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EDITORIAL

Dear friends and colleagues;

Due to some technical problems (or my technical incompetence) the IWGO – NEWSLETTER appears later than projected. Nevertheless we are able to distribute this issue of the NEWSLETTER before the end of the year 2009.

In this IWGO – NEWSLETTER 29/2 we provide a summary of report requested of the Directorate General for Health and Consumers of the European Commission entitled “Analysis of the economic, social and environmental impacts of options for the long-term EU strategy against *Diabrotica virgifera* (Western Corn Rootworm), a regulated harmful organism of maize, to support the drafting of the Commission Impact Assessment”. This report was compiled and submitted to the European Commission by the Food Chain Evaluation Consortium (FCEC), Civic Consulting - Agra CEAS Consulting, Van Dijk Management Consultants - Arcadia International.

Our German colleagues Drs. M. Zellner and A. Kunert, Bavarian State Research Center for Agriculture (LfL), Institute for Plant Protection, Freising, Germany, and Dr. U. Heimbach and Ms. K. Schwabe, Julius Kühn-Institute (JKI), Institute for Plant Protection in Field Crops and Grassland, Braunschweig, Germany, provide an article summarizing the *Diabrotica* research projects recently funded in Germany.

In addition, we have an article from Andrew Lewer, the ENDURE web editor, CIRAD, France, who summarizes a new guide, produced by ENDURE’s maize case study team, examining non-chemical controls for corn borers. This guide was written by researchers from Switzerland (Agroscope ART), Spain (Universitat de Lleida) and France (Biotop), focusing on non-chemical ways of dealing with the European corn borer (*Ostrinia nubilalis* or ECB) and the Mediterranean corn borer (*Sesamia nonagrioides* or MCB).

Finally, we add the abstracts of the posters presented at the 23rd IWGO Conference in April 2009 for those who were not able to attend this meeting.



(Harald K. BERGER)

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News Related to IWGO Matters

- **National German *Diabrotica* Research Meeting at Freising close to Munich, Germany, successfully implemented**
Beginning of December 2009, the first German speaking Diabrotica meeting was held to inform invited participants about the current state of the art of the ongoing Diabrotica research projects funded by the German or state governments in Germany. There is now a web page available please see <http://diabrotica.jki.bund.de/>
- **Big Diabrotica damage in Italy**
Dr. Mauro Agosti and Dr. Rich Edwards report about big damage from Diabrotica in Brescia Province and other areas of the Lombardy Region in Italy in 2009. Based on digging out roots in their research plots and rating the damage, it was not unusual for them to find roots in the untreated plots with root damage ratings of 1.5 to 2.5 (lowa 0 to 3 scale).
- **Special Issue for IWGO in Journal of Applied Entomology**
A good number of manuscripts have been submitted for our IWGO Proceedings which will be again published as a special issue of the Journal of Applied Entomology. The Editor-in-Chief of the Journal of Applied Entomology, Prof. Stefan Vidal, and the IWGO Convenors would like to thank you for using this opportunity and for submitting interesting and high quality manuscripts. It looks like that most probably 12 manuscripts will be accepted for this special issue. At this point in time papers from Miller (USA), Mitchell (USA), Toth (Hungary), Dillen (Belgium), Toepfer (Hungary), Lundgren (USA), Furlan (Italy), Meissle (Switzerland), and Toepfer (Switzerland) have been accepted but we expect acceptance soon for Wessler (Netherlands), Xu (China), and van Rozen (Netherlands). The special issue of the IWGO Conference will be published approximately in June/July 2010, which is later than expected but it was difficult like always to meet deadlines.

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Article (text compiled by H.K. Berger)

Analysis of the economic, social and environmental impacts of options for the long-term EU strategy against *Diabrotica virgifera* (Western Corn Rootworm), a regulated harmful organism of maize, to support the drafting of the Commission Impact Assessment

Framework Contract for evaluation and evaluation related services - Lot 3: Food Chain (awarded through tender no 2004/S 243-208899)

Final Report

Submitted by:

Food Chain Evaluation Consortium (FCEC)

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Executive Summary

Background and methodology

Diabrotica virgifera virgifera (Western Corn Rootworm) is the most important insect pest of maize in North America, where it is endemic, and probably the most important worldwide. The insect has been listed in the EU as a regulated harmful organism with quarantine status. It was first detected in Europe in former Yugoslavia in 1992 and has since spread and become established in nine Member States (MS); incidental findings have been made in three other MS (situation 2007). It is also established in some neighbouring non-EU countries. *Diabrotica* is considered as a serious threat to agriculture in the EU.

Maize is grown on large scale in many MS, mainly silage and grain maize for animal feed and human food production as well as for the production of starch, bioethanol or biogas. Seed and sweet maize are also cultivated on rather small surface areas in a few numbers of MS. Maize is certainly today the most profitable agricultural crop for farmers leading to the establishment of large areas with continuous maize cultivation (monoculture) in the EU.

Whilst Community emergency measures are already in place to control this pest, DG SANCO received two official requests from farmer's organisations to deregulate that insect pest mainly because they consider that efficient measures exist to limit the economic impacts of *Diabrotica* on the maize sectors e.g. insecticides.

Therefore, DG SANCO has mandated the FCEC consortium for the evaluation of the economic, social and environmental impacts of several policy options for the long-term

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strategy against *Diabrotica virgifera* to support the drafting of the Commission Impact Assessment. The methodological tools employed in this study have been documentary review and interviews with stakeholders. In particular, data have been collected in 9 MS representing 85% of total surface area cultivated with maize in the

EU27, i.e. France, Romania, Germany, Italy, Hungary, Poland, Spain, The Netherlands and Slovenia. As much as possible, key people have been identified in the national authorities (e.g. Ministry of Agriculture), the technical institutes (providing advice to farmers) as well as the professional associations. Identification of stakeholders has been carried out with the assistance of the NPPO of the MS concerned as well as the European Confederation of Maize Production (ECMP). Key experts, mainly the ones who participated in the EU-funded Diabr-act project (<http://www.diabract.org/>), have also been a valuable source of information for the study. Other stakeholders representing the maize value chain have been contacted and interviewed at European level.

