From Science to Field
Maize Case Study – Guide Number 1

Non-chemical control of corn borers using *Trichogramma* or *Bt* maize

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Food Quality and Safety

6TH FRAMEWORK PROGRAMME

Corn borers in Europe – major pests of maize

Biology and distribution

The European corn borer (*Ostrinia nubilalis*, ECB) is a widespread and major pest of maize in Europe. The small nocturnal moths lay clusters of between 10 and 40 eggs on the lower leaf surface. Larvae chew leaves and tunnels in the stems of the maize plants, weakening them and causing them to break. Furthermore, the ears of maize can be damaged. While the pest has one generation in Northern Europe, two to three generations occur in Southern countries. Developed larvae overwinter in maize stubble. In Mediterranean countries, another stem boring species, the Mediterranean corn borer (*Sesamia nonagrioides*, MCB), may cause most serious damage. Its lifecycle is similar to that of ECB, but females lay eggs between the sheath and the stem of maize plants. Because larvae enter the stem just after hatching, they are always protected from both natural enemies and chemical insecticides.

Damage

Due to the tunnelling of the larvae, stems often break and complicate harvesting. Reduced plant development and nutrient transport result in yield losses averaging 7% and can reach up to 30% in heavily infested fields. In sweet maize production, ears with feeding damage are not marketable. Furthermore, wounds caused by corn borer feeding facilitate infestation by fungal diseases. Mycotoxins, which are produced by some growing fungi, can lead to quality reduction of the grains if the allowable threshold levels are exceeded.

Insecticides

In the European Union, between 0.7 and 0.9 million hectares are treated with insecticides against corn borers. However, spray insecticides or on-plant micro-granulates are only efficient when applied before the larvae of ECB enter the maize stems. Furthermore, with maize plants reaching 1m or higher at this stage, special equipment is necessary. In addition, commonly used insecticides (such as oxadiazine, pyrethroid and organophosphates) are known to have adverse effects on non-target arthropods including natural enemies and pollinators.

Cultural methods

Cutting stems close to the ground and ploughing plant remains under in autumn or early spring are methods used to reduce the number of emerging adults and thus the number of eggs laid in the new crop. However, no-till or reduced tillage methods can be more suitable in some areas in order to better preserve the soil.

Trichogramma – a biological control alternative

Trichogramma species are microscopic wasps (< 1mm) that search for and parasitize eggs of ECB. New *Trichogramma* wasps develop from egg to adult in the host eggs. Currently about a dozen of the 200 worldwide species are commercially used. Against ECB, the most effective species is *Trichogramma brassicae*. The wasps need to be released every year because they are not able to overwinter in large numbers under European conditions. However, *Trichogramma* is not able to parasitize the hidden eggs of the MCB.

Above: A *Trichogramma* egg card. © Biotop, Valbonne, France.

Application

Egg cards containing *Trichogramma* wasps can be easily attached to the maize plants by hand at the beginning of the egg-laying period of the ECB. The optimal date of release

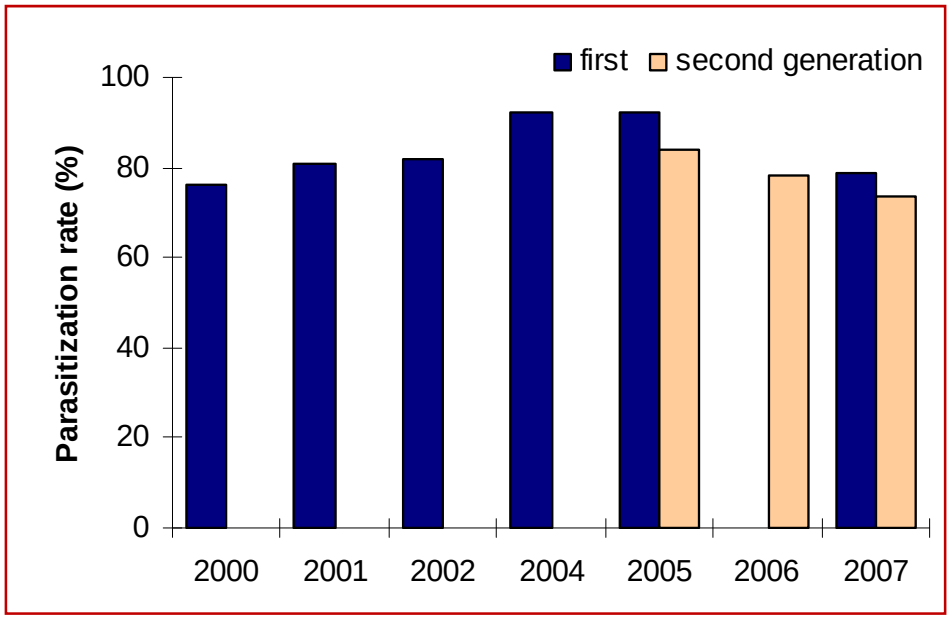
can be reliably forecasted based on temperature sum, caterpillar pupation surveys and trapping of first adults. The product can be customised to different crop types (grain, silage, seed or sweet maize). Against the first generation of the pest, between 100,000 and 225,000 wasps are released, usually from 25 to 50 release points per hectare. An area of between 3 and 5 hectares can be covered per hour and per person. *Trichogramma* can also be released against the second generation of ECB. High levels of infestation, warm temperatures and higher plants typically require between 225,000 and 600,000 wasps from 50 release points per hectare and applications times will therefore be longer (between 2 and 3 hectares per hour and per person).

