Glyphosate (*N*-(phosphonomethyl)glycine) is a broad-spectrum systemic herbicide used to kill weeds, especially annual broadleaf weeds and grasses known to compete with commercial crops grown around the globe. Initially patented and sold by Monsanto Company in the 1970s under the tradename *Roundup*, its US patent expired in 2000.

Glyphosate is marketed in different solution strengths under many tradenames:[11] Roundup, Buccaneer, Razor Pro (41%), Genesis Extra II (41% w/ Surfactant), Roundup Pro Concentrate (50.2 %), Rodeo (51.2%), Aquaneat (53.8%), and Aquamaster (53.5%).[12] These products contain other ingredients, causing them to have different effects from glyphosate alone.[13] Roundup herbicides are usually water-based solutions containing glyphosate, a surfactant, and other substances. Other formulations contain additional active ingredients to improve the speed of action.

Glyphosate kills plants by interfering with the synthesis of the amino acids phenylalanine, tyrosine and tryptophan. Glyphosate has also been shown to inhibit other plant enzymes,[19][20] and also has been found to affect animal enzymes.[21]

Glyphosate is effective in killing a wide variety of plants, including grasses, broadleaf, and woody plants.[22] It has a relatively small effect on some clover species.[23] By volume, it is one of the most widely used herbicides.[24] It is commonly used for agriculture, horticulture, and silviculture purposes, as well as garden and verge maintenance.

Glyphosate is supplied in several formulations for different uses:

- Ammonium salt
- Isopropylamine salt
- Glyphosate acid - standalone, as ammonium salt or as isopropyl salt
- Potassium salt

Products are supplied most commonly in formulations of 120, 240, 360, 480 and 680 g active ingredient per litre. The most common formulation in agriculture is 360 g/l, either alone or with added surfactants.

For 360 g formulations, European regulations allow applications of up to 12 litres per hectare for control of perennial weeds such as couch grass. Rates of 3 litres per hectare are practiced for control of annual weeds.

While the effects of glyphosate on the usage of herbicides is disputed its use has changed the herbicide use profile away from atrazine, metribuzin, and alachlor.

Glyphosate is rated least dangerous in comparison to other herbicides and pesticides, such as those from the organochlorine family.[38] Roundup has a United States Environmental Protection Agency (EPA)

Toxicity Class of III (on a I to IV scale, where IV is least dangerous) for oral and inhalation exposure.[39] It does not bio-accumulate, and breaks down rapidly in the environment.[40]

The United States Environmental Protection Agency (EPA) considers glyphosate to be relatively low in toxicity, and not to have carcinogenic effects.[41] The EPA considered a "worst case" dietary risk model of an individual eating a lifetime of food entirely from glyphosate-sprayed fields, and with residue levels remaining at their maximum levels, and concluded no adverse effects would exist under these conditions[41] In 2007, the EPA selected glyphosate for further screening for endocrinal disruptor effects, not because of suspected effects, but because glyphosate is a widely used herbicide (the EPA has stated selection for screening does not itself imply risk).[42][43]

Laboratory toxicology studies suggest other ingredients combined with glyphosate may have greater toxicity than glyphosate alone. For example, a study comparing glyphosate and Roundup found Roundup had a greater effect on aromatase than glyphosate alone.[13] Another study has shown Roundup formulations and metabolic products cause the death of human embryonic, placental, and umbilical cells *in vitro*, even at low concentrations. The effects are not proportional to glyphosate concentrations, but are dependent on the nature of the additives used in the formulation.[44] Many common materials that contain surfactants, such as shampoo, can cause similar effects in *in vitro* experiments.

Statistics from the California Environmental Protection Agency's Pesticide Illness Surveillance Program indicate glyphosate-related incidents are one of the highest reported of all pesticides.[45][46] This is proportionate with usage for the number of people exposed, rather than the severity of symptoms associated with each incident.[46] Based on hospitalisation glyphosate would be considered relatively safe, since, over a 13-year period in California, none of the 515 pesticide-related hospitalisations recorded were attributed to glyphosate.[46]

A review of 58 studies of the effects of Roundup on a range of organisms concluded that "for terrestrial uses of Roundup minimal acute and chronic risk was predicted for potentially exposed non-target organisms". It also concluded there were some risks to aquatic organisms exposed to Roundup in shallow water. More recent research suggests glyphosate induces a variety of functional abnormalities in fetuses and pregnant rats.[48] Also in recent mammalian research, glyphosate has been found to interfere with an enzyme involved testosterone production in mouse cell culture[49] and to interfere with an estrogen biosynthesis enzyme in cultures of human placental cells.[50]