In addition, 7 models have been developed to analyse the costs and environmental impacts associated to each policy option, in each of the 9 MS considered for the study and on a timeline of 25 years. It must be noticed that the data analysis is based on a large number of assumptions, mainly because differences exist in the range of data available per MS, per type of maize or per area. The data in each MS also vary according to the production system of maize, the level of requirement defined in the national legislation, the geographical characteristics, the intensity of maize cultivation, etc. The FCEC considers that the main added value of the analysis is not to provide a precise picture of what would happen for each policy option in each region of each MS but well in the comparison between the options.

Policy options

The policy **option 1** consists in leaving the existing provisions as they are (baseline policy option) These provisions aim at slowing down the spread of the pest from infested regions into free regions and include obligatory crop rotation for eradication of isolated outbreaks (rotation 1:3 in the focus zone and 1:2 in the safety zone) as well as recommended crop rotation possibly combined with insecticide treatments in the Containment Programmes (defining measures applicable in the containment zones and the rest of the infested zones)¹. Compared to policy option 1, policy options 2a, 2b and 3 relax the existing provisions up to complete deregulation (policy option 3). They contribute to more rapid infestation of the entire EU and are as follows:

Policy option 2a: Maintain the provisions on eradication but restrict them to protected zones; drop the provisions for the containment and suppression. The FCEC has considered a pan-European approach for the establishment of the protected zones, which consists in protecting FR, DE, ES, NL DK, PT, BE and LU from natural spread of *Diabrotica*, through the placing of a 40 km wide buffer zone at the French and German borders with PL, CZ, AT, CH and IT. Crop rotation 1:2 or 2:3 combined with seed and soil treatment is applied in the buffer zone. Farmers in the infested zones apply control measures in the areas with continuous maize cultivation (i.e. monoculture), 5 years after first infestation. They start with applying crop rotation 2:3 with seed and soil treatment and progressively introduce crop rotation 1:2.

Policy option 2b: Relax the present provisions for both eradication and containment of the pest; i.e. the obligatory frequency in focus zone is relaxed from 1:3 to 1:2; the provision for the Containment Programmes is deregulated. In the infested zones, farmers apply control measures in the areas with continuous maize cultivation 5 years after first infestation. They

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start with applying crop rotation 2:3 combined with seed and soil treatment and progressively introduce crop rotation 1:2.

Policy option 3: Repeal all *Diabrotica* legislation at EC and MS level and leave the decision on control measures to the farmers. Under this option, isolated outbreaks are no more eradicated. Farmers in the infested zones apply control measures in the areas with continuous maize cultivation 5 years after first infestation. They start with applying crop rotation 2:3 with insecticide treatment and progressively introduce crop rotation 1:2.

Contrarily, policy options 4a, 4b and 5 strengthen the existing provisions with the objective of maintaining the pest to its current range (options 4a and 4b) or eradicating it entirely from the EU (option 5), as follows:

Policy option 4a: Strengthen the present provisions for containment of the pest at the border of current infested zones; i.e. make crop rotation and pesticide use obligatory for the containment zones and the rest of the infested zones. This option distinguishes between 4 combinations of measures in the containment zones and in the rest of the infested zones as follows:

1. Crop rotation 1:3 with foliar treatment in the containment zones and crop rotation 1:2 without insecticide in the rest of the infested zones;
2. Crop rotation 1:3 with foliar treatment in the containment zones and crop rotation 2:3 with foliar, seed and soil treatment in the rest of the infested zones;
3. Crop rotation 1:3 with foliar, seed and soil treatment in the containment zones and crop rotation 1:2 without insecticide in the rest of the infested zones;
4. Crop rotation 1:3 with foliar, seed and soil treatment in the containment zones and crop rotation 2:3 with foliar, seed and soil treatment in the rest of the infested zones. Control measures in the containment zones are applied on the surface area with continuous maize cultivation or cultivated according to a less strict frequency (e.g. 1:2, 2:3). In case of crop rotation 2:3 combined with foliar, seed and soil treatment in the rest of the infested zones, the insecticide treatment is applied on the entire maize surface of the rest of the infested zones.

Policy option 4b: Strengthen the present provisions for containment of the pest at the border of current infested zones; i.e. prohibit maize cultivation in the containment zones. Compulsory measures are defined as regards the rest of the infested zone, which are the same as the ones defined for policy option 4a.

Policy option 5: Adopt new legislation for the complete eradication of the pest from the territory of the EU and maintain the future pest-free status; i.e.

- 1) prohibition of maize cultivation in the current infested and containment zones for a period of at least two years;
- 2) permanent obligation for the whole territory of the EU for eradication measures (as in current provisions) for any outbreak;
- 3) creation of a permanent buffer zone free of maize at the border with infested non-EU countries;
- 4) Permanent monitoring obligations for the presence of the pest.

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Article

German *Diabrotica* research program

by Dr. Michael Zellner¹, Dr. Udo Heimbach², Kristin Schwabe², & Dr. Antje Kunert¹

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The Western Corn Rootworm (*Diabrotica virgifera virgifera* LeConte) is economically the most important corn pest world wide. Its first appearance in Southern Germany in 2007 was followed by further infestations in additional locations in the following years.

Germany neighbours countries in which *Diabrotica* is established and repeated introduction of the beetles is expected. Control measures on *Diabrotica* being a quarantine pest in Europe are carried out in Germany. In order to improve and adapt control measures for *Diabrotica* including chemical and non chemical options for German conditions two substantial research programs were generated in cooperation of the German agricultural ministry (responsibility JKI) with the Free State of Bavaria (responsibility LfL).

The objective of this program is to achieve profound knowledge of the economic impact of *Diabrotica* establishment and quarantine measures, of sustainable chemical and non chemical control of *Diabrotica* and finally to draft an expert report for quarantine and containment strategies. In total 23 projects have already started in spring 2009 in collaboration with project partners from Austria, Hungary and Romania.

Research on *Diabrotica* issues like biology, chemical treatments, any integrated measure, economic impact of measures, host plants and alternatives to mono-maize production are carried out. The individual projects will be presented on a joint German-English *Diabrotica*-Homepage of the LfL and the JKI, which will be made available from November 2009 on (<http://diabrotica.jki.bund.de>).

