



Securing the food supply: preventing herbicide-resistant weeds in corn crops

Clearing the way for seedlings

Hard-to-kill weeds are becoming increasingly common in fields of corn. Crop protection researchers at Bayer CropScience are now entering the battle against these harmful plants with a two-fold strategy: they have combined two especially efficient chemical entities into one all-new herbicide. Equipped with an additional protective mechanism, Adengo® (marketed as Corvus® in the United States) gives young corn plants a vital head start – and is helping to safeguard the food supply worldwide.

At first glance, Aztecs and chicken nuggets have nothing in common. Yet without the Mesoamerican Indians and their agricultural achievements, our modern diet would consist of a lot less fried chicken, juicy steaks, milk and tortillas. Hundreds of years ago, the native inhabitants of Mexico were already cultivating the most important cereal of our time – corn. This popular grain is not usually directly visible in human food-stuffs, but is nonetheless an important ingredient in the production of milk, eggs, beef, pork and poultry. Due to its high protein and starch content, more than half of the corn harvested worldwide is processed into animal feed – and that amount is growing.

As prosperity in emerging nations increases, so does their meat consumption. In many countries, especially in South and Central America, corn in the form of whole kernels, meal and oil is also used as a staple food. In addition to approximately 70 percent water, corn also contains carbohydrates, protein, fat and minerals such as calcium, potassium, phosphorus, iron and sodium, and numerous vitamins. According to the Food and Agriculture Organization of the United Nations (FAO), some 800 million tons of corn

were harvested in 2009 – more than rice, wheat or rye.

Corn thrives best when it has lots of water and light, and temperatures of between 20 and 30 degrees Celsius. The corn plant is relatively flexible regarding soil quality and usually grows up to three meters high in fields, and even up to seven meters in extreme cases. Weeds then no longer pose serious competition.

Tough competition for light, water and nutrients

"Once the rows have closed, hardly any light reaches the ground. Most types of weeds will not re-emerge under these conditions," says Raimund Trapp, Global Asset Manager Corn and Soybean Herbicides at Bayer CropScience in Monheim. Things are different in spring, however, when the small corn seedlings are just pushing their way through the soil. Per square meter of field, eight to ten of the tiny corn plants must fight it out against in some cases thousands of different types of weeds – assorted grasses and dicotyledonous weeds ranging from *Abutilon theophrasti* or velvetleaf all the way to *Xanthium strumarium*, the common cocklebur. The crop plants must

compete with these invaders for light, water and nutrients.

Without herbicides, weeds would take over the field in no time, leaving the corn to wither away. "This is why it is so important to clear corn fields of weeds early on," says Trapp. Yet eliminating weeds is becoming steadily more difficult everywhere around the world. In modern farming, the soil is being worked less and less. That brings both advantages such as a reduced energy consumption and improved CO₂ balance as well as disadvantages like the ever more complex demands made on herbicides. "In order to ensure sustainable farming with the herbicides currently available, it is especially important to prevent the build-up of resistance in weeds to these treatments. But there are areas, primarily in North and South America, where resistance is already a reality," reports Trapp. In a few areas, specific weeds such as the dicotyledonous

Corn scientists at work: in a Bayer CropScience trial field in Monheim, Raimund Trapp (left) and Dr. Reinhard Friessleben (large photo) check the progress of their test plants. In Bayer CropScience's laboratories in Research Triangle Park, North Carolina, Laura Schouten (photo, right) examines the quality and nutrient content of individual corn kernels.



Yellow all-rounder

Corn has been cultivated for thousands of years now; some 5,000 different kinds have been identified. Crop yields from corn plants vary widely in industrialized and developing countries: in the United States, one hectare of land produces an average of 9.5 tons of corn, while the same size of plot yields just 2.3 tons in Mexico. In EU countries, the average is approximately 6.3 tons per hectare. The gluten in corn is ground into meal for use in poultry or pig feed, while the high-fiber husks are used to make food for cattle. As a rule of thumb, seven kilograms of grain-based feed are needed to produce one kilogram of beef. The ratio for poultry is two to one.

In industrialized countries, corn is increasingly being used not just as animal feed, but as an energy plant as well. In the United States, corn is fermented into bioethanol on a large scale. Between 1998 and 2008, the amount of corn used for this purpose increased six-fold. In Europe, corn is sometimes converted into methane in biogas plants. Corn also serves as the base material for bioplastics. Bacteria transform corn starch into lactic acid, the fundamental building block of polylactide (PLA), which is then used to produce biodegradable films, plastic cups, insulation material and even medical products.



Staple food: freedom from weeds is an important precondition if corn plants are to develop well and deliver high-quality yields.

Amaranthus rudis are already resistant to three different classes of active substances. Resistance to glyphosate, a broad-spectrum foliar herbicide in wide usage, has been recorded with reports that it is already spreading rapidly in some areas. This is a problem for farmers in North America in particular. Corn has long been the most important crop there – nearly 40 percent of the world's corn comes from the United States. "There are many ways to slow the development of resistance and prevent it from spreading. If these techniques are neglected and resistance does develop to important classes of active substances, the long-term economic viability of corn crops in such areas can no longer be guaranteed," says Dr. Harry Streck, Head of Integrated Weed Management and Resistance at Bayer CropScience in Frankfurt.

