Ten Years of Roundup Ready - where are we now?

Corn Herbicide Use Data

Year	Corn Area Applied PRE	Rate lbs. ai/A Acetochlor	Area Applied Glyphosate	Area Applied Glufosinate	Area Applied Sulfonylureas (Accent + Beacon)
2005	**49%**	**1.27**	**49%**	7%	12%
2003	50%	**1.73**	22%	9%	25%
2002	43%	1.58	11%	9%	34%
1999	**62%**	1.61	**7%**	ND	33%
1996	73%	1.72	0%	0%	33%

RR Corn Introduced in 1998
LL Corn Introduced in 1997

Soybean Herbicide Use Data

	Sb Area Applied PPI/PRE	Rate lbs. ai/A Trifluralin	Area Applied Glyphosate	Area Applied Imidazolinones (Pursuit + Raptor)
2004	15%	0.79	85%	7%
2002	23%	0.77	79%	16%
1999	**39%**	0.78	**48%**	40%
1996	**62%**	0.73	**7%**	64%
1994	71%	0.8	4%	70%

RR Sb Introduced in 1996

Trends:

Rate of adoption is slower in RR corn than for RR Soybeans; Change in adoption of glyphosate use was 7% to 49% in 6 years for corn and this same rate of increase occurred in 3 years for soybean.

Decline of soil-applied residual herbicides is less dramatic in corn than in soybean over these adoption periods; 23% reduction over 3 years in soybean and 13% reduction over 6 years in corn. Use of soybean soil-residual herbicides has continued to decline to 15% land area by 2004.

One recent trend in soil residual herbicide use in corn is a decrease in acetochlor use rate by 26% over the 2003 to 2005 time period.

In both corn and soybean, as glyphosate use increases the use of ALS herbicides dramatically decreases. Glufosinate, though often linked to a Bt-trait has had limited market penetration in the corn market.

New herbicide resistant traits:

Increased soybean tolerance to ALS herbicide current STS/RR stack
Liberty Link soybean – proposed for 2008
New glyphosate resistance trait (Optimum GAT) an enhance metabolism trait proposed for 2009 in soybean and 2010 in corn.
Dicamba/RR soybean stack proposed for 2012

Implications of Trends

RR soybean use must be near its peak and glyphosate is the dominant herbicide in the soybean market. **The question that remains is what is the peak market penetration for RR corn in MN? Also, can some chemical diversity (i.e. different modes of action) be retained on the corn acres?** Currently (2005 data), 41% corn ground is treated with atrazine (0.5 lbs a.i./A), 24% is treated with a plant growth regulator and 17% is treated with mesotrione (Callisto).

Decline in soil-applied herbicides use is not always a bad thing. In soybean the primary soil-applied herbicides used were the preplant incorporated dinitroanalines herbicides: trifluralin and pendimethalin. A decline in their use also reduces the need for tillage. Decline in the use of the dinitroanalines herbicides as well as the decline in use of the imidazolinone (soybean) and sulfonylurea (corn) chemistry has greatly **reduced the number of complaints regarding herbicide carryover and in-season herbicide-induced crop injury.**

The **recent trend of a decrease in the acetochlor use rate by 26% over the 2003 to 2005 time period** relates to the extensive risk management approach to corn weed control that our weed management team has been researching over the last 3 years. Our research has shown that using one-half of the labeled use rate of acetocholor followed by a V2-V5 application of glyphosate is as effective as a two-pass postemergence treatment of glyphosate with less risk of yield loss due to a late initial application of glyphosate. In our research we used 1.25 pt./A of Harness. **The 2005 standard use rate of acetochlor converts to a 1.5 pt/A Harness average use rate which is the labeled use rate for Harness when it is applied as part of a planned sequential application with glyphosate. Therefore glyphosate tolerant corn has made it possible to reduce preemergence herbicide rates.** However, the question remains, how can we retain some level of chemical diversity in the corn and soybean rotation to delay the development of herbicide resistant weeds or weed species shifts?

