Biocontrol in Selected Crops Number 3: Maize

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Food Quality and Safety
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Maize in European agriculture

Maize is one of the most popular and widely grown crops in the world. In terms of production (FAOSTAT, 2008), the main European producing countries are: France (16 million tonnes) followed by Ukraine (1.15 million tonnes), Italy (1 million tonnes) and Hungary (0.9 million tonnes). Together the countries of Eastern Europe accounted for a total production of 42 million tonnes, which corresponds to 35% of total production. However, in terms of yield (Hg/Ha) Western Europe and Southern Europe have the best performances (see Figure 1).

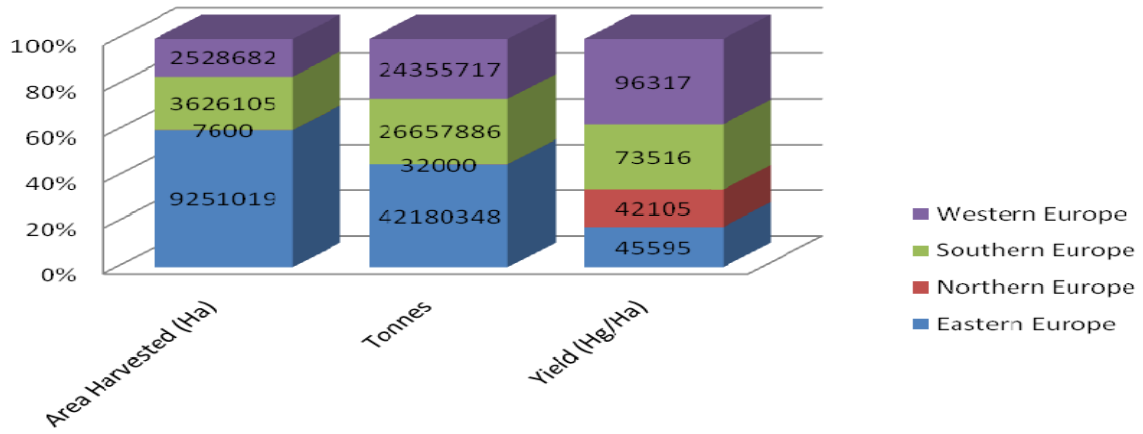
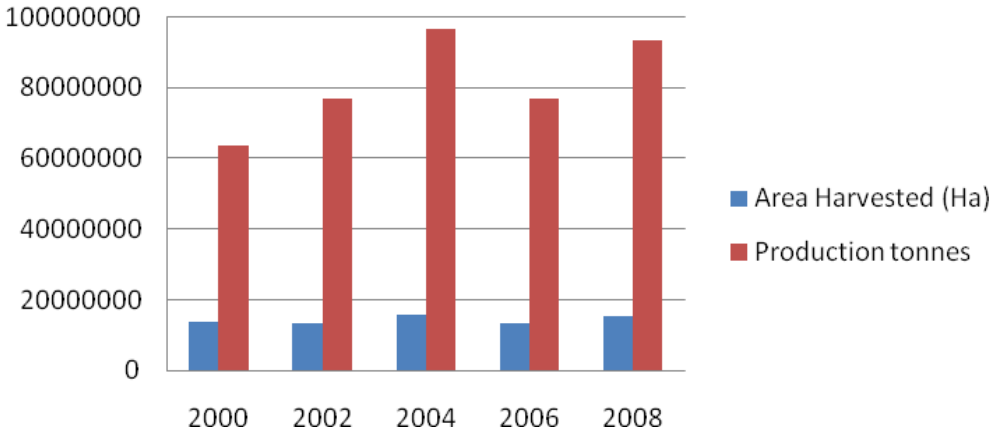


Figure 1: Maize production in Europe

During the past eight years there has been a positive trend in maize yields, while the harvested area has remained substantially the same (see Figure 2).

Figure 2: European maize production over the past eight years



Pesticides and herbicides are widely used by maize growers. More sustainable production methods are readily available but, unfortunately, are not widely disseminated. We strongly believe that biological controls and improved cultural practices (rotations) can be integrated into IPM strategies to reduce pesticide use dramatically.

Short overview of the main threats in maize production

Many diseases and pests can affect maize during the growing season.

Diseases more frequent during production

Above: *Fusarium* ear rot infection. © Elzbieta Czembor, IHAR, Poland.

> **Fusarium ear rot:** caused by several species of *Fusarium* spp. and is the most common fungal disease on corn ears. Typically, symptoms of fusarium ear rots are a white to pink or salmon-coloured mould, beginning anywhere on the ear or scattered throughout, but it rarely involves the whole ear. Infected kernels are often tan or brown, or have white streaks. These fungi can produce mycotoxins.

