UNIVERSITÄT
BERN

flashMOOCs – Transcript

With the flashMOOCs video series, the University of Bern is giving you an insight into interesting educational content on current scientific and social issues.

Video: «Control Insect Pests – The Western Corn Rootworm»

Author: Prof. Dr. Matthias Erb, Institute of Plant Sciences, University of Bern, http://www.ips.unibe.ch/

License: Licensed under a Creative Commons Attribution 4. International License

Link: http://www.flashmoocs.unibe.ch/themen/western_corn_rootworm

---

«Every year, insect pests have the potential to consume plants that could feed 1.2 billion people. Current pest control strategies reduce this number to about 600 million but are often unsustainable and harmful to the environment.

Why do we struggle so much to manage insect pests in agriculture?

In this course, you will learn about the advantages and limitations of major pest control approaches. And you will learn about the important role that basic research plays in understanding the biology of insect pests and developing new, sustainable pest management strategies. The western corn rootworm, one of the most damaging insect pest in agriculture, will serve as an illustrative case-study for this course.

Introduction

In this course we will discuss challenges and opportunities that we face in our quest to control important agricultural pests. We will look at the western corn rootworm as an example of a pest that is very damaging to agriculture and that is very hard to control because it defeats most pest control strategies.

The western corn rootworm is a specialist maize pest whose larvae feed on maize roots. The corn rootworm is a big problem in the United States and is invasive in Europe. It currently causes

economic losses of over 2 billion US dollars, and its negative impact is likely to increase in the future, as maize cultivation expands and the climate changes.

Models predict, for instance, that maize growing regions in China may be at risk of invasion.

Select one of the marked regions to read more about local damage cases.

The rootworm's life cycle

The adult western corn rootworm lives above ground and lays eggs into the soil in autumn. The eggs overwinter in the soil, where they can withstand temperatures as low as -10°C. Almost perfectly synchronized, the larvae then emerge from the eggs in spring, when maize is planted. The larvae then move to the roots of young maize plants and develop on the maize root system.

Western corn rootworm larvae preferentially feed on maize crown and brace roots. Thereby, they reduce plant water uptake and stability. This results in substantial yield losses.

The life cycle is completed when the adults emerge from the soil, copulate and search for new egg laying sites.

Many different people, including farmers, plant breeders, scientists as well as biotech companies are trying to find new ways of controlling important agricultural pests and many different strategies are being tried as we speak.

Which approach would you take to fight a major pest such as the western corn rootworm? Would you …

- *spray insecticides,*
- *deploy genetically modified maize plants,*
- *sow naturally resistant maize plants,*
- *use crop rotation,*
- *or would you use biological control?*

1. Spray insecticides

You would spray insecticides – ok.

Insecticides are an important tool to fight many insect pests. They have helped to increase crop harvests over the last century to feed a growing world population. However, there are a number of emerging problems that are associated with their use.

One problem associated with the use of insecticides is that many insect pests, including the western corn rootworm, evolve resistance over time. The strong selection pressure exerted by insecticides on the herbivores essentially renders them insensitive after several years and thereby reduces the efficacy of the insecticides.

Also keep in mind that some insect pests can be very difficult to reach with insecticide sprays. Western corn rootworm larvae for instance feed below ground which means that you cannot directly spray them with the insecticide because you cannot directly touch them.

Insecticides targeting corn rootworms are, therefore, applied on the seeds before sowing. The problem with this method is that the farmer cannot adjust the application of the insecticide, as the seeds need to be coated before sowing. This means, insecticide will be applied, independently of whether the pest is actually present in a given year or not.

Also because of their potential negative environmental impact, there is increasing pressure to move away from insecticides, at least when economically and ecologically sound alternatives are available.

The discussion about whether insecticides such as neonicotinoids should be banned is ongoing. We have collected several articles from the media that reflect different points of view on this topic.

Click on the buttons as starting points to get more information and form your own opinion.

2. Deploy genetically modified maize

You would deploy genetically modified maize. Interesting idea.

Transgenic plants are plants that carry foreign genes. For instance, maize plants that carry genes from bacteria that produce insecticidal toxins. These plants are heavily used in the US to control insect pests, including the western corn rootworm.

Transgenic plants carrying such insecticidal toxins can be very efficient in controlling herbivore pests. However, not unlike pesticides resistance can evolve against those traits. The western corn rootworm for instance can develop resistance against bacterial toxins very quickly. And our colleagues in the US have shown that three generations of selection in the green house are sufficient for resistant western corn rootworm larvae to evolve.

As the toxins were originally isolated from soil bacteria, it's assumed that the corn rootworm was already in contact with those toxins and evolved resistance long before these toxins were integrated into transgenic plants. Growing genetically modified plants then favors western corn rootworm individuals that carry the resistance traits, which again results in their proliferation within rootworm populations.

New resistant transgenic plants are constantly being developed. Including varieties that carry multiple bacteria toxins and varieties that carry transgenes which switch off essential genes in the western corn rootworm through RNA interference.

Biotechnology is often thought to hold substantial promise for the future of pest control strategies, even though the evolution of resistance of certain pests does remain a challenge. Also keep in mind, that consumer acceptance of transgenic plants and plants that are produce through new biotechnological approaches remains low in certain parts of the world, which limits our capacity to use those technologies for pest control.

