

Biological pest control for gentle crop protection

Bio-protection against nutrient robbers

The roots of soy, cotton and corn plants are attractive sources of nutrients for pests like nematodes. Almost as soon as they hatch, these tiny creatures attack the vital nutrient pipelines of the plants. The result: reduced crop yields and billions of dollars' worth of damage. Researchers at Bayer CropScience have now developed a new defense system: specially optimized natural bacteria protect the seeds with a biological film and guard the plants against the hungry pests.

The thieves are actually still babies: tiny, almost transparent, but extremely voracious, the young threadworms – known as nematodes – have an urgent need for nutrients after hatching. They prefer to dine on the roots of crops like corn, soy and cotton. The pests penetrate to the tips of the roots, sucking up nutrients and thus interrupting the metabolic activities of the crop plants. The result: yellow leaves, stunted stalks and dramatically reduced harvests.

Experts from the Society of Nematologists estimate that the tiny worms of no more than one millimeter in length cause financial damage of up to US\$ 3 billion each year world-

wide. Until now, farmers have relied primarily on chemical substances known as nematicides to combat these pests.

Bacterial barrier stops nematode attacks

However, "there are an increasing number of good possibilities in the area of biological pest control. They also comply with the ever tighter requirements imposed by the regulatory authorities," explains Dr. Ralf Heupel, Global Project Manager at Bayer CropScience in Monheim. He and his colleagues in Monheim and the United States have developed

a new biological agent that relies on natural methods to protect crop plants against nutrient robbers. The basis for the agent, marketed under the name Votivo™, was developed by the Israeli company Agro-Green, from which Bayer CropScience has acquired several biological products.

While carrying out screening work for biological pest control of nematodes several years ago, the Israelis discovered a bacterial strain known as *Bacillus firmus*. Initially, they used this strain to create a product for soil management. The researchers from Bayer CropScience had other ideas, however: Jennifer Riggs, Product

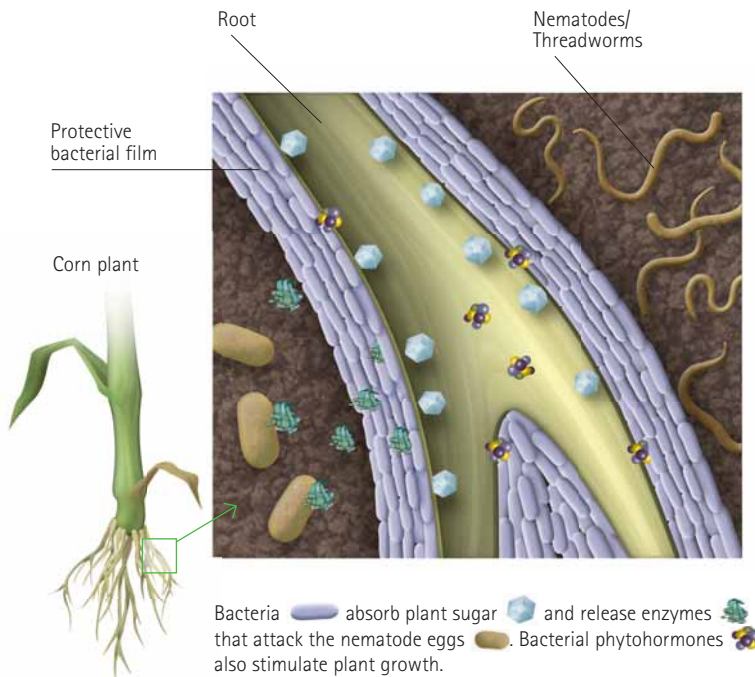


Invisible glutton: as soon as it has hatched from its egg in the soil, a young threadworm starts searching for food (photo left). In order to eat, the pests penetrate to the tips of the roots, sucking up the nutrients and thus interrupting the metabolic activities of the crop plants. A newly developed biological agent is designed to protect crops against attack by root nematodes. In the greenhouse, Dr. Ralf Heupel and Dr. Wolfram Andersch (photo right, from left) check the effect of the new biological agent on cucumber seedlings.



Natural protective wall

Bacteria (Bacillus firmus) form a thin film around a young root before voracious threadworms can discover the new source of nutrients. As a result, the nematodes have no chance to suck up sugar or amino acids. The bio-protector also forms enzymes and produces phytohormones.



of the seed in order to form a living protective sheath. "This is the only way to form an even film of spores when treating corn or cotton seeds and thus protect against nematodes," explains Dr. Wolfram Andersch, a biologist at CropScience in Monheim. He is studying the mechanisms of action used by *Bacillus firmus* in detail.

