Glyphosate-Resistant Weeds Worldwide

Ian Heap
Director of the International Survey of Herbicide-Resistant Weeds, Corvallis, OR 97370
Email: IanHeap@weedscience.org Survey Website: http://www.weedscience.org

The intent of the International Survey of Herbicide-Resistant Weeds is to document practical cases of field selected, genetically inherited resistant weed biotypes that survive a rate of herbicide to which the indigenous population was controlled. This information assists farmers and academics in the development of effective weed control systems for the field and assists herbicide manufacturers in the development of appropriate stewardship programs for their products. The survey currently (1/24/2013) records 396 unique types of herbicide-resistant weeds in 210 weed species (123 dicots and 87 monocots). The herbicide sites of action most prone to resistance are the ALS inhibitors (129 resistant species) the triazines (69 species), and the ACCase inhibitors (42 species). Glyphosate has generally been considered a low risk herbicide for selection of resistance, but low risk does not mean "no risk", and given the massive area treated with glyphosate annually it is not surprising that 24 weed species have evolved glyphosate resistance (Table 1).

In 1996 Roundup Ready Soybeans were introduced in the United States and since then there has been a rapid adoption of Roundup Ready crops (primarily soybean, maize, cotton, canola and sugar beet). Figure 1 shows the correlation between the increase in Roundup Ready crops and the evolution of glyphosate-resistant weeds. Roundup-Ready crops are not entirely responsible for the selection of glyphosate-resistant weeds, 12 weed species have evolved glyphosate-resistance in orchard and non-crop situations.

The USA leads the world in the area planted to Roundup Ready crops and consequently has the highest number of glyphosate-resistant weed species (13) Table 2. Brazil and Argentina also have large areas planted to Roundup Ready Crops and both have 5 glyphosate-resistant weeds. Australia has selected 6 glyphosate-resistant weeds, primarily through the repeated use of glyphosate in summer fallow situations and orchards. Spain and South Africa have selected 5 and 3 glyphosate-resistant weeds respectively in orchards as well.

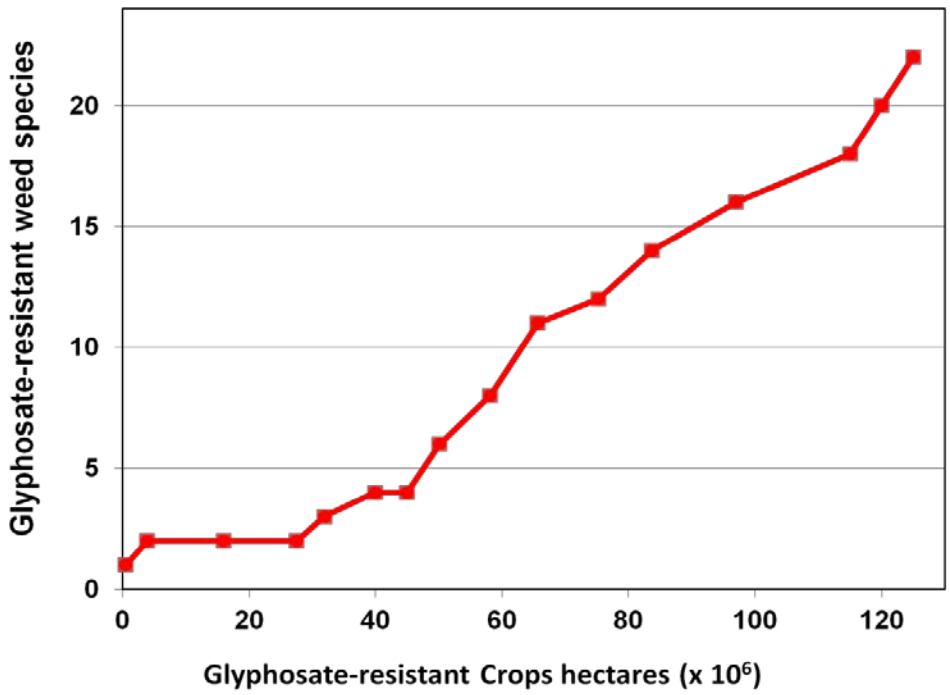
Table 1. Global list of glyphosate-resistant weeds.

