Novel principle of action protects beneficial organisms in fruit orchards and market gardens

Gentle protection **against the juice thieves**

Is it lettuce, strawberries or pears on the menu today? Sucking pests like aphids and whiteflies seem to think that fruit orchards and market gardens are their own personal juice bars. Researchers working for Bayer CropScience have developed an insecticide with an entirely new mechanism of action. Movento® protects plants from within, helping farmers all over the world grow crops from apples through to zucchini, without damaging beneficial organisms like ladybirds or ichneumon wasps.

Every apple-grower's nightmare: the woolly aphid. These purplish-black insects ravage crops of Cox's Orange, Goldparmane, James Grieve and Jonathon apples. Once they have taken up residence in the bark of apple trees, it is very hard for the fruit-grower to get rid of them. Their name comes from the waxy secretion with which they cover their bodies, which makes them look as if they have been rolled in wool. The devastation that these pests can cause in just one orchard was seen in the hamlet of Heidenfahrt am Rhein, in Germany's Rhineland Palatinate region, in the spring of 2008. "You could see the aphids' secretions shimmering between the leaves, like a thick, fluffy layer of white wax. Young shoots looked as if they had mold," comments Dr. Michael Klüken, a scientist working in Agricultural Product Development at Bayer CropScience in Monheim. He counted up to 30 aphids per centimeter.

The aphids mainly attack young shoots and forks in trees, sucking the sap. This causes shoots and fruits to wither. Growths appear where the bark has been damaged. This is called woolly aphid canker. These malignant growths are themselves a perfect entry point for fungal pathogens. Woolly aphids, whose waxy coat protects them against predators, can wriggle into even the tiniest cracks in the bark. They spend the winter in the area around the roots. Attempts to control them using conventional contact insecticides are largely unsuccessful. For this reason, many fruit-growers use brushes or loppers to try to keep a grip on infestation. But this approach cannot entirely eliminate the pests.

Dual action from the tip of the leaf to the root

However, a minor miracle occurred in the Heidenfahrt orchard: some of the trees were spared. The trees in question had previously been treated with the novel Bayer insecticide Movento®. The results surprised even experienced Bayer scientists. "The difference was incredible. The trees that had been treated with Movento were practically aphid-free," reports Klüken. Bayer's new crop protection product protects treated plants from the inside out. This means that it does not act in the same way as many other substances that are sprayed directly onto the insects. As a result, Movento® is not harmful to beneficial organisms in areas where crops are being grown. And the way it is distributed around the plant is also revolutionary. "The active substance in Movento, spirotetramat, is absorbed through the leaves into two transport systems that extend from the roots to the tips of the leaves," explains Karl-Wilhelm Münks, Movento® project leader at Bayer CropScience in Monheim. These "plant arteries" are called the xylem and phloem. The xylem is like a one-way street running from the roots upwards. Water and nutrient salts lost from the surface of the leaves through water evaporation are rapidly replaced. The main content of the phloem is sugar and nutrients produced during photosynthesis. Plant sap travels at a quite leisurely pace along these routes to any point where energy is needed.

For the time being, spirotetramat is the only insecticide that is able to travel throughout plants via the phloem. Other "systemic" insecticides can only penetrate the xylem. But like many other insects, woolly aphids suck sap directly from the phloem. And it is precisely here that the active ingredient sneaks in,

Drama in the orchard: the white secretions of the woolly aphids primarily cover the young shoots of the fruit trees (large photo) and cause them to wither, for example in apple plantations. Here Dr. Reiner Fischer, Karl-Wilhelm Münks and Dr. Michael Klüken (photo right, left to right) from Bayer CropScience assess the damage.

