embryos opens concerns about the clinical findings from human offspring in populations exposed to glyphosate-based herbicides in agricultural fields."[105]

A recent study detected glyphosate in 43.9% of human urine samples taken from participants living in urban areas in 18 European countries. It concluded, "the evidence suggests that a significant proportion of the population could have glyphosate in their bodies – and it is not clear where it is coming from."[106]

Another recent study found glyphosate in samples of breast milk in lactating mothers in the US. The levels found were 76 ug/l to 166 ug/l. That is 760 to 1600 times higher than the European Drinking Water Directive allows for individual pesticides, but less than the 700 ug/l maximum contaminant level (MCL) for glyphosate in the US decided upon by the EPA based on the false premise that glyphosate was not bio-accumulative.[107]

Independent work on rats has shown that both glyphosate and its metabolite AMPA were eliminated slowly from plasma and, although bioavailability was only 23.21%, it is likely that glyphosate is distributed throughout the body by the blood's circulation and there may be considerable diffusion of it into tissues to exert systemic effects[108] and where it may accumulate.

Bioaccumulation is a normal process of growth and nurturing of organisms. All animals, including humans, bioaccumulate nutrients and can bioaccumulate substances in the body to levels that can cause harm. A typical food chain bioaccumulation process is plant uptake from soil or spray, animal eating plant, human eating animal. Each step can result in increased bioaccumulation including toxins where absorption of a substance is at a rate greater than that at which the substance is lost or eliminated.[101]

Researchers in one study concluded that animals and humans eating transgenic soy "chronically incorporate unknown amounts of this herbicide" and residues of glyphosate in the tissues and organs of food animals that have been fed with transgenic feed are not taken into account in legislation[109] nor studied in detail.

7.2 – Glyphosate – mechanisms of action

In a study published in February 2014, researchers detailed how they evaluated the effect "on haemolysis, haemoglobin oxidation, reactive oxygen species (ROS) formation and changes in morphology of human erythrocytes" (red blood cells) "exposed to different concentrations of glyphosate and its metabolites and impurities (0.01–5 mM) for 1, 4 and 24 h."

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[104] 'Pesticide Roundup provokes cell division dysfunction at the level of CDK1/cyclin B activation'. Marc et al, 2002, Chem Res Toxicol. 2002 Mar;15(3):326-31. http://www.ncbi.nlm.nih.gov/pubmed/11896679. Glyphosate-based herbicides are toxic and endocrine disruptors in human cell lines', Gasnier et al, 2009, Toxicology 262 (2009) 184–191, http://www.gmoseralini.org/wp-content/uploads/2013/01/Gasnieral.TOX_2009.pdf

[105] 'Glyphosate-Based Herbicides Produce Teratogenic Effects on Vertebrates by Impairing Retinoic Acid Signaling', Paganelli et al, Chem. Res. Toxicol., 2010, 23 (10), pp 1586–1595 DOI: 10.1021/tx1001749, Copyright © 2010 American Chemical Society, http://pubs.acs.org/doi/abs/10.1021/tx1001749

[106] http://www.foeeurope.org/sites/default/files/press_releases/foee_1_introducing_glyphosate.pdf

[107] Honeycutt Z, Rowlands H. 2014. Glyphosate Testing Report: Findings in American Mothers' Breast Milk, Urine and Water. Moms across America and Sustainable Pulse. http://www.momsacrossamerica.com/glyphosate_testing_results. See 100 for bioaccumulation.

[108] Anadón et al 2009, http://www.ncbi.nlm.nih.gov/pubmed/19607892.