Crop protection with built-in anti-resistance strategy

Recently, affected farmers have been able to use a new agent for weed control: the herbicide Adengo®, developed by researchers from Bayer CropScience. This broad-spectrum agent is a powerful

weapon against numerous grasses and broadleaf weeds. "Adengo contains two active ingredients that each attack a different metabolic process in the same weeds. As a result of the interaction between these two active substances, Adengo is highly effective and even has a built-in anti-resistance strategy," explains Streck.

One of the two anti-weed agents is the tried-and-proven active ingredient isoxaflutole. It blocks an enzyme that plants need to produce the pigment carotene, which shields the green leaf pigment chlorophyll from overexposure to light. Without carotene, the leaves of the weeds have no protection against sunlight. If too much sunlight penetrates the deeper layers of the leaves, it destroys the chlorophyll that plants need to absorb light for photosynthesis. As a result, the leaves bleach and the weed dies. Isoxaflutole even eliminates problematic plants such as velvetleaf, fat hen and the dreaded ragweed.

The second building block in Adengo® is a new compound from the Bayer CropScience laboratory called thiencazuron-methyl. This active substance blocks another enzyme found only in plants which is responsible for

the assembly of three essential amino acids used to create various proteins. If plants cannot produce the three essential building blocks of proteins, they die. "Thiencazuron-methyl is an extremely strong, broad-spectrum representative of an important class of active substances," says Streck.

Safeners protect corn kernels against new herbicide

Both isoxaflutole and thiencazuron-methyl have a powerful effect on all kinds of plants. This is why Adengo® contains a third active ingredient, the safener cyprosulfamide. It protects corn plants from being damaged by the herbicide. "Cyprosulfamide accelerates breakdown of the active substances in the corn plant, but not in the weeds," explains Streck. The concentration in the corn plants thus remains below the activity threshold, especially under adverse growing conditions. The young crop plants are left to develop normally.

"Because much lower application rates are needed as compared to the current standard herbicides, Adengo can be used in all crop production systems – both in conventional farming



Crop protection agent in tests: to verify the efficacy of Adengo® under real-life conditions in field tests, trial technician Karl-Hans Hebbecke applies the substance to Bayer CropScience's test fields in Monheim using a special device.

and in no-till farming, for instance in herbicide-tolerant corn," says Trapp, explaining another key advantage of the new product. "This trait makes it valuable to farmers and contractors for solving a wide variety of problems." After all, Adengo® is highly effective in both tilled and untilled fields.

The type of soil also plays a secondary role in the product's efficacy, and Adengo® is very easy for farmers to apply. "When sprayed early, Adengo becomes active precisely when the weeds begin to germinate," says Trapp. "If the weather turns dry after treatment, the herbicide remains on the ground and is not broken down by sunlight. If the active substances come into contact with water, however, they are activated and can be absorbed by plants." This means that when it rains, weeds begin to sprout and then Adengo® goes into action. The germinating seeds absorb the herbicide via their roots and other parts, dying very shortly thereafter as a result. "We call it synchronized weed control," says Trapp.

Even newly germinated weeds don't stand a chance against Adengo® as the active substances are also absorbed by the young leaves. Transport systems

then carry the substances to the inside of the plant, which then quickly dies.

In order to bring the increasing weed problems under control, researchers from Bayer CropScience are focusing on more than just developing new active substances. "We also offer seminars on integrated weed management," underscores Trapp. It is important that the herbicide be applied at a sufficient application rate and distributed evenly over the field. "Incorrect usage can promote the development of resistant species," he adds.

Avoiding resistance: research budget increased

Even though all of these preventative measures are already well known, they cannot always be optimally implemented in practice. This is exactly why the problem of resistance is likely to plague large-scale agriculture for quite some time to come, say the researchers at Bayer CropScience. To this end, the subgroup has strengthened its research and development activities. The goal is to safeguard the food supply for the world's rapidly growing population – for example corn oil, tortillas and beef.

Interview



More corn for the world

research spoke with **Abdolreza Abbassian, Secretary of the Intergovernmental Group (IGG) on Grains and a grain expert from the Food and Agriculture Organization of the United Nations (FAO) in Rome.**

How important is corn in human nutrition?

Corn is important, but last year only 14 percent of the world's harvest, 116 million tons, were processed directly into food. The crop's importance varies from region to region, however: in Latin America and southern Africa in particular, more than half of the corn cultivated is used for human consumption. Cornmeal and corn oil are staple foodstuffs in these areas.

What else is corn used for?

Primarily as animal feed. In 2009/10, 466 million tons of the world's corn harvest were used for that. Indirectly, this corn also goes into the human food chain. The third category is industrial usage. Corn is processed into starch, sweetener, glue, bioethanol or a base material for polymers. In 2009/2010, a total of 223 million tons of corn were used for industrial purposes and as seed, or were lost post-harvest.

Why has corn production risen so sharply in the past few years?

About seven or eight years ago, the demand for biofuel in the United States began to grow. Production there has exploded recently, with U.S. farmers responding very quickly to the growing demand. Approximately 30 percent of the corn produced in the United States is now processed into bioethanol.

Will demand continue to grow in the future as well?

Demand for meat in emerging countries such as China and India will grow in the mid- and long-term future. So will the demand for production of bioethanol. According to forecasts, corn farmers will be able to keep pace with this increased demand. In certain regions of the world, it is still possible to further increase the yield per hectare.



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