Weeds of Concern in the Corn and Soybean Rotation

Remember what some of the up and coming problem annual weeds in soybeans were as we hit the peak of Imidazolinone use around 1994 and 1995 in MN?

Three big concerns were the development of the ALS resistant waterhemp (now they are so common that most biotypes in MN are assumed to be ALS resistant), common lambsquarters and common ragweed.

In 2004 and 2006 Kevin Cavanaugh surveyed participants of the Ag Professional Update series across MN. Kevin's 2004 assessment indicated that after RR corn and soybean began to be used with great frequency weeds such as velvetleaf, Venice mallow, common sunflower, and grass species have become less troublesome. In their place, waterhemp, common lambsquarters, common ragweed, and giant ragweed became more troublesome to control. In NW MN wild buckwheat and kochia where also considered to be troublesome weeds. The most troublesome grasses were barnyardgrass, woolly cupgrass, and yellow foxtail.
In 2006, waterhemp andcommon lambsquarters were considered the most troublesome weeds in corn and soybean with common and giant ragweed as runners up. In NW MN wild buckwheat and biennial wormwood where frequently mentioned in soybean and foxtail and woolly cupgrass in corn.

Soybeans

C. lambquaters	**102**
Waterhemp (all species)	**89**
C. ragweed	**29**
Wild buckwheat	13
G. ragweed	12

Corn

Waterhemp (all species)	**55**
C. lambquarters	**49**
Foxtails	31
G. ragweed	**25**
Woolly cupgrass	23

When asked if they were having more trouble controlling weeds with glyphosate than in 2000, 139 responded yes, 80 responded No, 40 had no response and 3 were not sure.

Weed biotypes with confirmed resistance to glyphosate:

Horseweed – Confirmed resistance in eastern USA
Waterhemp – Confirmed resistance in MO in 2005, also ALS resistant
Common ragweed – Confirmed resistance in MO in 2004
Giant ragweed – Confirmed resistance in OH, IN in 2006

Levels of resistance range from 2X-8X
To my knowledge only horseweed resistance is traced to a change in a single gene, others appear to be due to changes in multiple genes.

Impact of volunteer RR crops:

In RR soybeans, seed quality reports of foreign matter report less weed seed in 2003-2004 grain shipments than in 1991, however during this time period there has been a significant increase in volunteer corn (listed as other crops).

Publications on Glyphosate Stewardship:

Facts about glyphosate resistant weeds – In Print
Understanding glyphosate to increase performance – In Print
Economic implications of stewardship/BMP's for glyphosate use – Draft
Biology and management of common lambsquarters - Layout
Biology and mgt of common ragweed - Draft
Biology and mgt of giant ragweed - Draft
Biology and mgt of common waterhemp - Draft
Biology and mgt of wild buckwheat – In Print
Biology and mgt of horseweed – In Print

Link to Horseweed Publication:
http://www.ces.purdue.edu/extmedia/GWC/GWC-9-W.pdf
Link to Wild Buckwheat Publication:
http://www.ces.purdue.edu/extmedia/GWC/GWC-10-W.pdf

Herbicide Resistance Risk Assessment

	Risk of Resistance		
Mgmt. Option	**Low**	**Moderate**	**High**
Diversification of Herbicides	> 2 modes of action	2 modes of action	1 mode of action
Weed Control Tools Used	Cultural Mechanical Chemical	Cultural Chemical	Chemical
Use of Same Mode of Action per Season	Once	More than Once	Many Times
Cropping System	3 or more Crop Rotation	2 Crop Rotation	1 Crop -No Rotation
Frequent Reports of Resistance to Mode of Action?	Unknown	Limited	Common
Weed Infestation	Low	Moderate	High
Control in Last 3 Years	Good	Declining	Poor

From: Herbicide Resistance Action Committee:
http://www.plantprotection.org/hrac/Guideline.html