[109] 'Detection of Glyphosate Residues in Animals and Humans'. Krüger et al., J Environ Anal Toxicol 2014, 4:2 http://dx.doi.org/10.4172/2161-0525.1000210, J Environ Anal Toxicol4: 210. doi: 10.4172/2161-0525.1000210, http://omicsonline.org/open-access/detection-of-glyphosate-residues-in-animals-and-humans-2161-0525.1000210.pdf

They concluded their "results clearly show that the changes induced in the erythrocytes can occur only as a result of poisoning with these compounds" and list AChE, acetylcholinesterase, AMPA, aminomethylphosphonic acid, PMIDA, N-(phosphonomethyl)iminodiacetic acid, ROS, reactive oxygen species, H2R123, dihydrorhodamine 123, and NAC, N-acetylcysteine.[110]

In 2009, researchers published the paper 'Glyphosate Formulations Induce Apoptosis and Necrosis in Human Umbilical, Embryonic, and Placental Cells'.[111] Apoptosis is the natural process of programmed cell death that allows human foetuses to develop fingers, toes and other features. Necrosis is the premature death of living cells and living tissues. The study evaluated the toxicity of four different glyphosate-based herbicides in Monsanto's Roundup products range in solutions diluted 100,000 times. This is far below the level at which it is used in agricultural applications and corresponds to levels detected in foods for human consumption and animal feeds.

The researchers tested applications on three distinct human cell types - embryonic, placental, and umbilical – and tested glyphosate alone and the Roundup formula. All of the heavily diluted Roundup formations caused total cell death within twenty-four hours through necrosis, showing Roundup induces apoptosis, causing DNA fragmentation, shrinkage of the nucleus, and fragmentation of the nucleus. It induced complete cell death, whereas glyphosate alone induced only apoptosis. Conclusive evidence proved Roundup adjuvants change the permeability of the three human cells studied, showing they are not inert ingredients as claimed. The researchers concluded: ". . . the proprietary mixtures available on the market could cause cell damage and even death around residual levels to be expected, especially in food and feed derived from (Roundup) formulation-treated crops".

Researchers tested urine samples from a farmer who sprayed a glyphosate-based herbicide on his land. They included his family as two children were born with birth defects that could potentially be allied to pesticides.[112] Glyphosate residues were measured in samples taken a day before, during, and two days after spraying using liquid chromatography-linear ion trap mass spectrometry. Glyphosate presence reached a peak of 9.5 µg/L in the farmer after spraying, and 2 µg/L were found in him and in one child living 1.5 kilometres from the field, two days after the applications. The researchers noted that oral or dermal absorptions could explain the differential pesticide excretions, even in family members at a distance from the fields. Limits of detection and quantification were respectively 1 and 2 ppb.

In 'Impacts of environmental toxicants on male reproductive dysfunction', Wong and Cheng (2011) highlighted the role of endocrine disruptors in embryonic development include epigenetic effects:

"Studies in the testis and other organs have illustrated the importance of environmental toxicant-induced oxidative stress in mediating disruption to cell junctions. This, in turn, is regulated by the activation of PI3K/c-Src/FAK and MAPK signalling pathways, with the involvement of polarity proteins. This leads to reproductive dysfunction such as reduced sperm count and reduced quality of semen."[113]

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[110] 'The effect of metabolites and impurities of glyphosate on human erythrocytes (in vitro)', Marta Kwiatkowskaa, Bogumiła Hurasb, Bożena Bukowskaa, Pesticide Biochemistry and Physiology, Volume 109, February 2014, Pages 34–4,3http://dx.doi.org/10.1016/j.pestbp.2014.01.003.

[111] Benachour and Séralini, University of Caen, Laboratory Estrogens and Reproduction, France, Chem. Res. Toxicol., 2009, 22 (1), pp 97–105 DOI: 10.1021/tx800218n, © 2008 American Chemical Society http://pubs.acs.org/doi/abs/10.1021/tx800218n

[112] 'Glyphosate Exposure in a Farmer's Family', Mesnage et al, 2012, Journal of Environmental Protection, Vol. 3 No. 9 (2012) , Article ID: 22645, DOI:10.4236/jep.2012.39115. http://file.scirp.org/Html/3-6701610_22645.htm

[113] E. W. Wong and C. Y. Cheng, "Impacts of Environmental Toxicants on Male Reproductive Dysfunction," Trends in Pharmacological Sciences, Vol. 32, No. 5, 2011, pp. 290- 299. doi:10.1016/j.tips.2011.01.001, http://www.ncbi.nlm.nih.gov/pubmed/21324536.