#	Species	Year	Countries	Crops
1	*Lolium rigidum*	1996	Australia, France, Israel, Italy, South Africa, Spain, USA	11
2	*Eleusine indica*	1997	Colombia, Malaysia, USA	4
3	*Conyza Canadensis*	2000	Brazil, China, Czech Republic, Spain, USA	10
4	*Lolium multiflorum*	2001	Argentina, Brazil, Chile, Spain, USA	11
5	*Conyza bonariensis*	2003	Australia, Brazil, Colombia, Greece, Israel, Portugal, South Africa, Spain, USA	10
6	*Plantago lanceolata*	2003	South Africa	2
7	*Ambrosia artemisiifolia*	2004	USA	1
8	*Parthenium hysterophorus*	2004	Colombia	1
9	*Ambrosia trifida*	2004	Canada, USA	3
10	*Sorghum halepense*	2005	Argentina, USA	1
11	*Amaranthus palmeri*	2005	USA	5
12	*Amaranthus tuberculatus*	2005	USA	4
13	*Digitaria insularis*	2006	Brazil, Paraguay	6
14	*Echinochloa colona*	2007	Argentina, Australia, USA	5
15	*Kochia scoparia*	2007	Canada, USA	4
16	*Urochloa panicoides*	2008	Australia	2
17	*Lolium perenne*	2008	Argentina	4
18	*Conyza sumatrensis*	2009	Brazil, Spain	2
19	*Poa annua*	2010	USA	2
20	*Chloris truncate*	2010	Australia	1
21	*Leptochloa virgate*	2010	Mexico	1
22	*Bromus diandrus*	2011	Australia	1
23	*Cynodon hirsutus*	2012	USA	1
24	*Amaranthus spinosus*	2012	Argentina	1

Table 2. Number of Glyphosate-Resistant Weeds in Countries

Country	# GRW	Country	# GRW
USA	13	Malaysia	1
Australia	6	Chile	1
Brazil	5	France	1
Spain	5	China	1
Argentina	5	Paraguay	1
South Africa	3	Czech Republic	1
Colombia	3	Greece	1
Israel	2	Poland	1
Italy	2	Portugal	1
Canada	2	Mexico	1

Figure 1. The Relationship between the adoption of Roundup Ready Crops and the evolution of glyphosate-resistant weeds.



Three plant families (Poaceae, Asteraceae, and Amaranthaceae) account for 92% of the reported cases of glyphosate-resistant weeds even though they only account for about 60% of weeds in crops. Grass weeds account for 13 of the 24 glyphosate resistant weeds and three of these are in the genus *Lolium* (*L. rigidum, L. multiflorum,* and *L. perenne*). Similarly there are three cases of glyphosate resistant weeds in the genus *Amaranthus* (*A. tuberculatus, A. palmeri,* and *A. spinosus*) and *Conyza* (*C. canadensis, C. bonariensis,* and *C. sumatrensis*). In addition there are two *Ambrosia* sp. (*A. artemisiifolia* and *A. trifida*). The lesson to be learnt from this is that if a weed evolves resistance to glyphosate then it is highly likely that close relatives will evolve resistance to glyphosate and should be managed accordingly.

The occurrence of glyphosate resistance is often associated with farming systems that rely upon glyphosate alone for weed control, minimum tillage, and the use of low rates glyphosate.

Glyphosate is the most useful herbicide ever developed and it is important that its effectiveness is maintained for as long as possible. Rotation of herbicide modes of action, the use of tank mixes with different modes of action, and integrated weed management are the primary tools that growers have to preserve glyphosate.