Legislations for the cultivation of transgenic plants differ between countries. In addition, consumer acceptance varies substantially.

Click on the buttons for more information.

3. Sow natrually resistant maize

You would sow naturally resistant maize plants. Sounds like a promising idea!

Through natural selection over millions of years, plants have evolved a rich arsenal of strategies that help them to cope with insect pests. And in theory, it should be possible to use some of those natural strategies to make crops more resistant or tolerant against crop pests. Maize is no exception. Maize actually possesses a series of defenses including toxic metabolites, so called benzoxazinoids which help maize to resist insect pests.

These metabolites increase the resistance of maize plants against aphids and other leaf-feeding insects. Furthermore, maize has a responsive immune system. It is activated by herbivore attack and results in the production of defenses such as antidigestive proteins, which reduces herbivore damage. Unfortunately, research shows that the western corn rootworm overcomes all these resistance strategies.

When western corn rootworm larvae feed on roots for instance, they suppress the plant immune system and trigger the release of nutrients. Furthermore, the larvae are fully resistant to benzoxazinoids. What's even worse, they misuse these compounds to identify maize plants and find the most nutritious roots.

Taken together our research suggests that the western corn rootworm has adapted to the natural defense mechanisms of maize plants. These adaptations are the basis of the success of the western corn rootworm as major a maize pest. To us this suggests that our capacity to use the natural resistance factors of maize to fight the western corn rootworm may be severely limited. And this is also true for other insect pests on many different crops.

4. Crop rotation

You would use crop rotation. That is a clever idea! If you don't grow maize, you deprive the western corn rootworm of its food source.

Crop rotation is an important strategy to fight many agricultural pests. It is heavily used in conventional and organic agriculture. Beware, however: There are a few issues you have to consider.

Crop rotations have many advantages for agriculture. They improve soil health and they can indeed suppress specialized pathogens and insect herbivores. However, they do not always work as we intent them to, as we will see now for the western corn rootworm.

Farmers in the US experienced this when rotating between maize and soybean. Research by US scientists shows that adult western corn rootworms even feed on soybean leaves. They carry gut microbes that help them to deal with soybean defenses. After feeding on soybean leaves, the adults lay their eggs into the soil. The eggs overwinter and the larvae hatch in spring. Exactly that time when the farmers rotate the field and sow maize.

Short rotations, which are often of commercial interest do not always work to effectively suppress insect pests such as the western corn rootworm. Longer rotations are often employed in organic farming for instance and remain an efficient way of maintaining productivity and suppressing insect pests. However, they also require a substantial amount of expertise and infrastructure and they can lead to increased costs of production, at least in the short run.

5. Biological control

You would use biological control.

Using natural enemies to control herbivore pests is a promising strategy, especially in organic agriculture.

Entomopathogenic nematodes are small, insect killing worms. They live in the soil, where they attack and infect insect larvae. After entering a larva, the nematodes release a bacterium, which kills the insect host in a few days. The nematodes and the bacteria then feed on the insect host, reproduce and finally emerge from the cadaver to find a new host.

Entomopathogenic nematodes are commercially available and can be applied to the soil using modified farming machinery. These biological control agents are increasingly used to control soil borne pests, including the western corn rootworm.

Our work in collaboration with colleagues here in Bern and in Germany shows that biological control of the western corn rootworm is limited by a very clever strategy that the western corn rootworm uses to defend itself. The corn rootworm larvae have evolved the ability to take up plant toxins, toxins, coming from maize, store them in their body, excrete them and reactivate them as a mean of self-defense against entomopathogenic nematodes which we would like to use for biological control.

In a nutshell, you could say that the herbivore uses the weapon of the plant to fight its own battles and that reduces the capacity of biological control agents to control the western corn rootworm.

It is a cruel but fascinating paradox that natural plant resistance factors protect the pest instead of the plant in this case.

Based on the current state of research, we are now trying to find natural enemies that are not affected by the toxins that the western corn rootworm larvae take up from the plant. And we hope that in the future identifying more efficient natural enemies will help to control the western corn rootworm using an environmentally friendly and hopefully sustainable pest control strategy.

6. What else can we do?

As you see, there are many strategies available to fight important agricultural pests such as the western corn rootworm. However, none of them is perfect:

Insecticides are not sustainable because the pests develop resistance and because of concerns regarding their environmental impact. Genetically modified plants can also suffer from pest resistance and face variable consumer acceptance. Natural defenses of plants such as maize are of limited use, as specialized pests have adapted to them. And long crop rotations require substantial expertise and infrastructure.

As a scientist, I am convinced that a good understanding of the biology of insect pests is important to control this pest in agriculture. Over the last ten years, we have identified major strategies that the corn rootworm uses to exploit its host plant. We have contributed to a better understanding of how the western corn rootworm resists major control strategies. This knowledge is now guiding us

towards the development of new control strategies that will hopefully in the future help to better control this devastating pest.

You cannot fight what you do not understand. Therefore, basic research in plant sciences and in plant-herbivore interactions is fundamental if we are to develop new, environmentally friendly and sustainable pest control strategies with the aim to contribute to feeding the planet.

Further information: www.flashmoocs.unibe.ch