Other researchers have also demonstrated endocrine disruption, concluding "a real cell impact of glyphosate-based herbicides residues in food, feed or in the environment has thus to be considered, and their classifications as carcinogens/mutagens/reprotoxics" discussed.[114]

Researchers Anthony Samsel and Stephanie Seneff have proposed that glyphosate may inhibit cytochrome P450 (CYP) enzymes and that this is an overlooked component of its toxicity to mammals.[115] CYP enzymes play a crucial role in detoxifying xenobiotics. They suggest glyphosate enhances the damaging effects of other food-borne chemical residues and environmental toxins. They also suggest that interference with CYP enzymes acts synergistically with disruption of the biosynthesis of aromatic amino acids by gut bacteria, as well as impairment in serum sulphate transport. They put forward the argument that the consequences are most of the diseases and conditions associated with a Western diet, which include gastrointestinal disorders, obesity, diabetes, heart disease, depression, autism, infertility, cancer and Alzheimer's disease.

The journal *Anaerobe* published a study which confirms the herbicide's ability to adversely affect gut bacteria populations, i.e. generate dysbiosis, in particular predispose to increased botulism in cattle.[44] [116]

7.3 Acute effects

Glyphosate in spray form may cause eye or skin irritation, and/or irritation in the nose and throat. Swallowing it can increase saliva, burn the mouth and throat, cause nausea, vomiting, and diarrhoea, and death. It is used as a suicide agent in some countries.

If pets touch or eat plants wet with spray from glyphosate-containing products they may drool, vomit, have diarrhoea, lose their appetite, or seem sleepy.[27]

Since 2000, a US government backed programme has been funding the Colombian government to aerial spray coca and opium crops.[117] In 2006, 171,613 hectares were sprayed with Roundup-Ultra which is 43.9% glyphosate, with adjuvants POEA and Cosmo-Flux 411 F.[118] PANAP says this has resulted in widespread animal deaths and food crop losses, and human ailments commonly include: vomiting; diarrhoea; abdominal pain; gastrointestinal infections; itchy, burning skin; rashes and infections (particularly in children); blisters; burning or weeping eyes; blurred vision; conjunctivitis; headaches; fever; rapid heartbeat; palpitations; raised blood pressure; dizziness and balance disorders; chest pains; numbness; insomnia; depression; debilitation; breathing difficulties; respiratory infections; dry cough; sore throat; an unpleasant taste in the mouth; reduced cognitive capacity; seizures; impaired vision, smell, hearing; drop in blood pressure; twitches and tics; muscle paralysis; peripheral neuropathy; loss of gross and fine motor skills; excessive sweating; severe fatigue.[51]

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[114] 'Glyphosate-Based Herbicides Are Toxic and Endocrine Disruptors in Human Cell Lines,' Gasnier et al, Toxicology, Vol. 262, No. 3, 2009, pp. 184-191. doi:10.1016/j.tox.2009.06.006, http://www.gmoseralini.org/wp-content/uploads/2013/01/Gasnieral.TOX_2009.pdf
'Occupational Exposure of Forest Workers to Glyphosate during Brush Saw Spraying Work,' Jauhiainen et al, American Industrial Hygiene Association Journal, Vol. 52, No. 2, 1991, pp. 61-64. doi:10.1080/15298669191364334, http://oeh.tandfonline.com/doi/abs/10.1080/15298669191364334?queryID=%24{resultBean.queryID}&#.U1bO-KKVrSM

[115] Entropy 2013, 15(4), 1416-1463; doi:10.3390/e15041416. 'Glyphosate's Suppression of Cytochrome P450 Enzymes and Amino Acid Biosynthesis by the Gut Microbiome: Pathways to Modern Diseases', Samsel and Seneff pub. 18 April 2013. http://www.mdpi.com/1099-4300/15/4/1416

[116] Monika Krüger, Awad Ali Shehata, Wieland Schrödl, Arne Rodloff. 'Glyphosate suppresses the antagonistic effect of Enterococcus spp. on Clostridium botulinum'. Anaerobe. 2013 Feb 6. Epub 2013 Feb 6. PMID: 23396248

[117] http://link.springer.com/chapter/10.1007/978-0-387-36903-7_2#page-1

[118] Pesticide Action Network Asia and the Pacific, Glyphosate 2009 www.panap.net/sites/default/files/monograph_glyphosate.pdf

7.4 – Glyphosate – associated allergic reactions

Novel DNA introduced into a plant's genome can result in the production of proteins that may be new to the human diet. The more transgenic plants present in the food chain, the more people will potentially be consuming proteins new to their diet. Allergic reactions to these new proteins may not reveal themselves immediately.