Adoption

Since *Trichogramma* first became available on the market in 1980, the technique has been improved continuously. Currently, wasps are released on about 150,000 hectares, mainly in France, Germany and Switzerland, every year.

Efficacy

Trichogramma wasps have been developed into a product with high reliability. If the manufacturers' recommendations are followed, the efficacy is comparable to chemicals and more than 75% of ECB eggs are commonly parasitized and destroyed. In areas where ECB has two or three generations per year, a good control of the first generation is crucial to reduce attacks from the following generations and to get better global results.



Parasitization rate of first and second generation ECB after mass release of *Trichogramma* wasps. Source: Biotop, Valbonne, France.

Environmental risks

Some *Trichogramma* wasps may leave the maize fields and parasitize eggs of non-target insects. However, field studies have shown that parasitization rates in natural habitats around maize fields remained low after the mass release of *Trichogramma*. Furthermore, parasitization of natural enemies as well as competition with indigenous egg parasitoids was found to be insignificant under field conditions. Most of the released wasps die after the egg-laying period of ECB. Cardboard egg cards are biodegradable and there are no known risks for human health. The product can thus be considered environmentally friendly.

Costs

The costs of biological control using *Trichogramma* depend on which country the farmer is based, distribution systems and doses. In France, for example, the end-user price against the first generation of European corn borers is between €35 and €40 per hectare (excluding the costs of labour) and thus

comparable with chemical insecticides (at around €20 to €40 per hectare). For the control of the second generation, the end-user price can be calculated at around €45 to €55 per hectare.

Bt maize – a new technology against corn borers

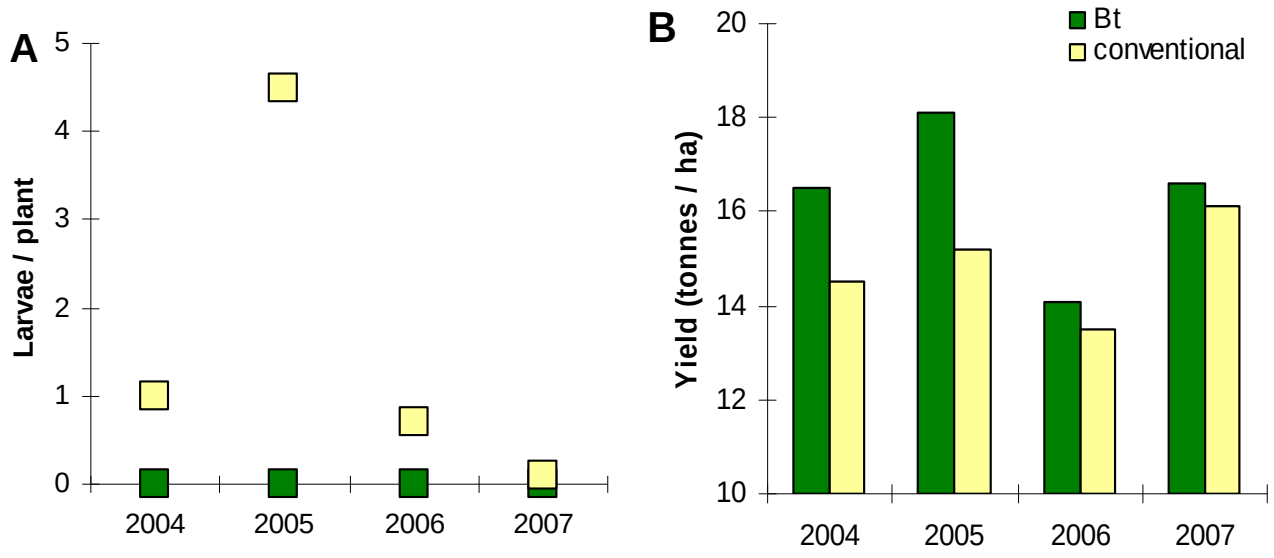
Genetic engineering has been used to develop maize plants that produce an insecticidal protein from the bacterium *Bacillus thuringiensis*. The insecticide is expressed over the whole growing season in the whole plant, which allows efficient control of stem boring moths such as ECB and MCB.

Adoption

In the European Union, *Bt* maize for corn borer control has been approved since 1998, even though some countries prohibit its cultivation. Currently, many *Bt* maize varieties containing the transformation event MON810 are registered in the European catalogue of varieties. In Europe, 108,000 hectares of *Bt* maize were grown in 2008, with Spain accounting for 75% of the total area.

Efficacy

Bt maize provides almost 100% protection against all generations of corn borers and most larvae die shortly after feeding.