Dermal exposure to ready-to-use glyphosate formulations can cause irritation, and photo-contact dermatitis has been reported occasionally; these effects are probably due to the preservative Proxel (benzisothiazolin-3-one). Severe skin burns are very rare. Inhalation is a minor route of exposure, but spray mist may cause oral or nasal discomfort, an unpleasant taste in the mouth, tingling and throat irritation. Eye exposure may lead to mild conjunctivitis, and superficial corneal injury is possible if irrigation is delayed or inadequate.[51]

Roundup showed no toxic effects when fed to animals for two years, and only produced rare cases of reproductive effects when fed in extremely large doses to rodents and dogs. An increase in cancer rates in animal studies has not been demonstrated, and it is poorly absorbed in the digestive tract. Glyphosate has no significant potential to accumulate in animal tissue.[53][54]

Glyphosate is used with five different salts, but commercial formulations of it contain surfactants, which vary in nature and concentration. As a result, humans who have ingested this herbicide may suffer poisoning not with the active ingredient alone, but with complex and variable mixtures.[51]

Certain surfactants used in some glyphosate formulations have higher toxicity to fish and invertebrates, resulting in some formulations of glyphosate not being registered for use in aquatic applications.[62] Monsanto produces glyphosate products with alternative surfactants that are specifically formulated for aquatic use, for example "Biactive" and "AquaMaster".[63] According to Monsanto, "Conservation groups have chosen glyphosate formulations because of their effectiveness against most weeds as glyphosate has very low toxicity to wildlife".[64]

Glyphosate's effect on soil life may be limited, because when glyphosate comes into contact with the soil, it rapidly binds to soil particles and is inactivated.[65][66] Unbound glyphosate is degraded by bacteria. Low activity because of binding to soil particles suggests glyphosate's effects on soil flora are limited. Low glyphosate concentrations can be found in many creeks and rivers in the US and in Europe.[67]

Roundup is not registered for aquatic uses,[72] and studies of its effects on amphibians indicate it is toxic to them.[73] Other glyphosate formulations registered for aquatic use have been found to have negligible adverse effects on sensitive amphibians.[74]

Glyphosate is one of the pesticides that pose the greatest danger to amphibians.[70] Fish and aquatic invertebrates are more sensitive to Roundup than terrestrial organisms.[47] Glyphosate is generally less persistent in water than in soil, with 12 to 60 day persistence observed

in Canadian pond water, yet persistence of over a year has been observed in the sediments of ponds in Michigan and Oregon.[39]The EU classifies Roundup as *R51/53 Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment*.[71]

The first documented cases of weed resistance to glyphosate were found in Australia, involving rigid ryegrass near Orange, New South Wales.[83] Some farmers in the US have expressed concern that weeds are now developing glyphosate resistance, with 13 states now reporting resistance, and this poses a problem to many farmers, including cotton farmers, that are now heavily dependent on glyphosate to control weeds.[84][85] Farmers' associations are now reporting 103 biotypes of weeds within 63 weed species with herbicide resistance.[84][85] This problem is likely to be exacerbated by the use of Roundup-Ready crops.[86]

A non-peer reviewed report, published in November, 2009, "Impacts of Genetically Engineered(GE) Crops on Pesticide Use in the United States: The First Thirteen Years" using USDA data shows US farmers have applied 383 million more pounds of herbicides on GE crops since 1996, including soybeans, than they likely would have applied on non-GE varieties of these crops. The report states the rise in pounds per acre is associated with the replacement of older, higher-risk herbicides with glyphosate, with 46 percent of the total increase occurring in the last two years studied (2007 and 2008). It identifies the problem as an increase in herbicide-resistance.