Many symptoms identified in a UK study into allergic reactions to transgenic soy may be related to glyphosate exposure; e.g. irritable bowel syndrome, digestion problems, chronic fatigue, headaches, lethargy, skin complaints. Other glyphosate-tolerant crops may potentially present similar results.[119]

7.5 - Glyphosate – reproductive health

Exposure to glyphosate-based herbicides, even at very low doses may result in reproductive and hormonal problems, miscarriages, low birth weights, pre-term deliveries, and birth defects.[51]

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.[51]

Some 95% of Argentina's annual crop of 47 million tonnes of soybean is transgenic Roundup Ready soybean on which 200 million litres of glyphosate are applied annually, mainly by aerial spraying.[51] Two years after widespread aerial spraying of Roundup onto transgenic soybean crops began in 2002, human birth malformations were reported in rural areas.

Professor Andres Carrasco was an embryologist at the University of Buenos Aires Medical School. He and researchers from the UK, US, Brazil and Argentina have shown glyphosate causes malformations in frog and chicken embryos at doses far lower than those used in agricultural spraying and well below maximum residue levels in products presently approved in the European Union (20 mg/kg for soy).[120] The test animals used by Carrasco's group share similar developmental mechanisms with humans.

The researchers concluded their results "raise concerns about the clinical findings from human offspring in populations exposed to Roundup in agricultural fields." Professor Carrasco stated, "The findings in the lab are compatible with malformations observed in humans exposed to glyphosate during pregnancy." He claimed, "The toxicity classification of glyphosate is too low. In some cases this can be a powerful poison."

In 1997, the maximum residue level (MRL) allowed for glyphosate in soy in the EU was raised 200-fold from 0.1 mg/kg to 20 mg/kg. Carrasco found malformations in embryos injected with 2.03 mg/kg glyphosate. Soybeans can typically contain glyphosate residues of up to 17mg/kg. Levels of up to 97 mg/kg have been reported in seven of 11 maize samples in Argentina, tests three months later producing the same results. At that time the MRL was 20 mg/kg. This has since been raised by the US FDA to 40 mg/kg.[121]

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119 http://www.responsibletechnology.org/gmo-dangers/health-risks/articles-about-risks-by-jeffrey-smith/Genetically-Engineered-Foods-May-Cause-Rising-Food-Allergies-Genetically-Engineered-Soybeans-May-2007

120 http://ec.europa.eu/sanco_pesticides/public/?event=activesubstance.detail

121 Paganelli, A., Gnazzo, V., Acosta, H., López, S.L., Carrasco, A.E. 2010. Glyphosate-based herbicides produce terato-genic effects on vertebrates by impairing retinoic acid signaling. Chem. Res. Toxicol., August 9. http://pubs.acs.org/doi/abs/10.1021/tx1001749. Study Shows Monsanto Roundup Herbicide Link to Birth Defects, by F William Engdahl, Global Research, 30 September 2010, http://www.globalresearch.ca/study-shows-monsanto-roundup-herbicide-link-to-birth-defects/21251.

7.6 - Glyphosate – genotoxicity, endocrine disruption and cancer

Exposure to glyphosate-based herbicides, even at very low doses may result in various cancers - especially haematological cancers such as non-Hodgkin lymphoma, and hormonal cancers such as breast cancer. Several epidemiological studies have linked exposure to glyphosate with non-Hodgkin lymphoma, hairy cell leukaemia, multiple myeloma, and DNA damage.[51]

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.[51]

A 2013 study found the effects of pure glyphosate on oestrogen receptors mediated transcriptional activity and their expressions. Results indicated that low and environmentally relevant concentrations of glyphosate possessed estrogenic activity, in particular causing the growth of breast cancer cells, and there was an additive estrogenic effect between glyphosate and genistein, a phytoestrogen in soybeans.[122]