In the following the research projects, the responsible institution and the objectives are listed:

Biology, monitoring, prognosis and control threshold

- **Improving the knowledge on the biology of *Diabrotica virgifera virgifera* (JKI)**
The objective of the study is to improve the knowledge on the biology of *Diabrotica* in order to improve the methods for prognosis of the occurrence in infested areas and for controlling of the pest.
- **Population dynamics (LfL)**
To investigate population dynamics and the damage potential of the Western Corn Rootworm, field experiments with maize are conducted in emergence cages in Austria and Romania. The climatic conditions in Austria are comparable to those in the region of the foothills of the Alps and the Bavarian Forest, while the climatic conditions in Romania

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are similar to the remaining regions of Bavaria. This experiment is complemented by observations the suitability of diverse crops as hosts for *Diabrotica virgifera virgifera*.

- **Development of a simulation model on population dynamics of *Diabrotica virgifera virgifera* (JKI)**

To develop a computer aided decision making tool (e.g. date predictions) for scheduling monitoring surveys and for the prediction of optimal dates for application of pest control. The model will be useful in case *Diabrotica* establishes in German corn growing regions.

- **Monitoring and containment measures (LfL)**

The monitoring with pheromone traps is a crucial tool to control the effectiveness of containment measures. So far, only few experiences are available about the monitoring at low population densities of the beetle. The aim is to improve the monitoring by testing different types of traps and the density of the traps.

- ***Diabrotica* eggs in soil samples (LfL)**

The establishment of an extraction method for the eggs of *Diabrotica virgifera virgifera* from soil samples is the topic of another subproject. Investigation of the soil can give information about the expected damage caused by nematodes and a variety of other pests as well as pathogens to which the intended crop is susceptible. A comparable method for *D. virgifera* would reduce the risk of cultivating maize concerning yield losses and, in addition, would reduce the protective application of soil granules or insecticide seed treatments. Therefore, this method would provide an important contribution to integrated plant protection.

- **Energy crop plants as host plants (LfL)**

The objectives are the investigation of a possible importance of alternative energy crop plants, used for the application in biogas plants, as food plants for the larvae of *Diabrotica virgifera virgifera*, subsequently, the investigation of different possibilities of crop rotation. The experiments are carried out in the lab where the host suitability of alternative crop plants and monocotyledonous energy plants is investigated at relevant developmental stages where larval damage can be expected.

- **Volunteer cereals as host plants (LfL)**

The main focus is to show if winter wheat and volunteer cereals, respectively, are suitable as host plant for the Western Corn Rootworm and therefore, if larval

development is possible in late ripening grain or early volunteer grain. The experiment is carried out under similar conditions as in Germany, in a higher infested area in Austria. Emergence cages are used to determine the hatching of beetles.

Integrated controls – preventive and agronomic aspects

- **Effect of non-maize crops (LfL)**

This project investigates the oviposition behavior of the beetle. Females of the Western Corn Rootworm lay their eggs partially in neighboring non-maize fields. If maize is grown on these fields the following year, *D. virgifera* finds the optimal host plant. Thus, *Diabrotica* can lead to yield decreases, while its population increases. This project, conducted in Hungary, should show if there are differences in attractiveness of different crops for oviposition.

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- **Influence of time of harvest (LfL)**

The experiments conducted in Austria observe dispersion behavior and egg deposition of *Diabrotica* beetles after an early maize harvest, thus comparing silage maize and grain maize. The objectives are to give an answer to the following question: Does an early maize harvest lead to a higher migration of beetles and therefore to a higher dispersion and egg oviposition in neighbouring fields? And, does larval development and beetle hatching continue after an early maize harvest.

- **Effect of soil tillage and flooding on the mortality of *Diabrotica* population (JKI)**

The objective of this project is to determine how the local deposition of eggs and the period of hatching changes as result of different soil cultivation. Especially fall and spring ploughing to a depth of 40cm is expected to affect mortality of the *Diabrotica* population; however, data is still missing but will be collected in the project under quarantine lab (JKI, Kleinmachnow) and field conditions (USA). The study also examines the effect of flooding on the mortality of *Diabrotica*.

- **Tilling methods (LfL)**

Influence on the mortality of eggs and larvae by different tilling methods is followed up in a subproject in Romania. The experiments are conducted under similar conditions as in Germany, but in areas with higher infestation. Three different techniques are examined: Stubble processing with grubber, ploughing and ploughing followed by a catch crop (mustard).

- **Underseeds in maize (LfL)**

A further experimental approach is testing the influence of special underseeds on the mortality of the larvae of *D. virgifera*. For that reason, maize is grown in containers with different types of underseeds, like perennial and Italian ryegrass,

white clover and sunflower. Larvae find the roots of their host plants by the CO₂-emission of growing roots. The hypothesis underlying this experiment is that by a diversification of root types, only a portion of the larvae will find their host plant and therefore the mortality will increase.

Integrated controls – Insecticides

- **Improvement of soil insecticides and seed treatment (JKI)**

In this project the effect of soil insecticides and seed treatments on the hatching success of *Diabrotica* individuals will be studied. Therefore, the reproduction potential of the pest will be assessed, which, in turn, influences containment and eradication success. Effects on adult hatch are unknown. Data obtained on root damages are not transferable to the reduction of hatching beetles because damages can be compensated by plant growth which is depending e.g. on soil moisture and characteristics of corn varieties. Additionally, the project will study the potential of entomophagous nematodes as a natural antagonist of *Diabrotica*. Experience with the practicability of use of these nematodes under real farm conditions is still missing.

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- **Laboratory and field experiments on sustainable control of adult beetles (JKI)**

In order to prevent the spread of *Diabrotica* and to hinder egg laying after an introduction into new areas also a control of adult beetles is essential. Combining field and laboratory experiments, effects of different insecticides containing attractive substances will be studied on adult beetles of *Diabrotica*.

Risk assessment, Technique, Avoiding negative effects on ecosystem

- **Method development for an evaluation of particle drift from insecticidal seed treatments during sowing and its risk assessment on bees (JKI)**

To improve the exposure assessment and evaluation of side effects of drift of dust deriving from insecticidal seed treatments on neighbouring areas lethal and sublethal effects will be studied on the honeybee (*Apis mellifera* L.)