On Fri Jan 20, 2007, Monsanto was convicted in France of false advertising of Roundup for presenting it as biodegradable, and claiming it left the soil clean after use. Environmental and consumer rights campaigners brought the case in 2001 on the basis that glyphosate, Roundup's main ingredient, is classed as "dangerous for the environment" and "toxic for aquatic organisms" by the European Union.[93] Monsanto appealed and the court upheld the verdict; Monsanto appealed again to the French Supreme Court, and in 2009 it also upheld the verdict. [94]

References

1. ^ ***a*** ***b*** *Glyphosate*, Environmental Health Criteria monograph No. 159, Geneva: World Health Organization, 1994, ISBN 92-4-157159-4
2. **^** Index no. 607-315-00-8 of Annex VI, Part 3, to Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006. *OJEU* L353, 31.12.2008, pp 1–1355 at pp 570, 1100..
3. **^** US EPA 2000–2001 Pesticide Market Estimates Agriculture, Home and Garden
4. **^** http://www.pestmanagement.info/nass/index.html
5. **^** *Huffington Post*. http://big.assets.huffingtonpost.com/EPA.STATS.pdf.
6. ^ ***a*** ***b*** Graves, Lucia (24 June 2011). "Roundup: Birth Defects Caused By World's Top-Selling Weedkiller, Scientists Say". *Huffington Post*.
7. **^** Environmental Fate of Glyphosate, Jeff Schuette, Department of Pesticide Regulation, California
8. **^** Alibhai, M. F.; Stallings, WC (2001). "Closing down on glyphosate inhibition---with a new structure for drug discovery". *Proceedings of the National Academy of Sciences* **98** (6): 2944. doi:10.1073/pnas.061025898. PMC 33334. PMID 11248008.
9. **^** Technology Administration: National Medal of Technology RECIPIENTS
10. **^** *People: Monsanto Scientist John E. Franz Wins 1990 Perkin Medal For Applied Chemistry*, The Scientist **1990**, 4(10):28 John Franz's Perkin Medal
11. **^** California Product/Label Database
12. **^** Glyphosate Roadside Vegetation Management Herbicide Fact Sheet
13. ^ ***a*** ***b*** ***c*** Richard S, Moslemi S, Sipahutar H, Benachour N, Seralini GE (June 2005). "Differential effects of glyphosate and roundup on human placental cells and aromatase" (Free full text). *Environ. Health Perspect.* **113** (6): 716–20. doi:10.1289/ehp.7728. PMC 1257596. PMID 15929894.
14. **^** Resolva Weeds
15. **^** Steinrücken HC, Amrhein N (1980), "The herbicide glyphosate is a potent inhibitor of 5-enolpyruvyl-shikimic acid-3-phosphate synthase", *Biochem Biophys Res Commun* **94**: 1207–1212, doi:10.1016/0006-291X(80)90547-1, PMID 7396959.
16. **^** Purdue University, Department of Horticulture and Landscape Architecture, Metabolic Plant Physiology Lecture notes, Aromatic amino acid biosynthesis, The shikimate pathway - synthesis of chorismate.[1]
17. **^** Saccharomyces Genome Database - S. cerevisiae Pathway: chorismate biosynthesis [2]
18. **^** Schönbrunn E, Eschenburg S, Shuttleworth WA, Schloss JV, Amrhein N, Evans JN, Kabsch W. (2001), "Interaction of the herbicide

glyphosate with its target enzyme 5-enolpyruvylshikimate 3-phosphate synthase in atomic detail", *Proc Natl Acad Sci U S A* **98** (4): 1376–1380, doi:10.1073/pnas.98.4.1376, PMC 29264, PMID 11171958.

19. ^ (Su , L.Y. et al. 1992. The relationship of glyphosate treatment to sugar metabolism in sugarcane: New physiological insights. J. Plant Physiol. 140:168-173.)
20. ^ (Lamb, D.C. et al. 1998. Glyphosate is an inhibitor of plant cytochrome P450: Functional expression of Thlaspi arvensae cytochrome P45071B1/ reductase fusion protein in Escherichia coli. Biochem. Biophys. Res. Comm. 244:110114.)
21. ^ (Hietanen, E., K. Linnainmaa, and H. Vainio. 1983. Effects of phenoxy herbicides and glyphosate on the hepatic and intestinal biotransformation activities in the rat. Acta Pharma. et Toxicol. 53:103-112.)
22. ^ *Greenpeace*. (1997). Weed Killing Crops: Glyphosate and Your Food (archived)
23. ^ Integrated Pest Management
24. ^ ***a*** ***b*** US Environmental Protection Agency. (2006). Technical Factsheet on: GLYPHOSATE [3]
25. ^ e-phy: Le catalogue des produits phytopharmaceutiques et de leurs usages des matières fertilisantes et des supports de culture homologués en France
26. ^ Monsanto Company History - Monsanto Web Site - monsanto.com
27. ^ USDA/APHIS Environmental Assessment - In response to Monsanto Petition 06-178-01p seeking a Determination of Non-regulated Status for Roundup RReady2Yield Soybean MON 89788, OECD Unique Identifier MON-89788-1, U.S. Department of Agriculture Animal and Plant Health Inspection Service Biotechnology Regulatory Services, p. 13 [4]
28. ^ National Agriculture Statistics Service (2005) in Acreage eds. Johanns, M. & Wiyatt, S. D. 6 30, (U.S. Dept. of Agriculture, Washington, DC).
29. ^ Shipitalo MJ, Malone RW, Owens LB (2008). "Impact of Glyphosate-Tolerant Soybean and Glufosinate-Tolerant Corn Production on Herbicide Losses in Surface Runoff". *Journal of Environment Quality* **37** (2): 401–8. doi:10.2134/jeq2006.0540. PMID 18268303.
30. ^ Shipitalo MJ, Malone RW, Owens LB (2008). "Impact of glyphosate-tolerant soybean and glufosinate-tolerant corn production on herbicide losses in surface runoff". *J. Environ. Qual.* **37** (2): 401–8. doi:10.2134/jeq2006.0540. PMID 18268303.
31. ^ Benbrook, Charles. "Evidence of the Magnitude and Consequences of the Roundup Ready Soybean Yield Drag from University-Based Varietal Trials in 1998". *Ag BioTech InfoNet Technical Paper* **1**. CiteSeerX: 10.1.1.41.823.
32. ^ Caviness, C.E., and H.J. Walters. 1971. Effect of phytophthora rot on yield and chemical composition of soybean seed. Crop Science 11:83-84