Other studies have shown that it causes oxidative stress, cell-cycle dysfunction, and disruption to RNA transcription, all of which can contribute to carcinogenicity.[51]

In 2001, 200 cases of cancer were reported in the Argentinean village of Ituzaingo which has 5000 residents. By 2009 there were 300, 41 times the national average. The community has also seen many malformed babies born. After documenting the tragedies, a group took their case to court. In 2006, the provincial Supreme Court ruled to prohibit the use of agrochemicals within 1000 metres of residential areas in the province of Cordoba.[123]

7. 7 Other health impacts

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-Deficit/Hyperactivity Disorder (ADHD). Under other effects, a PANAP report says: "Glyphosate damages liver cells and interferes with a number of enzymes important in metabolism."[51]

Jasper et al (2012)[124] found exposure to Roundup, even at low doses and for a relatively short period of time, can induce serious hepatic and haematological damage. Long-term exposure from contaminated soil or water, even at low concentrations, can lead to serious human health problems, including liver damage, anaemia, and conditions associated with ROS, such as different types of cancer and neurodegenerative diseases.

Brief exposure to a Brazilian glyphosate formulation caused liver damage in rats the researchers concluded indicated irreversible damage to liver cells. [125] [126]

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[122] 'Glyphosate induces human breast cancer cells growth via estrogen receptors', Thongprakaisang et al, Food Chem Toxicol. 2013 Sep; 59:129-36. doi: 10.1016/j.fct.2013.05.057. http://www.ncbi.nlm.nih.gov/pubmed/23756170

[123] http://www.cipamericas.org/archives/1765

[124] 'Evaluation of biochemical, hematological and oxidative parameters in mice exposed to the herbicide glyphosate-Roundup®', Jasper et al, Interdiscip Toxicol. Sep 2012; 5(3): 133–140. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3600513/

[125] 'The effects of sub-chronic exposure of Wistar rats to the herbicide Glyphosate-Biocarb®', Benedettia et al, Toxicol Lett. 2004 Nov 2;153(2):227-32. http://www.ncbi.nlm.nih.gov/pubmed/15451553

[126] 'Effects of phenoxyherbicides and glyphosate on the hepatic and intestinal biotransformation activities in the rat', Hietanen et al, Acta Pharmacol Toxicol (Copenh) 53 (2): 103–12. doi:10.1111/j.1600-0773.1983.tb01876.x. http://www.ncbi.nlm.nih.gov/pubmed/6624478

A 2013 review paper on glyphosate prepared for the Scottish Parliament can be viewed on http://www.gmwatch.org/index.php/news/archive/2013/15047-glyphosate-destructor-of-human-health-and-biodiversity. The findings detail the impact of glyphosate on human health and the environment.

Despite such findings of adverse, or at least questionable, effects, there remains no official monitoring of the consequences to the human population ingesting transgenes or from glyphosate-based herbicides and consumers have no official notification of risks.

8 - Glyphosate – the conclusion

Glyphosate may be one of the most biologically disruptive chemicals in the human and physical environment, in part because of its wide range of effects at the cellular level and in part because the extraordinary extent of its use and its insertion into our daily diet means constant exposure to it of virtually everyone. The range of diseases now associated with glyphosate-based herbicides should ring alarm bells. Their biological effects are primary. Virtually every bodily system can be adversely affected.

In their study, researchers Anthony Samsel and Stephanie Seneff state[122]: "Our systematic search of the literature has led us to the realization that many of the health problems that appear to be associated with a Western diet could be explained by biological disruptions that have already been attributed to glyphosate. These include digestive issues, obesity, autism, Alzheimer's disease, depression, Parkinson's disease, liver diseases, and cancer, among others. While many other environmental toxins obviously also contribute to these diseases and conditions, we believe that glyphosate may be the most significant environmental toxin."

The toxic effects of glyphosate take a considerable time to manifest overtly and no health or regulatory body is officially looking for what effects may have occurred, making it easy to claim glyphosate is not harmful, and allow usage and sales to continue.