The following questions are covered by field-, semi-field and laboratory trials:

How can dusts be taken up by bees? Is the uptake and the resulting extent of damage influenced by different ways of exposition, e.g. during active oral uptake in comparison to passive uptake (e.g. direct contact with dusts, respiratory uptake)?

Where is dusts detected in the colony? To which extent are the life stages of bees (adults, larvae) exposed?

Are there possibly sublethal effects with decreased performance and resistibility of bee colonies which do not result in enhanced mortality but cause a weakening

of the colony? Which lethal damages may follow the different paths of contaminated products (e.g. pollen, bee bread, nectar)

Which filtering capacity of dust particles is to be expected for different neighbouring crops?

- **Spreading scenarios of the Western Corn Rootworm and probability of introduction by the international trade (JKI)**

Predictions of the spreading rate of *Diabrotica* under natural conditions and with containment measures will be generated in a model. Hence, it will be possible to estimate the effects of a *Diabrotica* introduction and to compare the results of different containment measures with the incidence of natural spread. Furthermore the project aims at providing high risk maps of *Diabrotica* for regional maize growing areas. This project also focuses on the probability of introduction of *Diabrotica* adults through the international traffic depending on the risk assessment of the different means of transport and origins of infestation.

- **Evaluation of a verified process for seed drilling regarding drift of dust (JKI)**

A verified process for seed drilling in order to minimize the drift of dust from insecticidal seed treatments will be evaluated in this project.

- **Optimizing of application technique of pest control in high maize stocks (JKI)**

Chemical control of adult beetles of *Diabrotica* is carried out in the form of high-clearance tractors; data on application technique is still missing but will be collected in this project. The project also examines the drift caused by high-clearance tractors.

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Alternatives to maize as forage

- **Feeding experiments in fattening cattle and milk production (LfL)**
An increase of the number of beetles could sooner or later lead to restrictions in maize cultivation and as a consequence to restrictions to growing maize silage for feeding cattle. Consequently, the substitution of maize by Lucerne-grass and grass silage for fattening cattle is observed. For milk production the ideal composition is important considering the respective concentrate in combination with different silages from forage crops. Therefore, also the substitution of maize by wheat in the concentrate is investigated.
- **Alternatives for maize in arable feed cropping (LfL)**
Possible alternatives to maize in arable feed cropping are checked in direct comparison to maize in field trials. The aim is to evaluate the region-specific yield and quality data of forage crops.

Economics

- **Economic effects – Individual analysis (JKI)**
The objectives of the project are to calculate the individual effects of *Diabrotica* with respect to different eradication and containment strategies and to reduce the beetle population by usage of different adaptation strategies
- **Economic effects of different plant health strategies (JKI)**
Economic impacts of *Diabrotica* are evaluated with respect to different eradication and containment strategies and their costs and benefits within specific maize growing regions and for the whole of Germany based on dynamic spread models.
- **Economic impact of eradication and containment measures (LfL)**
The main focus is on the determination of the economic impact of techniques applied so far and to evaluate new techniques for eradication and containment of the Western Corn Rootworm for different types of farms and in different regions. For eradication and containment of the Western Corn Rootworm different plant health measures can be applied. Most important are crop rotation and chemical plant protection. Depending on the type of farm and the geographical position these techniques can be deeply disruptive to the farm structure and require different adaptation strategies by the farmers. Because the containment measures can have an impact on the whole farm, calculation of the marginal income is not sufficient. For the evaluation of the economic consequences, a whole-farm simulation is necessary.

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Article

New ENDURE guide: non-chemical solutions to beat corn borers

by Andrew Lewer, ENDURE web editor, CIRAD, France

Wasps are unlikely to win many popularity contests and genetic engineering has plenty of detractors too, but both offer very efficient ways of controlling a major pest affecting maize crops in Europe.

Their usefulness is explained in a new guide¹, produced by ENDURE's maize case study team, examining non-chemical controls for corn borers, the larvae of which can cause crop losses of up to 30% in badly infested plots. Part of the From Science to Field series, the guide provides practical, scientifically sound advice particularly useful for agricultural advisers and extension services.

Written by researchers from Switzerland (Agroscope ART), Spain (Universitat de Lleida) and France (Biotop), the guide focuses on non-chemical ways of dealing with the European corn borer (*Ostrinia nubilalis* or ECB) and the Mediterranean corn borer (*Sesamia nonagrioides* or MCB).

ECB is widespread in Europe (and indeed is found in Canada and as far west as the Rocky Mountains in the USA), with the small nocturnal moths laying clusters of between 10 and 40 eggs on the lower surfaces of maize leaves. Larvae chew leaves and tunnel in the stems of maize plants, weakening them and causing them to break. Furthermore, maize ears can also be damaged and the wounds caused by feeding leave crops vulnerable to fungal diseases. The pest has one generation per year in Northern Europe, and two to three generations in Southern Europe.

In Mediterranean countries, MCB may cause the most serious corn borer damage. Its lifecycle is similar to that of ECB, but females lay their eggs between the sheath and the stem of maize plants. Larvae enter the stem just after hatching, protecting them from chemical insecticides.

And chemical insecticides are not a straightforward solution for ECB either, say researchers, despite the fact that between 0.7 and 0.9 million hectares of maize crops are treated with insecticides against corn borers every year across the European Union. One problem is the fact that contact spray insecticides or on-plant micro-granulates are only effective if applied before ECB larvae enter the maize stems. Furthermore, maize plants will often be 1m tall or even higher at this stage, making special equipment necessary. In addition, commonly used insecticides are known to have adverse effects on non-target arthropods, including natural enemies and pollinators.

¹ Meissle M, Bigler F, Mouron P, Kabiri F, Pons X, 2009. Non-chemical control of corn borers using Trichogramma or Bt maize. From Science to Field: Maize Case Study – Guide Number 1. Available online: http://www.endure-network.eu/endure_publications/endure_publications2

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A century of *Trichogramma*

ENDURE's researchers have identified two efficient alternatives to chemical controls for corn borers. One of these, using the release of *Trichogramma* wasps, is a biological control that is also proving useful for protecting other crops such as apples and vegetables, and has a long history in agriculture.