Pest in focus: aphid infestation can be recognized from the waxy secretions (photo left) produced by the insects which are the perfect breeding ground for harmful fungi. In the greenhouse, Dr. Michael Klüken and Mirjam Patten (photo right, left to right) from Bayer CropScience test how well the new insecticide Movento® spreads throughout the plant when it is applied to just one leaf.

undergoing many changes within the plant. In its basic form, spirotetramat is only moderately water-soluble but quite highly fat-soluble, and chemically neutral. This is important so that it can penetrate the waxy coat on the surface of the leaves. Once inside the plant, an enzyme splits off a small appendage of the chemical. The resulting substance, the enol form of spirotetramat, has different physical and chemical properties: a weak acid, it is much more water-soluble. This allows the substance to diffuse into both the xylem and the phloem, where it is carried further with the sap.

Once the substance reaches the phloem, it changes again: it loses a proton, because the pH levels here are higher than in the xylem. This gives a further boost to the substance's solubility in water. The consequence is that spirotetramat can no longer leave the phloem: it remains captured in the transport system and spreads throughout the entire plant. It reaches the parts where previously aphids, whiteflies and psyllids were able to hide safely from predators and crop protection products: the roots and the innermost leaves of lettuces and cabbages.

Innovative contraceptive for aphids

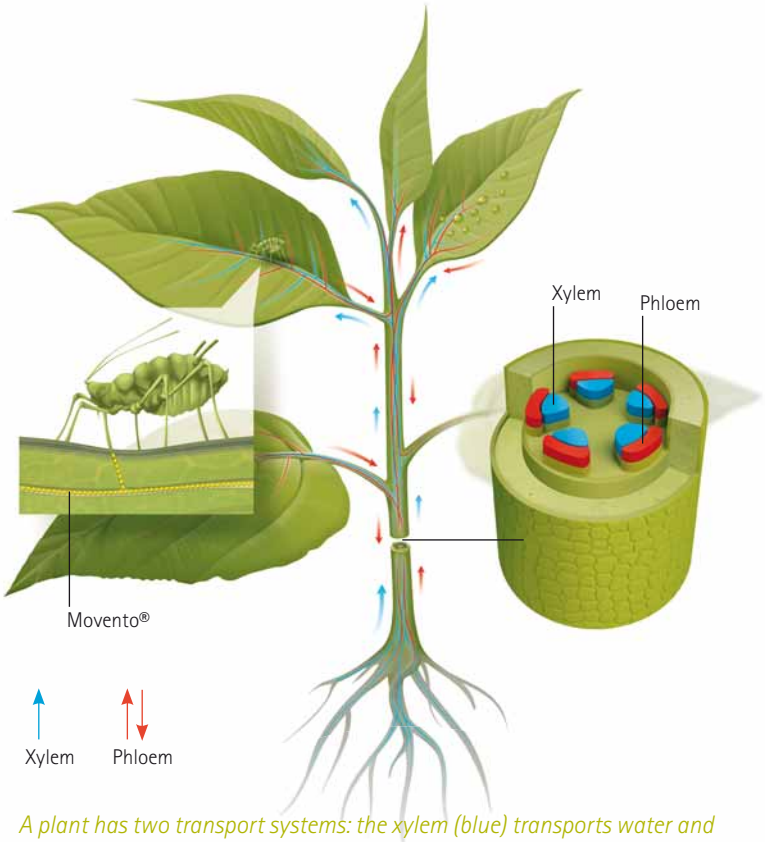
Bayer's new substance blocks an enzyme in insects' bodies, ACCase (acetyl-CoA carboxylase), which is important to fat synthesis. This does not immediately kill adult animals, but makes it impossible for them to breed. Eggs are often infertile, and larvae dry out after they shed their skin. "Spirotetramat is a kind of aphid contraceptive, as they need a working fatty acid biosynthesis mechanism in order to reproduce," explains Dr. Reiner Fischer, who works for Bayer CropScience in Monheim (see also *research* 20, page 42: "Endurance is the key ...").