33. ^ Roundup Ready 2 Yield- Monsanto Web site http://www.monsanto.com/rr2y/
34. ^ G. R. Heck, *et al.* (1 January 2005). "Development and Characterization of a CP4 EPSPS-Based, Glyphosate-Tolerant Corn Event" (Free full text). *Crop Sci.* **45** (1): 329–339. doi:10.2135/cropsci2005.0329.
35. ^ T. Funke *et al.* (2006). "Molecular basis for the herbicide resistance of Roundup Ready crops" (Free full text). *PNAS* **103** (35): 13010–13015. doi:10.1073/pnas.0603638103. PMC 1559744. PMID 16916934.
36. ^ IRC Americas Program Commentary (2005): Plan Colombia's Drug Eradication Program Misses the Mark[*not in citation given*]
37. ^ New Super Strain of Coca Plant Stuns Anti-Drug Officials. Jeremy McDermott. The Scotsman (Scotland) 27 August 2004[*dead link*]
38. ^ Raspberry IPM Manual -Pesticide Selection
39. ^ ***a*** ***b*** ***c*** U.S. EPA ReRegistration Decision Fact Sheet for Glyphosate (EPA-738-F-93-011) 1993. [5]
40. ^ http://www.monsanto.com/products/Documents/glyphosate-background-materials/gly_human_risk.pdf
41. ^ ***a*** ***b*** http://www.epa.gov/oppsrrd1/REDs/factsheets/0178fact.pdf
42. ^ USEPA Federal Register http://www.epa.gov/endo/pubs/draft_list_frn_061807.pdf
43. ^ Accustandard, Chemical Reference Standards, http://www.accustandard.com/asi/np_endocrine_disruptors.php3
44. ^ Benachour, Nora; Gilles-Eric Séralini (December 23, 2008). "Glyphosate Formulations Induce Apoptosis and Necrosis in Human Umbilical, Embryonic, and Placental Cells". *Chemical Research in Toxicology* **22** (1): 97. doi:10.1021/tx800218n. PMID 19105591.
45. ^ GGoldstein DA, Acquavella JF, Mannion RM, Farmer DR (2002). "An analysis of glyphosate data from the California Environmental Protection Agency Pesticide Illness Surveillance Program". *J. Toxicol. Clin. Toxicol.* **40** (7): 885–92. doi:10.1081/CLT-120016960. PMID 12507058.
46. ^ ***a*** ***b*** ***c*** California EPA 1996, California Pesticide Illness Serveillance Program Report HS-1733 [6]
47. ^ ***a*** ***b*** ***c*** JP Giesy, KR Solomon, S Dobson (2000). "Ecotoxicological Risk Assessment for Roundup Herbicide". Reviews of Environmental Contamination and Toxicology 167: 35-120
48. ^ Daruich J, Zirulnik F, Gimenez MS (March 2001). "Effect of the herbicide glyphosate on enzymatic activity in pregnant rats and their fetuses". *Environmental Research* **85** (3): 226–31. doi:10.1006/enrs.2000.4229. PMID 11237511.
49. ^ Walsh LP, McCormick C, Martin C, Stocco DM (August 2000). "Roundup inhibits steroidogenesis by disrupting steroidogenic acute regulatory (StAR) protein expression". *Environmental Health Perspectives* **108** (8): 769–76. doi:10.2307/3434731. JSTOR 3434731. PMC 1638308. PMID 10964798.