Number of corn borer larvae (A) and yield average (B) in *Bt* maize compared with conventional maize in Catalonia, Spain. Source: Salvia et al (2008), DARP, Generalitat de Catalunya, Dossier Técnic 27: 3-14.

Environmental risks

A large number of laboratory and field trials have revealed no detrimental effects of *Bt* maize on beneficial arthropods, such as natural enemies, soil organisms, or pollinators. *Bt* proteins are harmless to humans and animals. Currently available *Bt* maize varieties produce low toxin concentrations in pollen, which minimises the risk for moths and butterflies outside the maize field. Maize has no wild relatives in Europe, thus out-crossing poses no environmental risk. To ensure the coexistence of conventional cultivars with *Bt* plants, minimum distances (defined by each country) to neighbouring non-*Bt* maize fields have to be respected by farmers. Furthermore, farmers are required to plant a certain percentage of conventional maize to reduce the likelihood of resistance development. In Spain, for example, the percentage is 20% for fields larger than 5 hectares. In some countries, fields cropped with *Bt* maize have to be documented in a public register.

Costs

When buying *Bt* maize seeds, farmers need to pay a 'technology fee' in addition to the price of conventional maize. This fee is defined by the seed companies and may vary from region to region. For example, in the Lleida region of Catalonia, Spain, where there is medium to high corn borer pressure, *Bt* maize is €40 to €45 per hectare more expensive than conventional maize. In contrast to other control methods, however, farmers have no extra costs for labour, machinery or chemicals.

Maize producing insecticidal *Bt* protein against corn borers. © Michael Meissle, Agroscope ART, Switzerland.

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Other ENDURE publications about maize (available at www.endure-network.eu):

- Maize Case Study Guide Number 2: Western Corn Rootworm in Europe: Integrated Pest Management is the Only Sustainable Solution
- Maize Case Study Guide Number 3: Prevention Of Ear Rots Due To *Fusarium* Spp. On Maize And Mycotoxin Accumulation
- Integrated Weed Management Case Study Guide Number 1: Maize Cropping With Less Herbicide
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- Maize Based Cropping Systems Case Study Guide Number 5: Strumenti Innovativi di IPM Raccomandati per Sistemi Colturali Basati sul Mais in Pianura Padana, Italia
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Controllo non chimico di Piralide e Sesamia nel mais con *Trichogramma* o mais *BT*

Riassunto

Piralide e Sesamia sono fitofagi minatori del mais (*corn borers*) molto diffusi in Europa e causano perdite di resa fino al 30%. Un'alternativa ai trattamenti con insetticidi contro la Piralide è il controllo biologico con il parassitoide delle uova *Trichogramma brassicae*. Queste piccole vespe sono utilizzate in Europa in circa 150.000 ettari ogni anno, soprattutto in Francia. Distributori contenenti le vespe (*egg cards*) sono applicati alle piante di mais all'inizio del periodo di ovideposizione dei minatori. Efficacia (più del 75% delle uova del fitofago sono distrutte) e prezzo (35-40 euro per la prima generazione) sono paragonabili al trattamento insetticida. Un'altra opzione è l'uso di mais *BT* geneticamente modificato, che produce una proteina insetticida dal batterio *Bacillus thuringiensis* efficace anche contro la Sesamia, non controllata da insetticidi o *Trichogramma*. In Europa nel 2008 sono stati coltivati 108.000 ettari di mais *BT*, soprattutto in Spagna. Il mais *BT* garantisce quasi il 100% di protezione contro tutte le generazioni di Piralide e Sesamia. Non sono stati riportati casi di effetti negativi del mais *BT* sull'ambiente o la salute di uomini o animali. I semi di mais *BT* sono di solito più costosi degli altri, ma non si devono poi sostenere altri costi per il controllo. In conclusione, il controllo biologico di Piralide e Sesamia con *Trichogramma* o mais *BT* sono due opzioni efficaci, competitive e in grado di ridurre il carico ambientale di insetticidi.

Per ulteriori informazioni si prega di contattare:

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A proposito di ENDURE

ENDURE è la rete europea per lo sfruttamento durevole delle strategie di protezione delle colture. ENDURE è una Rete di Eccellenza (NoE) con due obiettivi principali: la ristrutturazione della ricerca e dello sviluppo europei sull'impiego di prodotti fitosanitari, che vede ENDURE leader mondiale nello sviluppo, e l'attuazione di strategie sostenibili di controllo dei parassiti, mediante:

> la costituzione di una stabile comunità di ricerca sulla protezione delle colture
> la fornitura agli utenti finali di una più ampia gamma di soluzioni a breve termine
> lo sviluppo di un approccio olistico alla gestione sostenibile delle specie nocive
> il bilancio e l'informazione sui cambiamenti nelle politiche di protezione.

Diciotto organizzazioni in 10 paesi europei si sono impegnate per quattro anni (2007-2010), con il sostegno finanziario della Commissione Europea del Sesto Programma Quadro, priorità 5: qualità dei prodotti alimentari e sicurezza.

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