> **Fusarium stalk rot:** caused by several species of *Fusarium* spp. Stalk rot is generally thought of as a problem of senescing plants. A higher incidence of stalk rot is common when conditions such as water stress and foliar diseases occur. The earliest symptoms of stalk rot are wilted plants in the field. Infected plants take on a grayish green hue and then turn tan. Outward symptoms of the disease are indefinite discoloured patches on the lower internodes

> **Crazy top:** caused by *Sclerophthora macrospora* and *Sclerospora* spp. The disease is most prevalent in warm and humid regions. The expression of symptoms is greatly affected by plant age, the species of the pathogen and the environment. Usually, there is chlorotic striping of leaves and leaf sheaths, and dwarfing. Downy mildew becomes conspicuous after development of a 'downy growth' on or under the leaf surface. This condition is the result of conidia formation, which commonly occurs early in the morning.

> **Corn smut:** caused by *Ustilago maydis*. The plant may be infected at any time in the early stages of its development but gradually grows less susceptible after the formation of the ear. Any part of the plant above the ground can be invaded, although it is more common on the ears. Hot, dry seasons are favourable for the growth of the fungus. The boil is composed of a white, smooth covering enclosing a great mass, sometimes four or five inches in diameter, of black, greasy or powdery spores. After the spores mature, the covering becomes dry and brittle, breaks open and allows the black powdery contents to fall out.

> **Head smut:** caused by *Sphacelotheca reiliana*. It is responsible for a variety of symptoms and both tassel and cobs may be partially or completely smutted. This disease is, in general, rare.

> **Rhizoctonia root rot and stalk rot:** caused by *Rhizoctonia solani.* The lesion is brown to blackish brown, sinks twoards the centre and is produced on the crown and prop root. The infected plant easily lodges or falls down during light winds or rain.

> **Common rust:** caused by *Puccinia sorghi.* The disease occurs severely under cool, wet conditions.

> **Pythium root rot:** caused by *Pythium graminicola.* It causes wilting of the whole plant at the yellow ripe stage. During the onset, the roots turn brown and then the whole plant withers around the yellow ripe stage. Typically, the ear of an infected plant hangs down.

> **Pythium stalk rot:** caused by *Pythium aphanidermatum.* This disease occurs sporadically. The surface of the culm just above the ground at first discolours to a brown shade and is water-soaked. The rot

extends rapidly to the inside of the culm. Brown and spindle-shaped lesions are sometimes produced on the surface of the culm. The culm softens and rots and the whole plant twists and falls down.

Available biocontrol solutions (commercially used biocontrol agents)

Pathogen	Micro-BCA	Macro-BCA	Semiochemical	Natural product
***Fusarium* spp.**	***Trichoderma harzianum***			
Puccinia sorghi				
Pythium graminicola* and *Pythium aphanidermatum	***Trichoderma harzianum***			
Rhizoctonia solani	***Trichoderma harzianum***			
***Sclerophthora macrospora* and *Sclerospora* spp**				
Sphacelotheca reiliana				
Ustilago maydis				

Insect pests frequently damaging maize in Europe

> **European corn borer, *Ostrinia nubilalis* (Hübner) (Lepidoptera: Crambidae):** young larvae feed on tassels, whorl and leaf sheath tissue and also mine midribs; they also feed on silk, kernels, and cobs, or enter the stalk. Older larvae burrow into the stalk, the base of the corn ear, or into the ear cob or kernels. The presence of one to two larvae within a corn stalk is tolerable, but the presence of any larvae within the ear of sweetcorn is considered intolerable. Heavily bored stalks of grain corn suffer from lodging, reducing the capacity for machine harvesting. Boring by corn borers allows several fungi to affect corn plants, contributing to increase the level of associated mycotoxins that are dangerous for humans and livestock.

> **Mediterranean corn borer, *Sesamia nonagrioides* Lefèbvre (Lepidoptera: Noctuidae):** damage caused to corn is very similar to that produced by the European corn borer.

> **Cotton bollworm, *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae):** larvae feed on the leaves, tassels, ears (on the kernels) and the whorl. In general, this pest is less injurious than the corn borers.

> **Cutworms, *Agrotis* spp. (Lepidoptera: Noctuidae):** Cutworms are sporadic early-season pests that can reduce plant populations in a field. Larger larvae chop off seedlings at the soil plane, whereas small larvae climb plants and chew small holes in the leaves.