Bayer's experts are particularly proud of the fact that Movento® does no harm to beneficial organisms. This has been demonstrated by field trials on a range of crops in many countries. Insects such as ichneumon wasps and ladybirds do not absorb the active substance spirotetramat directly, and so it cannot damage them. In fact, Movento® treatment often makes life easier for these creatures as it weakens the defenses of pests. For example, when Klüken and his colleagues examined the trees that had been treated in Heidenfahrt, they found several mummified woolly aphids with holes in their abdomens. "This is the work of a type of ichneumon wasp," explains Klüken. "They pierced holes in the aphids and laid their eggs inside." Once the larvae had developed inside the aphids, the adults emerged through the holes. Persuasive evidence that this treatment does not affect the sensitive wasp at all. "Movento works hand in hand with beneficial organisms, and thereby contributes to integrated crop protection," comments Münks. The new Bayer substance also meets another ecological requirement: in the environment, it breaks down into water and car-

Astonishing keto-enols

In 1987, Dr. Reiner Fischer and his colleagues discovered a completely new substance class: keto-enols. Tests showed the scientists that some keto-enols had an amazing effect on spider mites. This discovery led to the development of the miticide Envidor®, launched in 2002. During further tests, Bayer CropScience's team also discovered a substance capable of controlling whitefly. Bayer CropScience launched Oberon®, based on the active substance spiromesifen, in 2005. But the scientists then discovered yet another interesting effect: a particular group of keto-enols killed aphids. That was the starting point for another innovative insecticide: Movento®. So far, Bayer CropScience has synthesized and tested over 10,000 keto-enols.

Through the plant in the sap



A plant has two transport systems: the xylem (blue) transports water and salts and the phloem (red) supplies all parts of the plant with nutrients, starting from the leaves. Movento® can penetrate both systems and therefore spreads through the entire plant, from the tips of the leaves to the roots. This allows the substance to reach even relatively inaccessible plant parts such as inside young shoots or deep in the root system. Sucking insects such as aphids tap into the phloem and take up the insecticidal active ingredient.

Check for success: under the microscope, the scientists can determine how well the active ingredient is distributed through the individual leaves by examining the cell structure.

bon dioxide within a few days, because light, water and soil organisms cause it to decompose rapidly. "Spirotetramat is pretty much the most ideal active substance you can imagine," according to Fischer.

It is largely thanks to his persistence and intuition that this impressive crop protection product exists at all. The search for the ideal substance turned out to be like looking for a needle in a haystack: Fischer and his colleagues synthesized hundreds of compounds until spirotetramat emerged as the best way of controlling sucking insects and mites. The team finally made its breakthrough thanks to an unusual idea. They combined their active substances with an adjuvant, in this case canola oil methyl ester (better known as biodiesel) - the first time this had been done in insecticide research. This helped the relatively weak substance pass through the outer waxy layer of the plants to reach the interior, and made it much more effective.

Environmentally sound innovation to combat sucking insects

FHN 8330 eventually became spirotetramat. The project team led by Karl Münks then performed field trials around the world with various types of fruits and vegetables and their pests, hoping to determine the optimum conditions of use for every climate and every crop all over the world. Bayer's experts also conducted comprehensive studies to investigate the environmental tolerance and toxicology of the new substance. Stresses Münks: "We operate in the most transparent way we can. For example, in the United States we have carried out field studies in citrus plantations in conjunction with beekeepers, fruit-growers and registration authorities in order to show that Movento is not harmful to bees."

The big day came in 2008 when the U.S. Environmental Protection Agency (EPA) approved Movento® in the reduced risk classification category. This was because Bayer had been able to show that Movento® is safer and less environmentally damaging than products which were previously available. Movento® will come on the market in most European countries in 2010 or 2011. Apple-growers are not the only people already waiting impatiently for this new weapon in the fight against woolly aphids: fruit and vegetable producers all over the world will gain from this new, gentle product to control sucking insects. Says Emmanuel Salmon, Global Asset Manager with Bayer CropScience, "Movento is an important innovation from Bayer CropScience in the field of insecticides and will help fruit- and vegetable-growers protect their harvests against insect pests for years and satisfy growing demands for quality from the food production chain."

www.bayercropscience.com
The search function on this website can be used to access further information about Movento®.