50. ^ Richard S, Moslemi S, Sipahutar H, Benachour N, Seralini GE (June 2005). "Differential effects of glyphosate and roundup on human placental cells and aromatase". *Environmental Health Perspectives* **113** (6): 716–20. doi:10.1289/ehp.7728. PMC 1257596. PMID 15929894.
51. ^ ***a*** ***b*** Bradberry SM, Proudfoot AT, Vale JA (2004). "Glyphosate poisoning". *Toxicological Reviews* **23** (3): 159–67. doi:10.2165/00139709-200423030-00003. PMID 15862083.
52. ^ Roundup PRO Herbicide MSDS
53. ^ Extoxnet Pip - Glyphosate
54. ^ http://npic.orst.edu/factsheets/glyphogen.pdf
55. ^ Alejandra Paganelli, Victoria Gnazzo, Helena Acosta, Silvia L. Lpez and Andrs E.Carrasco (2010-08-09). "Glyphosate-Based Herbicides Produce Teratogenic Effects on Vertebrates by Impairing Retinoic Acid Signaling" (abstract). *Chemical Research in Toxicology* **23** (10): 100809132507020. doi:10.1021/tx1001749. PMID 20695457.
56. ^ JA Springett and RAJ Gray (1992). "Effect of repeated low doses of biocides on the earthworm *Aporrectodea caliginosa* in laboratory culture". *Soil Biol and Biochem* **24** (12): 1739–1744. doi:10.1016/0038-0717(92)90180-6.
57. ^ Hassan, S. A.; Bigler, F.; Bogenschütz, H.; Boller, E.; Brun, J.; Calis, J. N. M.; Chiverton, P.; Coremans-Pelseneer, J. et al. (1991). "Results of the fifth joint pesticide testing programme carried out by the IOBC/WPRS-Working Group "Pesticides and beneficial organisms"". *Entomophaga* **36**: 55. doi:10.1007/BF02374636.
58. ^ CM Preston and J.A. Trofymow. 1989. Effects of glyphosate (Roundup) on biological activity of forest soils. In: Proceedings of Carnation Creek Workshop, ed. P. Reynolds. Namaimo 7–10 December 1987. Forest Canada/British Columbia ministry of forests, 122-140.
59. ^ Santos A, Flores M. (1995). "Effects of glyphosate on nitrogen fixation of free-living heterotrophic bacteria". *Letters in Applied Microbiology* **20** (6): 349–352. doi:10.1111/j.1472-765X.1995.tb01318.x. Retrieved 2009-04-15.
60. ^ Duke SO et al. (2007). "Herbicide effects on plant disease". *Outlooks Pest Manag* **18**: 36–40. doi:10.1564/18feb13. Retrieved 2009-04-15.
61. ^ Hileman, Bette (2005). "Common herbicide kills tadpoles". *Chemical & Engineering News* **83** (15): 11.
62. ^ Response to "The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities", Monsanto Corporation Backgrounder [7]
63. ^ Aquatic Use of Glyphosate Herbicides in Australia, Monsanto Corporation Backgrounder [8]
64. ^ [9]
65. ^ ***a*** ***b*** US EPA Reregistration Eligibility Decision - Glyphosate
66. ^ M.M. de Andréa, *et al.* (2003 2003). "Influence of repeated applications of glyphosate on its persistence and soil bioactivity". *Pesq.*

Agropec. Bras. **38** (11): 1329–1335. doi:10.1590/S0100-204X2003001100012.