Biological sheath gives roots a head start

Treated all over with the active substance, a process known as "seed dressing" to specialists, the seeds are protected against attack by the voracious little worms once in the soil. As soon as the root radicle develops, the nematode defense system activates. "Our biological agent thus gives the plant a unique head start. We are there before the worms arrive," explains Andersch. But the researchers are still studying additional details of how *Bacillus firmus* fights pests. "The events under the earth are actually a black box for us. We don't know what is happening in the darkness down there," says Andersch. The specialists from Bayer CropScience have already decoded several pieces of the puzzle, however: they know

Development Manager Seed Treatments at Bayer CropScience, and her team at Research Triangle Park in North Carolina wanted to use the micro-organisms to treat seeds: "After initial laboratory trials, we tested *Bacillus firmus* in cotton fields in 2006. A year later, the program was expanded to soybeans and corn," says Riggs.

Bacterial spores remain dormant until sowing

In a joint research project with Auburn University in Alabama, USA, the plant microbiologists also elucidated the fundamental mechanisms behind the bacterial colonization of roots and soil. The patented active ingredient ensures production of naturally occurring essential enzymes and phytohormones. The journey to

the finished product was a long one, however: "The fine art in developing the active ingredient was to mix the bacterial spores and liquid formulation, i.e. the vehicle, in such a way that the agent remains stable and thus non-perishable for approximately two years," explains Riggs. The new substance is produced in huge fermenters where the bacteria thrive and are brought to sporulation. In this condition, the metabolic activity of the micro-organisms comes to a complete standstill. They are able to survive in this state for long periods without water or nutrients. The spores do not awaken and germinate until enough "food" and the right temperature are present.

The scientists also had to find suitable excipients for ensuring that the bacteria can later attach to all areas

Interview



Damage inspector: the threadworm damage to these cucumber roots can be easily seen with the naked eye (photo right). Bayer researchers Susanne Lohmann and Dr. Ralf Heupel (photo left, from left) examine samples with a microscope in order to identify the tiny nutrient thieves. Jennifer Riggs (photo, center) checks seedlings taken from treated seed in a greenhouse at Bayer CropScience's U.S. headquarters.

that *Bacillus firmus* proliferates on the surface of the roots by absorbing and metabolizing excretory products from the roots such as organic amino acids and sugars which it then employs as nutrients. This foils the nematode "navigation system". After all, the tiny worms orient themselves to these substances to find their way to the much-sought-after source of nutrients. If this incentive is missing, the larvae receive fewer starting signals in the egg: the threadworms hatch too late or not at all. "Nematodes need young root tissue. If the root has already formed lignified tips, the pests can no longer penetrate them," explains Andersch.

Phytohormones increase stress resistance and harvest yields

Together with his colleagues, the biologist has already discovered one additional protective mechanism: the enzymes formed by the bacterial strain break down the proteins in the nematode eggshells. The worm larvae cannot continue developing and die off. In addition, phytohormones set free by the bacteria stimulate growth of the roots and shoots. "The plants thrive better over the entire grow-

ing season, are generally more resistant to stress factors such as heat or drought and yield larger harvests," says Andersch. *Bacillus firmus* has been on the market in the United States for treatment of corn seeds since September 2010. In order to provide U.S. farmers with comprehensive protection of their fields, the scientists at Bayer CropScience have combined Votivo™ with the standard product Poncho™, a chemical insecticide. "The two products are highly complementary in their mode of action," explains Heupel, who together with his colleagues is planning the progressive market launch of Poncho™/Votivo™ around the globe. "Next year, Poncho/Votivo will also be used to treat cotton and soy in the United States – we have already received approval. Our next step will be to focus on Brazil, Europe, South Africa and New Zealand. Treatment of other crops such as wheat and sugar beets is conceivable in the future as well," says Heupel.



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on the topic



"Variety in crop protection"

Dr. Johannes A. Jehle heads the Julius Kühn Institute for Biological Crop Protection in Darmstadt. *research* spoke with the molecular biologist about biological pest control.

How important is biological pest control for the agriculture of the future?

Biological crop protection has been experiencing sharp growth for several years now. That is attributable in part to pests developing increased resistance to chemical crop protection agents and in part to the growing trend towards ecological agriculture: many consumers want foodstuffs that are free of chemical residues. Furthermore, the environment benefits when the impact of crop protection on nature is reduced.

In what areas is the biological variant especially helpful?

Biological pest control is highly efficient in combating pests such as the codling moth, corn borer, spider mites and several types of fungal infections. The best results are obtained in crops with few key pests: due to their selectivity, biological procedures fight only the key pests without harming others. At present, there is no biological means of controlling weeds.

What advantages do microbiological crop protection agents such as fungus, bacteria and viruses offer – and what are their disadvantages?

The main advantage is their high selectivity: microbiological crop protection agents interact specifically with the pest alone. In addition, the pests seldom develop resistance. However, this selectivity does have one disadvantage: in cases of multiple pests, not all of them are always combated. In addition, biological procedures often need a little longer to take effect, but are usually longer lasting. However, farmers frequently feel that the high standards of effectiveness and required speed of action are not met.