Trichogramma species are microscopic wasps that are less than 1mm in size or smaller than the full stop at the end of this sentence. They have been used to seek and destroy the eggs of the most destructive caterpillar pests for more than 100 years. More than 140 species of *Trichogramma* have been identified around the world, and they are found in almost all habitats. Less than a dozen species have been mass-reared and used in crop protection programmes, a process that began in the early years of the last century.

In countries such as the USA, interest in using *Trichogramma* faded somewhat with the creation of effective chemical pesticides, says Professor Allen Knutson, of Texas A&M University System and author of *The Trichogramma Manual*. Interest remained strong in countries such as the former Soviet Union, where more than 700 *Trichogramma* factories were once in existence, though these have largely disappeared over the past 20 years.

Trichogramma species are currently released on more than 10 million hectares each year, according to Professor Jeff Bale of the UK's University of Birmingham and his co-authors, in their paper Biological control and sustainable food production, published in Philosophical Transactions of the Royal Society (available online at <http://rstb.royalsocietypublishing.org/content/363/1492/761.full?sid=488dbde6-dcd2-4821-a358-8ccfe7f650f1>). These releases are used to combat, for example, pests in vegetables, cereals and cotton in Russia, and maize, cotton, sugar cane and tobacco crops in Mexico.

Trichogramma actively seek out and parasitize ECB eggs. Put simply, female wasps search for ECB eggs and then lay an egg inside. These develop into larvae which feed on the ECB eggs and thus kill them. It is a tactic that is easy and economical to apply, says ENDURE's researchers. Unfortunately, MCB eggs are not attacked by *Trichogramma*, but by other egg parasitoids which cannot be mass reared and this means other tactics are needed where MCB pressure is high (see *Bt* maize below).

ENDURE'S researchers identify *Trichogramma brassicae* as the most effective species and the guide includes tips on choosing the best time to release them. Release is a simple process: cards containing *Trichogramma* eggs are attached to maize plants with each farmer or worker able to treat an area of between three and five hectares an hour. ENDURE's researchers suggest that between 100,000 and 225,000 wasps be released to counter the first generation of ECB, using 25 to 50 release points per hectare. Wasps can also be used against the second generation of ECB. In areas of high infestation, warm temperatures and taller plants, the release of between 225,000 and 600,000 wasps from 50 release points may be necessary.

Farmers, of course, will have two burning questions before adopting this tactic: is it effective and is it economical? According to ENDURE's researchers, the answer is yes on both

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counts. As long as manufacturers' recommendations are followed, efficacy is comparable to the use of chemicals, they say, with more than 75% of ECB eggs commonly parasitized and

killed. In areas subject to second and third generations, good control of the first generation is crucial to achieving the best overall results.

In terms of costs for farmers, this will depend very much on which country the farm is based, the distribution system for *Trichogramma* and the doses required. In France, for example, they calculate that it will cost a farmer between €35 and €40 per hectare to treat first generation ECB, not including labour costs. Treating the second generation will cost between €45 and €55 per hectare. Costs for chemical insecticides average between €20 and €40 per hectare in France.

So far, the adoption of *Trichogramma* for control of ECB has mainly been in France (Europe's largest producer of maize), Germany and Switzerland, with wasps released on around 150,000 hectares per year.

***Bt* maize: controversial but very effective**

While biological controls are widely available and broadly welcomed, the same cannot be said of genetically engineered crops, which remain banned in several European countries. Nevertheless, *Bt* maize was grown across some 108,000 hectares in Europe in 2008, Spain accounting for three-quarters of the total.

The reasons for its successful adoption in Spain (and widespread popularity in the USA) are not hard to find. *Bt* maize has been genetically engineered to produce an insecticidal protein from the bacterium *Bacillus thuringiensis* (hence the *Bt*). *B. thuringiensis* is a naturally occurring bacterium of particular interest to scientists and the chemical industry as it forms crystals known as cry toxins, which are effective in killing certain pests such as *Lepidoptera* (moths and butterflies) while harmless to other creatures, such as humans and farm animals.

B. thuringiensis has been used to control insect pests since the 1920s and is currently used to produce chemical insecticides such as Dipel and Thuricide. In the case of *Bt* maize, the insecticide is produced over the whole growing season in the whole plant, providing efficient control (almost 100%) of stem borers such as ECB and MCB.

Bt maize has been approved in the European Union since 1998, though its cultivation is currently prohibited in countries such as France, Hungary, Austria and, most recently, Germany, where a ban was introduced this year.

ENDURE's researchers have examined many laboratory and field trials which, they say, reveal no detrimental effects of *Bt* maize on beneficial arthropods, such as natural enemies, soil organisms or pollinators. They further note that the currently available *Bt* maize varieties produce low toxin concentrations in pollen, minimising the risk for moths and butterflies outside the maize field. In addition, maize, which originates in America, has no wild relatives in Europe and so there is no risk of out-crossing.

To ensure the coexistence of conventional cultivars with *Bt* plants, researchers note that the minimum distances set by each country must be respected by farmers and that a certain percentage of conventional maize must be sowed to reduce the likelihood of resistance

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developing. In Spain, for example, the percentage is 20% for any field larger than five hectares.

In terms of costs, farmers have to pay a 'technology fee' for *Bt* maize seeds which varies according to the seed company and region. They note that 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. However, farmers do not incur any extra costs for labour, machinery or chemicals.

If you found this article interesting, you may want to consult:

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Abstracts of Posters of the 23rd IWGO Conference Munich, Germany April 5-8, 2009

Poster 01

Containment strategy of *Diabrotica v. virgifera*, the Swiss model

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The western corn rootworm (WCR) was first detected in Switzerland in 2000 in the canton Ticino. Monitoring by pheromone traps was since conducted south and north of the Alps. Population dynamics have been studied by comparing a continuous maize field with rotated maize fields in the immediate surroundings. Our experiences with WCR populations in the Swiss territory are here briefly summarized:

1. Mandatory one year crop rotation in the canton Ticino slowed spread and even reduced the infested area significantly. WCR infestations north of the main Alpine mountain chain were rare and eradicated by crop rotation.
2. In a continuous maize cropping system population of WCR reached economic damage level after three years, but decreased also by unknown factors.
3. Switzerland with its control programme solely based on rigorous crop rotation may serve as an example of far-sighted WCR management preserving environment and saving money.