67. ^ Cox C. Glyphosate (Roundup) J Pest Reform. Garfunkle: 1998;18:3–17.
68. ^ Peluso M, Munnia A, Bolognesi C, Parodi S (1998). "32P-postlabeling detection of DNA adducts in mice treated with the herbicide Roundup". *Environmental and molecular mutagenesis* **31** (1): 55–9. doi:10.1002/(SICI)1098-2280(1998)31:1<55::AID-EM8>3.0.CO;2-A. PMID 9464316.
69. ^ Daruich J, Zirulnik F, Gimenez MS (March 2001). "Effect of the herbicide glyphosate on enzymatic activity in pregnant rats and their fetuses". *Environ. Res.* **85** (3): 226–31. doi:10.1006/enrs.2000.4229. PMID 11237511.
70. ^ Chivian, Eric; Bernstein, Aaron (2008). "Threatened Groups of Organisms Valuable to Medicine". In Eric Chivian. *Sustaining Life: How Human Health Depends on Biodiversity*. Oxford University Press, USA. p. 209. ISBN 978-0-19-517509-7.
71. ^ http://lscgw1.monsanto.com/esh/msdslib.nsf/2B20DAEB04E8631C0625689700650B45/$file/Roundup%20Ultra%203000-5059en-gb.pdf Roundup Material Safety Data sheet page 7, heading 16
72. ^ Monsanto Backgrounder 2005 Response to "The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities" [10]
73. ^ Rick A. Relyea 2005 "The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities" Ecological Applications 15:618–627
74. ^ Wojtaszek et al. Effects of vision herbicide on mortality, avoidance response, and growth of amphibian larvae in two forest wetlands Environmental Toxicology and Chemistry 23:832–842 2004
75. ^ Walsh LP, McCormick C, Martin C, Stocco DM (August 2000). "Roundup inhibits steroidogenesis by disrupting steroidogenic acute regulatory (StAR) protein expression". *Environ. Health Perspect.* **108** (8): 769–76. doi:10.2307/3434731. JSTOR 3434731. PMC 1638308. PMID 10964798.
76. ^ [11] Richard Dick, Nicola Lorenz, Michal Wojno and Matt Lane 2010, "Microbial dynamics in soils under long-term glyphosate tolerant cropping systems" 19th World Congress of Soil Science
77. ^ [12]"Scientist finding many negative impacts of Roundup Ready GM crops" from "The Organic and Non-GMO Report" January/December 2010
78. ^ Balthazor, Terry M and Laurence Hallas (1986) Glyphosate-degrading microorganisms in industrial waste treatment biosystems. Appl. Environ. Microbiol. 51:432-34.[13]
79. ^ [14] "Crop Production Factors Associated with Fusarium Head Blight in Spring Wheat in Eastern Saskatchewan", published online 26 August 2005 by M. R. Fernandeza, F. Sellesa, D. Gehlb, R. M. DePauwa and

R. P. Zentner.
80. ^ Glyphosate Factsheet (part 1 of 2) Caroline Cox / Journal of Pesticide Reform v.108, n.3 Fall98 rev.Oct00
81. ^ http://www.labmeeting.com/paper/18974220/torstensson-1989-influence-of-climatic-and-edaphic-factors-on-persistence-of-glyphosate-and-24-d-in-forest-soils
82. ^ Albers; Banta, G.; Hansen, P.; Jacobsen, O. (2009). "The influence of organic matter on sorption and fate of glyphosate in soil--comparing different soils and humic substances". *Environmental pollution (Barking, Essex : 1987)* **157** (10): 2865–2870. doi:10.1016/j.envpol.2009.04.004. PMID 19447533. edit
83. ^ ISU Weed Science Online - Are RR Weeds in Your Future II
84. ^ ***a*** ***b*** Glyphosate resistance is a reality that should scare some cotton growers into changing the way they do business
85. ^ ***a*** ***b*** More glyphosate resistant weeds
86. ^ http://www.chem.purdue.edu/courses/chm333/Roundup%20Article.pdf
87. ^ "Resisting Roundup". *The New York Times*. May 16, 2010.
88. ^ http://www.ucsusa.org/food_and_agriculture/science_and_impacts/impacts_genetic_engineering/report-documents-pesticide.html
89. ^ Pollack, Andrew (April 13, 2010). "Study Says Overuse Threatens Gains From Modified Crops". *The New York Times*.
90. ^ Neuman, William; Pollack, Andrew (May 3, 2010). "Farmers Cope With Roundup-Resistant Weeds". *The New York Times*.
91. ^ "Toxic Weed Control". *The New York Times*. May 12, 2010.
92. ^ Attorney General of the State of New York. Consumer Frauds and Protection Bureau. Environmental Protection Bureau. 1996. In the matter of Monsanto Company, respondent. Assurance of discontinuance pursuant to executive law § 63(15). New York, NY, Nov
93. ^ Monsanto Fined in France for 'False' Herbicide Ads
94. ^ http://news.bbc.co.uk/2/hi/europe/8308903.stm?utm_source&utm_medium&utm_campaign