



Integrated weed management



Think globally, act locally

The range of herbicides has narrowed over the past few years: Today, only three modes of action account for 50 percent of the market, while resistance is increasing steadily. Against this backdrop, Bayer CropScience is committed to ensuring the long-term availability of an effective armoury of weed control solutions for farmers around the world.

Glyphosate has undoubtedly been the herbicide of the century: Due to its flexibility in use, high degree of effectiveness and lack of soil residual activity it was very simple to use. In the mid-1990s, glyphosate tolerant corn, cotton and soybean varieties revolutionized agriculture as their use exploded in the marketplace, first in the USA, and later in South America. “The glypho-

Optimizing herbicide treatments is one of the key approaches to preventing the development of resistance in weeds.

Tests in the laboratory and glasshouse help to reveal resistance.



It all depends on the resistance type

A well-targeted therapy can be improved with precise diagnostics of the resistance profile, helping to avoid errors in treatment.

If a targeted enzyme possesses a mutation at the herbicide binding site, the diagnosis is target site resistance. In practical terms, this renders one or even several herbicides with the same mode of action completely ineffective, because the herbicide cannot bind to the mutated target sites. In most cases not even higher rates will effectively control the resistant weed.

If a weed has “merely” learned to metabolise the herbicide, thereby preventing it from reaching the site of action intact, the resistance is called metabolic. In this case, other herbicides with the same mode of action may still work, since there are often differences in metabolism between separate herbicides within a mode-of-action class. However, since populations of resistant weeds have appeared which can metabolise herbicides with completely different modes of action, it pays to know just which ones are affected.

sate-tolerance trait meant that you did not need a pre-emergence herbicide,” says Dr. Harry Streck, Bayer CropScience Head of Integrated Weed Management and Resistance Biology. “Farmers could spray right into the crop canopy once or twice and they only had to buy ONE product. It was as easy as pie.”

There seemed nothing more to say about herbicides and many companies abandoned or seriously curtailed herbicide research as a consequence. But nature struck back with a vengeance by developing glyphosate resistant plants such as the astonishing *Amaranthus palmeri* (Palmer amaranth). This “super weed” threatened the harvest with its size (up to three meters), its alarming seed production rate (up to a million seeds per plant) and its ability to transfer resistance genes among related Amaranthus species. “The resistance problem exploded in 2009,” recounts Chuck Farr, independent crop consultant in the US State of Arkansas. “It was unbelievable.

We worked non-stop. But I really loved it. We were working as real advisors again, offering the farmers much needed advice on effective alternatives and sustainable strategies.”

Prevention is better than cure

Managing herbicide resistant weeds such as Palmer amaranth, Chuck Farr recommended his growers use glufosinate-ammonium-based herbicides in concert with LibertyLink® crops, presently the only non-selective alternative to glyphosate tolerant systems. Containing a glufosinate-ammonium tolerance trait, a LibertyLink crop allows rotation of the herbicidal mode of action in cotton, canola, soybeans and corn. In the near future, Chuck Farr will hold an additional trump card in his hand: New double-stack seeds with combined traits for glufosinate-ammonium and glyphosate to manage resistance with two different herbicide classes.

“Our goal is the sustainable activity of herbicides,” says Harry Streck. “We want to get more glufosinate-ammonium out into the market which will contribute to saving glyphosate.”

In the years to come, resistance prevention and management will play an ever increasing and important role on a global scale. As a result, the herbicide business will become more complex, resulting in a greater need for professional advice and explanation. “Recommending the right strategy for integrated weed management requires intimate knowledge of the many different factors that interact in the field and that vary from farm to farm,” says Dr. Martin Hess, Integrated Weed Management and Resistance Biology. “This is why the Bayer CropScience sales representatives see their role as going far beyond just selling plant protection products. Monitoring the well-being of a farm, they play a role similar to that of a family doctor in human medicine.”



Like a good family doctor, they know the agronomic history of the farm and the personal farming style of the owner. Identifying early spots of resistance, they can support the farmer in developing a preventive strategy. “At the end of the day, it is always better – and cheaper – to spend money on prevention rather than wait for resistance to strike,” says Martin Hess.