Poster 02

Potential of applying artificial induced thelytokous line of *Trichogramma dendrolimi* for suppression of Asian corn borer

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Trichogramma dendrolimi has been the most widespread applied wasp for control Asian corn borer *Ostrinia furnacalis* in the northeast part and the north part of China where is the major maize producing area of China This species has been applied for over 40 years since 1970's. In order to reduce the mass rear cost and increase the

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control efficiency, One new line of the species was created by mean of horizontal transmission of a symbiont, wolbachia from the donate wasp of *Trichogramma embryophagum* to the receptor wasp of *T. dendrolimi*. The reproduction pattern of *T. dendrolimi* was converted from arrhenotoky to thelytoky .It imply that the new line was in possession of total female offspring and potential high control efficiency.A series trial was carried out to test the possibility to apply the new line in commercial mass-rearing and biological control. The comparison of the fecundity, developmental

duration, survival rate and dispersion, bionomics and ecological effects on the thelytokous line and the non thelytokous line was conducted. The result showed that tested trait was in most similarity, no significant difference was observed. Moreover, the comparison of field release trial for two line was done in 2007 and 2008 respectively. no any significant difference was observed too. It imply that the thelytokous *T. dendrolimi* is prospect very much in biological control of corn borer.

Poster 03

Are there realistic chances for future *Diabrotica* management in Europe? Some highlights from WCR in Germany, Slovenia, Romania and Switzerland

Hans E. Hummel

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Diabrotica virgifera virgifera (Col.:Chrysomelidae) (WCR) is now established as an alien invasive insect pest without known European natural enemies. Two decades after repeated introduction by traffic and trade, eradication attempts of WCR appear elusive and are no longer a viable option. Rather, European legislation calls for toxicological emergency measures on a case by case basis where and when new infestations are detected by a narrow grid of sensitive trapping efforts. Presently, central European countries like Germany are at the forefront of WCR attacks and human counter measures. As a result of all surveys, a dynamic picture of WCR distribution emerges with major foci in the Balkans, Eastern Europe and Northern Italy, some with economic damage levels. Our efforts concentrated on Germany, Slovenia, Romania and northern Ticino in Switzerland and showed a variety of scenarios, where WCR normally emerges as winner due to its tremendous ability to adapt to a variety of geographical, environmental and cultural conditions. Are there realistic chances for future WCR pest management in Europe? An exemplarily successful case history exists for Switzerland where an enforced national crop rotation scheme has been in effect for the last nine years and where WCR populations could be arrested at the level of the early 2000s. Less favorable appears the WCR status in Germany where in the Lake Constance area spot infestations of

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2007 could be stopped and did not reoccur in 2008, while both around Passau and in the upper Rhine valley area WCR is significantly expanding its territory. Both in Romania and Slovenia, WCR is still spreading. Prospects for sustainable management by crop rotation would appear better if all countries could agree on a common strategy.

Poster 04

Research into the population dynamics, the host plant specificity and the economic threshold of *Diabrotica virgifera virgifera*

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The Western Corn Rootworm (*D. v. virgifera*) is classified as a quarantine pest in Germany. In a scientific investigation, funded by the Federal State of Bavaria and coordinated by the Plant Protection Institute of the Bavarian State Research Center for Agriculture, strategies for the limitation of the migration and an integrated control of *D. v. virgifera*, adapted to the local Bavarian situation, are to be developed. Main targets:- Investigation on the population-dynamics of *D. v. virgifera* in maize-monoculture, starting from different numbers of individuals per plant.- Assessment of the yield response of a defined *D. v. virgifera* population, with the aim to receive information on the economic threshold of the pest.- Evaluation of the development of *D. v. virgifera* on different crops, with the target to delimit the migration of the pest by applying an appropriate crop rotation.- Test of the influence of a chemical control of *D. v. virgifera* by seed treatment, granulate- or spray-application on the population-development of the pest. All tests have to be performed by using gauze-covered cages, to ensure a controlled population-development without any influence by the natural *Diabrotica* -population. The trials will be carried out at different sites in Rumania by 'Agrotest Romania', in cooperation with Banat's University of Agricultural Sciences and Veterinary Medicine in Timisoara, under supervision of Prof. Dr. K.F. Lauer. In the presentation the project will be described in detail. The methodology will be discussed.

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Poster 05

Sexual dimorphism of WCR – a review of morphological characters and novel data on the hairless patch of male tarsi

K. Gloyna*, D. Voigt & T. Thieme

**BTL Bio-Test Labor GmbH Sagerheide, Sagerheide, Germany;*

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Poster 06

The BT Economic Analysis Tool (BET) for maize management

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New gene based GMO technologies are a prophylactic management strategy in an IPM program. Thus, a decision to manage *Ostrinia nubilalis* populations is made at the point of seed purchase and not during the growing season when the pest is present. It has long been known that *O. nubilalis* density in a field during the past year has little or no correlation with the pressure that is likely to occur in the coming year. Therefore, farmers are faced with purchasing a pest management product without knowing what level of pest pressure they will have in the field. This paper discusses a web-based system (<http://www.btet.psu.edu/>) designed to help farmers assess the economic value and risk associated with new *Bt* maize technology using 33 years of historic temperature data. Temperature data are spatially interpolated to a 2 km² spatial resolution. The system considers maize maturity group, planting date, geographic location in the United States (2 km² spatial resolution), *O. nubilalis* voltine types present at the geographic location, density of the multivoltine population, density of univoltine population, corn price, pest control efficiency, seed technology cost, planting rate, and average expected yield. The system is interactive, allowing the user to change variables in the system and see how this affects the average net benefit of the technology. It also provides a historic view of the likelihood of a positive benefit to the technology. The system can be used for field management decisions or as a teaching tool.