There is no need to take risks with glyphosate-resistant transgenic crops when there already exists effective, sustainable solutions to the problems that this novel technology is claimed to address. Conventional plant breeding, in some cases helped by safe modern technologies like gene mapping and marker assisted selection, continues to outperform genetically engineered crops in producing high-yield, drought-tolerant, and pest- and disease-resistant plants that can meet present and future food needs.[127]

Agro-ecological methods of farm management render the use of glyphosate redundant. Numerous methods exist to manage weeds without recourse to chemicals that undermine both human health and ecological stability.

Physicians and Scientists for Global Responsibility New Zealand Charitable Trust
June 2014

Reviewed by Meriel Watts, PhD; Coordinator Pesticide Action Network Aotearoa NZ

[127] 'An evidence-based examination of the claims made for the safety and efficacy of genetically modified crops' (June 2012)Earth Open Source http://earthopensource.org/index.php/reports/58

Further material for your convenience

'Introducing Glyphosate, the world's biggest selling herbicide', Friends of the Earth Europe, June 2013
http://www.foeeurope.org/sites/default/files/press_releases/foee_1_introducing_glyphosate.pdf

GeneWatch UK and Greenpeace International maintain a register of documented releases of transgenic organisms and contaminated foodstuffs on www.gmcontaminationregister.org.

'Who Owns Nature? Corporate Power and the Final Frontier in the Commodification of Life' on
www.etcgroup.org/sites/www.etcgroup.org/files/publication/707/01/etc_won_report_final_color.pdf.

Glyphosate Effects on Crops, Soils, Animals and Consumers, Europe – UK 31 October 2011, Don M Huber, Emeritus Professor of Plant Pathology, Purdue University, Lafayette, IN,
http://www.nvlv.nl/downloads/Powerpoint_presentatie_lezing_Don_Huber_25_okt_2011.pdf

'Glyphosate: The Elephant in the Room' a power-point presentation http://people.csail.mit.edu/seneff/, scroll down and click on "(Powerpoint Slides) (PDF Version)".

'Glyphosate poisoning', Bradberry et al, 2004, Toxicol Rev. 2004;23(3):159-67.
http://www.ncbi.nlm.nih.gov/pubmed/15862083

US National Pesticide Information Centre http://npic.orst.edu/factsheets/glyphotech.html and
US Environmental Protection Agency - Technical Factsheet on: GLYPHOSATE
http://www.epa.gov/safewater/pdfs/factsheets/soc/tech/glyphosa.pdf

Glyphosate fact sheet - Pesticide Action Network UK http://www.pan-uk.org/pestnews/Actives/glyphosa.htm

Glyphosate Facts 2013 Industry Task Force on Glyphosate
http://www.glyphosate.eu/glyphosate-basics/what-glyphosate

Avoiding Glyphosate Resistance in New Zealand, A Ministry for Primary Industries Sustainable Farming Fund Project -
http://www.groundworkassociates.co.nz/glyphosate/

NZ Grassland Association - www.grassland.org.nz/

Human contamination by glyphosate, Friends of the Earth Europe, June, 2013
http://www.foeeurope.org/sites/default/files/publications/foee_4_human_contamination_glyphosate.pdf

GLYPHOSATE FACTSHEET - Critical Habitat Project of the Centre for Ethics and Toxics:
http://environmentalcommons.org/glyphosate.pdf

World Health Organisation - Chemical hazards in drinking-water - glyphosate and AMPA
http://www.who.int/water_sanitation_health/dwq/chemicals/glyphosate/en/

Organic Consumers Association Comments on New Study Showing Glyphosate Found in Mothers' Breast Milk, 7 April 2014,
http://www.organicconsumers.org/articles/article_29697.cfm

Food and Agriculture Organization of the UN - GLYPHOSATE N-(phosphonomethyl)glycine)
http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Specs/glypho01.pdf

Sierra Club Canada – Glyphosate N-(phosphonomethyl)glycine
http://www.sierraclub.ca/national/programs/health-environment/pesticides/glyphosate-fact-sheet.shtml

Glyphosate-tolerant crops in the EU, pub 30 October 2012, compiled by agricultural economist Dr Charles Benbrook for Greenpeace. http://www.greenpeace.org/international/en/publications/Campaign-reports/Genetic-engineering/Glyphosate-tolerant-crops-in-the-EU/