What then, are the components of an effective prevention strategy? “Diversity is the key,” says Joachim Kaiser, Integrated Weed Management and Resistance Biology. “Planting the same crop repeatedly and partnering it always with only one single herbicide, gives the weeds ample time to adapt to the same treatment year after year, until it become resistant to a particular herbicide or mode of action. That is why the fight against resistance always focuses on providing variety.” The selection pressure can be reduced by crop and chemical rotation, for example by scheduling a summer crop, if primarily growing winter crops, and alternating different herbicidal modes of action during the season. Deep tillage helps to reduce the seed bank in the soil and keeps the seeds of some problem weeds like Palmer amaranth from germinating in huge numbers, covering the surface like a green carpet. Delayed planting

times can also make a difference: If the weeds have time to germinate after ploughing and before sowing, they can be controlled either mechanically or with an herbicide.

Exploring the secrets of resistance

If worse comes to worse and the weed resists a treatment, the time has come for the family doctor to consult a specialist. The Bayer CropScience sales rep turns the case over to the diagnostics team in Frankfurt/Main (Germany), asking them to detect the cause of the herbicide failure. The required analyses are performed in a state-of-the-art laboratory which Bayer CropScience set up staffed with specialists and specialized analytical instruments. Located in the company’s herbicide biology and phyto regulator research institute, it offers a special service: Identifying in detail the components of a weed’s individual resistance profile, the team provides the diagnostic equivalent of a “blood analysis” for weeds suspected of being resistant to herbicides.

Today, hundreds of samples sent by courier containing live weeds arrive for analysis in Frankfurt every year. Each sample is an urgent cry for help; someone out there needs to know what the



Following the first discovery of resistance in the USA, *Amaranthus palmeri* has become one of the most difficult weeds to control there.

In order to confirm the development of resistance, suspect weed strains are treated in the glass-house with various herbicides at different application rates.

verdict is: Is it really a case of resistance? If so, what type of resistance is it, and how many modes of action are affected? Which herbicides are still effective? What shall I spray in the coming season?

This state-of-the-art emergency analysis is supported by the traditional diagnostics in the greenhouse, where weeds are grown from the seeds of the previous season. Testing the weeds for resistance under real-life conditions allows the team to fine-tune herbicide mixtures for the coming season.

Out there in the field, the Bayer CropScience sales representatives connect all the information that is now available: the detailed resistance profile, the greenhouse diagnosis, and their own long-term knowledge of the individual farm. This allows them to work out a specific customized strategy for the individual needs of the farmer. Next to the rotation of crops and herbicides, tillage practices, and altering planting times, their recommendations might also include certain other assorted precautions, such as cleaning harvesters between fields or to make sure that neither machines nor boots transfer the resistance from one field to the next.

Expanding the arsenal

Stricter registration legislation and a declining number of companies engaged in herbicide research mean that the range of herbicides is declining, while resistance is advancing rapidly on a global scale. That is just one of the reasons that Bayer CropScience is committed to staying in the business and fighting this trend. To strengthen its basis the company plans to further expand its research activities.

Bayer CropScience herbicide researchers are busy identifying resistance trends as they develop and focusing on finding resistance busters – new molecules with novel modes of action to fight problem weeds. Simultaneously, Bayer CropScience is investing significant resources into safener research to ensure that herbicides with marginal

selectivity but an extremely interesting weed control spectrum will be marketed in the future. Selectivity research identifies both protective safener substances and herbicide tolerance traits, two completely different mechanisms that immunize the crop against the herbicide, thus expanding the application range of new and old herbicides.

Today, the company's research effort has results to show: "In the past few years, we have launched more herbicides than our competitors," says Harry Streck. "We are the leading company in safener research and our research pipeline is brimming." For Chuck Farr and his Arkansas colleagues there is also another trump card in the offing: As

of 2015, Bayer CropScience plans to launch a triple-stack soybean variety. A co-development of several partners, the soybean is immune to both glyphosate and glufosinate-ammonium, and to a third mode of action – the herbicide class of HPPD inhibitors (e.g., Laudis®, Balance® and Husky®). Combining tolerance to three separate modes of action in one seed is a strategy that should certainly do the trick of bringing resistant weeds to their knees – including some pernicious species of the future. ◀

Gabriele Polensky



In January 2010, around 300 leading weed science experts met in Miami to discuss the situation regarding resistance in weeds.

"Like treasures"

"The discovery of new mechanisms has become so rare in the past few years, that we need to treat the ones we have like treasures," said Professor Stephen Powles from the University of Western Australia during his visit to the "First Pan American Conference on Weed Resistance". Almost 300 leading weed experts from business and academia rallied in Miami in January 2010, to discuss the global rescue of herbicide molecules. Hosting the conference, Bayer CropScience provided an international platform to put this pressing topic into the limelight, and to build a joint network for resistance research and management with leading researchers, agricultural advisers, trade journalists and registration experts.