> **Western corn rootworm, *Diabrotica virgifera virgifera* Le Conte (Coleoptera: Chrysomelidae):** both adults and larvae feed on the plant, but larval root feeding is the main cause of damage. Larval feeding may destroy individual roots or root nodes, and reduce plant growth, stability and yield. Severe root injury may result in lodging of corn plants, making harvesting more difficult. The adults are responsible for the damage of leaves, corn silk, pollen and corn cob, causing additional losses, particularly in maize production for grain, seed or sweetcorn.

> **Wireworms, *Agriotes* spp. (Coleoptera: Elateridae):** early in the season wireworms may destroy germinating seeds and cut off seedlings at the soil line. Wireworms also attack young plants, resulting

in weakened plants or a reduced stand. Damage is most likely to occur where corn is planted into a field formerly used for pasture or for growing weedy alfalfa.

Biocontrol solutions for insect pests of maize in Europe

Insect pest	Macroorganism	Microorganism	Genetically modified cultivars	Semiochemical	Other solutions
European corn borer, *Ostrinia nubilalis*	Parasitoid wasps: *Trichogramma* spp.	*Bacillus thuringiensis* var. *kurstaki* and var. *aizawaii* (bacterium)	*Bt* maize producing Cry proteins from *B. thuringiensis*	Sex pheromone: - monitoring of males Semiochemicals: - monitoring of females	Trap plants around corn field
				Sex pheromone: - mating disruption	
Cotton bollworm, *Helicoverpa armigera*	Parasitoid wasps: *Trichogramma* spp.	*Bacillus thuringiensis* var. *kurstaki* and var. *aizawaii* (bacterium)	*Bt* maize producing Cry proteins from *B. thuringiensis*	Sex pheromone: - monitoring of males	
		Nucleopolyhedrovirus			
Mediterranean corn borer, *Sesamia nonagrioides*		*Bacillus thuringiensis* var. *kurstaki* and var. *aizawaii* (bacterium)	*Bt* maize producing Cry proteins from *B. thuringiensis*	Sex pheromone: - monitoring of males	
				Sex pheromone: - mating disruption	
Cutworms, *Agrotis* spp.				Sex pheromone: - monitoring of males	
Western corn rootworm, *Diabrotica virgifera virgifera*		Entomopathogenic nematodes Entomopathogenic fungi	*Bt* maize producing Cry proteins from *B. thuringiensis*	Semiochemical-based insecticide baits	

Key	Available		In development	

SWOT analysis

> Strengths: biocontrol products are usually user and environment friendly.
> Weaknesses: used alone, their efficacy is considered lower than competitive chemicals. They need to be used at a lower level of infestation (threshold).
> Opportunities: easier registration.
> Threats: high cost and complicated to use.

References:
> Meissle et al. Pests, pesticide use and alternative options in European maize production: current status and future prospects. *J. Appl. Entomol. 134 (2010) 357–375.*
> ENDURE Maize Case Study leaflets 1, 2 and 3.

Recommendations for biocontrol in maize

Research and development

Technical institutes should look deeper into integrating biological and chemical control.

> Weed control is a big gap to be explored, both on the plantation row and in the control of invasive weeds (glyphosate resistant).

> Set up 'new application thresholds' adapted to the use of biologicals.

Policy makers and regulation

> Reinforce the trend towards zero pesticide residues.

Education, training, communication

> Involve farmers' organisations in the promotion of alternative protection systems.

> Demonstration plots, especially in reputable maize fields.

> Training courses.

Industry and distribution

> Development of more user friendly biological products.

> Make available application 'kits', including decision support tools.

> Active promotion (demonstrations, lectures, training etc).

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About ENDURE

ENDURE is the European Network for the Durable Exploitation of Crop Protection Strategies. ENDURE is a Network of Excellence (NoE) with two key objectives: restructuring European research and development on the use of plant protection products, and establishing ENDURE as a world leader in the development and implementation of sustainable pest control strategies through:

> Building a lasting crop protection research community

> Providing end-users with a broader range of short-term solutions

> Developing a holistic approach to sustainable pest management

> Taking stock of and informing plant protection policy changes.

Eighteen organisations in 10 European countries are committed to ENDURE for four years (2007-2010), with financial support from the European Commission's Sixth Framework Programme, priority 5: Food Quality and Security.

Website and ENDURE Information Centre:

www.endure-network.eu

This publication was funded by EU grant (Project number: 031499), under the Sixth Framework Programme, and is catalogued as Biocontrol in Selected Crops Number 3: Maize, published in November, 2010.