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Poster 07

Maize pests in Central Europe: data from 6 years of environmental risk assessment research with *Bt*-maize

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Herbivorous arthropods are severe pests of cultivated crops, responsible for considerable yield losses. In maize, the major pests are the European and Mediterranean corn borer (ECB, *Ostrinia nubilalis*; MCB, *Sesamia nonagrioides*), and the Western corn rootworm (WCR, *Diabrotica v. virgifera*). The latter species has gained importance in Europe and will be of significance in the future. Another species

that might gain economic significance is the corn earworm (*Helicoverpa armigera*). Against these pests, a number of genetically modified (GM) Bt-plants has been developed. Lepidoptera are controlled by Bt-varieties expressing the Cry1Ab, Cry1Ac, Cry1F, and Cry2Ab2 proteins. The WCR is controlled by varieties expressing Cry3Bb1, Cry34Ab1/Cry35Ab1, and mCry3A proteins. Under EU legislation, GM plants must undergo an Environmental Risk Assessment (ERA) before they are placed on the market. One aspect of this ERA is the potential impact of the entomotoxic proteins on non-target organisms. Data from field experiments with MON810 (2001 – 2004) and MON88017 (2005 – 2008) on the occurrences and field-densities of herbivorous arthropods are presented. The focus is on non-target organisms, since these may be affected by the Cry proteins expressed in the host plants, and since these might also reach secondary pest status. Aphids were the most abundant herbivorous arthropods, with considerable variations over the years. Plant- and leafhoppers (Auchenorrhyncha) and plant bugs (Heteroptera: Miridae) occurred consistently and in high densities over the two study periods. Leaf beetles (Coleoptera: Chrysomeliade) and especially the subgroup flea beetles (Halticinae) played only a negligible role.

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Poster 08

Evaluation of the effect of combined insecticide treatments against adults and seed coatings on *Diabrotica virgifera virgifera* and ECB populations

S. Canzi*, L. Furlan & M. Agosti

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Field studies were conducted in continuous maize fields, in Lombardy, Italy over a 4 year period (2005 – 2008) to evaluate the possibility of getting multiple effects on more pest species (*Ostrinia nubilalis* Hubner ECB, *Diabrotica virgifera virgifera* LeConte, wireworms) from summer foliar treatments (alfacipemetrina) timed on the base of the evaluation of the development of the species. Beetle population levels were over 25 beetle/Pherocon AM trap/day when beetle treatments were applied. The experimental design was a randomized complete block with 4 to 6 replications of each treatment. Treatments were foliar insecticide application at different WCR development stages and in the next year in the same plots different insecticide seed coatings (thiametoxam, clothiadinin). Larval and adult densities along with root damage ratings were estimated at the research locations. Foliar treatments significantly reduced adult WCR and larval ECB population. well effect statistically and immediately impacted WCR populations. In one case beetle WCR population reduction resulted in significant next year root damage containment. Insecticide seed coating did not significantly strengthened the effect of treatments against adults on

WCR and wireworms larval populations. Data from these studies showed that the number of WCR beetles emerging from untreated plots did not differ from the number of beetles observed emerging from those treated with insecticides. The impact of treatments on yield response was negligible in all cases.

Poster 09

Click beetles (Coleoptera: Elateridae) and their seasonal swarming in maize crops in the region of Danubian Plain in Bulgaria

M. Subchev*, T. Toshova, L. Furlan & M. Tóth

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Males of five species of genus *Agriotes* (Coleoptera: Elateridae) were caught in pheromone traps in maize crops in the region of Danubian plain in Bulgaria in 2002,

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2003 and 2005: *A. sputator* (L.), *A. ustulatus* (Schaller), *A. proximus* Schwarz, *A. gurgistanus* Fald. and *A. rufipalpis* Brullé. *A. ustulatus* males were caught only in the traps baited with a lure for this species, and *A. proximus* males – only in the traps baited with a lure for *A. lineatus*. High species specificity was found also for baits for *A. obscurus* but in relation to *A. rufipalpis* males. *A. sputator* and *A. gurgistanus* were attracted in a significant number to more than one bait. The swarming period of *A. sputator* lasted from the beginning of April till the middle of July. Catches of *A. proximus* were registered from the end of April till the middle of July and catches of *A. rufipalpis* – from the end of April till the second decade of September. A short swarming period was found for *A. gurgistanus* and *A. ustulatus* – in both species the swarming period began at the beginning– middle of June and lasted till the middle of July (*A. gurgistanus*) and the beginning of August (*A. ustulatus*). Information about the composition of the populations and the main aspects of the biology of click beetles in different regions are essential to implement IPM strategies.

Poster 10

Identifying *Agriotes* larvae using a DNA-based approach

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The basis of any wireworm risk assessment is the correct identification of the larvae. However, this is considerably hampered when morphological features are being used: current identification keys do allow identifying just eight of the 20 *Agriotes*

species in larval stage. Moreover, some morphological characters used for identification are hard to discriminate among some of the described species and their intraspecific variability has yet not been assessed. Here we used a DNA-based approach to identify *Agriotes* species in larval stage. Within each species adult beetles, which are readily identifiable, were collected from different locations all over Europe. From these beetles, part of the mitochondrial cytochrome oxidase subunit I gene was sequenced. For the “main” *Agriotes* species specific primers were designed; “main” in terms of distribution, abundance and pest status: *A. obscurus*, *A. ustulatus*, *A. litigiosus*, *A. sordidus*, *A. rufipalpis* respectively ‘groups’ due to low interspecific variation: *A. brevis/sputator* and *A. lineatus/proximus*. The application of the primers in a multiplex-PCR approach allows discriminating between these species/groups within a single-step reaction. Additionally, identification of the remaining 11 European *Agriotes* species can be done by comparing sequences we will provide for all 20 species at NCBI’s public database GenBank. Once established, this molecular identification system can easily be used by other researchers to routinely and securely differentiate between *Agriotes* at all stages.

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Poster 11

Is the pheromone of *Agriotes* click beetles a “classical” sex pheromone?

