Canadian Agronomist

DIGGING INTO RESEARCH

Trends in global herbicide resistance management

CATEGORY weeds | *March* 3, 2020

Trends in herbicide resistance management over the past decade were identified and include renewed efforts by the agrichemical industry in herbicide discovery, cultivation of crops with combined (stacked) HR traits, increasing reliance on pre-emergence vs. post-emergence herbicides, breeding for weed-competitive crop cultivars, expansion of harvest weed seed control practices, and advances in site-specific or precision weed management.

Over the past decade, the most significant change in strategy in herbicide-resistant weed management globally has been the increased focus on reducing the weed seed bank and maintaining low seed bank levels. For most growers today, the weed seed bank contains populations that are resistant to one or more herbicide modes-of-action (Groups). While a zero tolerance policy is now being advocated, this approach may not be agronomically or economically feasible.

This review covers recent developments and trends in herbicide-resistant (HR) weed management in agronomic field crops.

Renewed herbicide discovery

New herbicide mode-of-action discoveries were frequent through the 1950s to 1970s, but came to a halt by the end of the 1980s with the widespread adoption of glyphosate-resistant crops. Currently, an herbicide with a new mode-of-action has not been commercialized in more than 30 years. However, because glyphosate-resistant weeds are becoming problematic worldwide, crop protection companies have increased efforts to find new herbicide modes of action, which are slowing coming onto the marketplace. This search though is costly at about US$300 million and a timeline of at least 10 years to registration.

Potential sources of new herbicide modes of action include products that are by-products of microorganisms or extracts of plants (natural phytotoxins) or some antimalarial drugs. Herbicide discovery is now becoming more efficient, with adapted discovery processes combined with a highly automated screening process including molecular and enzyme structural modeling.

Changing adoption of herbicide-resistant traits

Although glyphosate-resistant (Roundup Ready) traits are dominant, changes in adoption of different herbicide-resistant traits is occurring. Soybeans in the United States illustrate this evolution where 94% of varieties have an herbicide-resistant trait, with the RR-only trait accounting for 30% of the market. However, in just 3 years, the Xtend trait (glyphosate + dicamba resistance) captured approximately 50% soybean market share by 2019. This fast adoption shows the importance of alternative traits to help manage glyphosate-resistant or multiple-resistant weeds.

The Liberty Link (glufosinate-resistant) trait has also grown in market share over the past 5 years with approximately 20% market share in US soybeans in 2019. This adoption also shows the need for alternative glyphosate-resistant traits to manage glyphosate-resistant weeds.

Two more stacked herbicide tolerant soybean trait have been introduced in the US. BASF introduced LL GT27, which will offer tolerance to pre-emergent-applied Group 27 isoxaflutole and post-applied glyphosate and glufosinate. Dow AgroSciences and MS Technologies (now Corteva Agriscience) also released Enlist E3 that is tolerant to glyphosate, glufosinate, and 2,4-D.

As stacked traits become more widely adopted, growers, seed retailers and agronomists will require training to ensure proper stewardship practices to optimize and prolong their benefits.

Herbicide resistance traits in cultivars of major agronomic crops

HR Trait	Soybean	Maize	Cotton	Rice	Canola	Wheat
ACCase inhibitor		X		X		X
ALS inhibitor		X		X	X	X
Triazine *					X	
Glyphosate	X	X	X		X	
Glufosinate	X	X	X		X	
Glyphosate+glufosinate	X	X	X			
Glyphosate+triazine*					X	
Glyphosate+dicamba	X		X			
Glyphosate+2,4-D+APP (ACCase)		X				
Glyphosate+isoxaflutole	X					
Glyphosate+glufosinate+dicamba	X		X			
Glyphosate+glufosinate+2,4-D	X		X			
Glyphosate+isoxaflutole+glufosinate	X					

* Australia only. Abbreviations: ACCase: acetyl-CoA carboxylase; ALS: acetolactate synthase; APP: aryloxyphen oxypropionate.

Source: Beckie et al. 2019

Increased pre-emergence herbicide use

Pre-emergent herbicide use dropped rapidly with the adoption of herbicide-resistant crops and no-till seeding systems. However in the last decade, the use of preplant and pre-emergence herbicides has grown in the U.S. from 25% to 70% of the soybean crop area to address the need to control glyphosate-resistant weeds.

The pre-emergent modes-of-action commonly used in field crops include Group 3 (dinitroanilines such as trifluralin), Group 5 (e.g., metribuzin), Group 8 (e.g., prosulfocarb, triallate), Group 14 (e.g., saflufenacil, flumioxazin, sulfentrazone), and Group 15 (e.g., pyroxasulfone).

Pre-emergent herbicides should also be combined with other modes-of-action during one or more application windows (pre-seeding, in-crop, post-harvest) in mixtures or in sequence to help manage herbicide-resistant weed development. For best performance, growers need to be aware of, and manage the multiple factors that influence weed control including soil temperature; soil moisture; crop residue type, abundance and distribution; and degree of soil disturbance by tillage and its impact on the distribution of soil organic carbon (organic matter) and texture (e.g., clay fraction) in the soil profile.

Research is needed to better understand the interaction between time of pre-emergence herbicide application and time of rainfall (or time of seeding) on crop injury and weed control. More research is also needed on agronomic practices that influence the effectiveness of these herbicides in conservation-tillage systems, such as crop seeding rate, row spacing, and fertilizer placement and timing.

Variety development includes weed competitiveness

Crop competitiveness against weeds is an important pillar of IWM. Currently, some cereal plant breeders are starting to select for weed competition, found in traits such as plant height, early vigour, and resource-competitive root systems.

In the future, integrating agronomic practices such as fertilizer timing and placement, crop seeding rate, and crop row spacing with weed-competitive cultivars will enhance the ability of the crop to suppress weeds, and provide the opportunity for growers to reduce their dependency on herbicide inputs. Future crop variety guides are envisioned to include weed-competiveness ratings, similar to that for yield or disease.

Harvest weed seed control growing

Harvest Weed Seed Control (HWSC) is becoming widely adopted by Australian growers as a weed management tool. These HWSC practices include:

- narrow-windrow burning,
- chaff cart towed behind the combine harvester,
- bale-direct system (baler towed behind the combine harvester),
- chaff-lining (chaff funneled into a narrow band behind the combine harvester),
- chaff tram-lining (chaff directed onto the combine harvester wheel tracks,
- weed seed destruction (e.g. integrated Harrington Seed Destructor).

In Australia, two of the most problematic weeds, annual ryegrass and wild radish, are well suited to HWSC. Ongoing field evaluation of different HWSC practices will help growers in North America understand and adopt this technology.

Site-specific weed management

Site-specific weed management (SSWM) adoption has been slow on large-scale dryland acres, but growers are more frequently using some technologies. Real-time weed control on summerfallow fields is rapidly being adopted. Weed-It and WeedSeeker sprayers detect weeds with sensors and only spray when a weed is detected. Herbicide savings of up to 90% have been reported.

Other SSWM tools that may be implemented in the future could be weed mapping by remote sensing, spraying weed patches with drones, and robotic (autonomous) weed control with herbicides or tillage.

The future

The vision for the future of HR weed management globally should center on reduced herbicide dependency, especially glyphosate, because of increasingly demands by grain buyers, herbicide resistance, and societal pressures. A key research question going forward is how much weed control is enough to consistently achieve the goal of low weed seed banks?

Beckie, H.J.; Ashworth, M.B.; Flower, K.C. Herbicide Resistance Management: Recent Developments and Trends. *Plants* **2019**, 8, 161. https://doi.org/10.3390/plants8060161