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Females of *Agriotes* click beetles produce sex pheromones which are highly attractive to males. Traps baited with the synthetic sex pheromones have been used for trapping click beetles in many countries of Europe. However, it was observed in several field tests that significantly higher numbers of female *A. brevis*, *A. ustulatus* and *A. sordidus* were caught in traps baited with the sex pheromones of these species than in unbaited traps. Similar indications were recorded also in other spp. In electroantennographic studies when screening a range of synthetic click beetle pheromone components on the antennae of *A. brevis* and *A. sordidus* females and males, females also gave strongest responses to the pheromone components of the respective species. Our preliminary results show that in these species females are capable of perceiving species specific pheromone signals, and also behaviorally respond to them. So it appears that the pheromone of these *Agriotes* species show characteristics of "aggregation" type pheromones. From the practical point of view pheromone products capable of attracting not only one sex can have a wider application in IPM approaches than "classical" sex pheromones attracting only one sex.

Poster 12

Western corn rootworm larval head capsule widths in irrigated fields in northern Italy

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Western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, larvae were collected in different irrigated maize fields in Brescia province (Northern Italy) in 2006, 2007 and 2008. The larvae were preserved in an alcohol-water solution for several months. At the end of each season, their head capsules were measured. Head capsule width, considered a valid indicator of larval instar stage, was measured using a dissecting scope outfitted with a measuring grid. Data for the three years (2063 samples) were combined and grouped in classes of increments of 20 µm width

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sizes. Frequency of larvae within each grouping was graphed as a histogram and three distinct peaks were observed. Peaks were interpreted to represent the peak frequency of the head capsule widths of the three larval instars. Assuming a normal distribution of head capsule widths, multiple nonlinear Gaussian curve regression was applied to the frequency histogram as described in Hammack et al. (2003). Centre of fitted normal curves were $227 \pm 3 \mu\text{m}$, $353 \pm 6 \mu\text{m}$, and $519 \pm 3 \mu\text{m}$ for the first, second and third instars, respectively. These values are higher than those reported by other authors in similar studies, suggesting that good soil humidity provided by irrigation and subsequent optimum plant development and nutrition could have a positive influence on WCR larval growth. Natural rainfall during the periods of larval development were quite different between 2007 (dry) and 2008 (wet). In 2008, the larvae in the fields receiving higher levels of natural rainfall than in 2007 showed greater larval head capsule widths thus supporting the positive effect of soil humidity on larval growth.

Poster 13

Comparison of the Pherocon AM trap and „The Whole Plant Count“ data for estimating WCR adult densities in two regions in Central Europe

R. Bažok*, I. Sivčev, J. Igrc Barčić, T. Kos & J. Kiss

**University of Zagreb, Faculty of Agriculture, Zagreb, Croatia*

Pherocon AM (PhAM) trapping and visual counting are widely used methods for identifying corn fields with economic levels of western corn rootworm adults in USA. The aim of our investigation was to compare the adult WCR data obtained by PhAM trapping and by “The whole plant count” in Croatia and Serbia. The investigations were carried in 2006 on 38 fields (Croatia) and on 22 fields (Serbia). Three to six PhAM traps were established in each corn field average size from 0.5 and 4 ha. Traps were inspected every two weeks in the period between July 15th and August 30. Visual count was conducted the same day as the trap inspection. Five pairs of corn plants were scouted three times (every 15 day) in Croatia, while in Serbia it was done once. Adult densities on PhAM traps were correlated to adult densities on the whole plant. In Croatia significant ($P= 0.0001$) medium positive correlation ($r^2 = 0.43$) was established. In Serbia significant ($P= 0.0001$) strong positive correlation ($r^2 = 0.87$) was established. The regression curves were linear with equation $y=0,0226x + 0,107$ for Croatia and $y = 0,022x - 0,03$ in Serbia. Visually determined 1 adult/plant corresponds to 40 (in Croatia) and to 50 (in Serbia) adults/trap/week which is similar or somewhat higher than already established and used in the USA. Comparison of PhAM trapping and visual “whole plant count” method through statistical analyses showed that there is strong correlation between

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them. It means that both methods can be used with equal value in population estimation at WCR densities experienced in our region. Activities were carried out under the FAO GTFS/RER/017/ITA project.

Poster 14

Two-year experiment of field screening in maize germplasm for resistance and tolerance to *Diabrotica virgifera virgifera* in Eastern Croatia

A. Brkić*, M. Ivezić, I. Brkić, E. Raspudić & D. Šimić

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As a part of resistance breeding program against Western Corn Rootworm (*Diabrotica virgifera virgifera* LeConte) at the Agricultural institute Osijek, Croatia, 127 maize genotypes were screened for reduced root damage (resistance trait) and for increased compensatory root growth (tolerance trait) in 2007 and 2008. The experiment was conducted in two replications as an alpha design planted at two locations under continuous maize growing conditions in Eastern Croatia, a major maize production area with natural *Diabrotica* occurrence. Results from pheromone trap monitoring showed two peaks on both locations in 2007 (July and August). In 2008 pressure was much higher, beetles were counted twice a week, and at one location peaked three times with over 2000 beetles per counting (six traps). For assessing resistance of maize genotypes, the lowa Node Damage Scale (0-3) was applied, while for assessing tolerance Visual Scale (1-6) was used for compensatory root growth. Across the locations and years, maize genotypes varied significantly for both root damage and compensatory root growth indicating feasible genetic variability for both traits. However, there was practically no correlation between the two traits. Based on these results, there is potential to improve maize resistance and tolerance to Western Corn Rootworm in Croatia although root damage and compensatory root growth are not correlated.

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Poster 15

DAS-1507 (Herculex™ I): a new tool for control of maize Lepidoptera in Europe

O. Dermody*, E. Owens & C. Bremer

**Pioneer Hi-Bred, Switzerland, Manno, Switzerland*

Sesamia nonagrioides and *Ostrinia nubilalis* are serious corn pests in Europe and current options to combat yield losses to these pests are limited in their effectiveness. Maize plants transformed with the DAS-1507 trait offer another option for broad spectrum control of these Lepidoptera, from seedling through ear development. This trait is currently undergoing regulatory review at the EU level and

once approved will be marketed as Herculex™ I. As well as its confirmed safety to all non-target insects in the field, maize containing the 1507 trait may have lower levels of mycotoxin contamination, resulting from fungal entry after insect attack. We have shown in Europe that this trait has high efficacy against the key stalk borers, *Ostrinia nubilalis* and *Sesamia nonagrioides*. We show here efficacy data from multiple field tests that support the economic benefits this trait provides to adopters. Additionally, we show how in three key pests in the USA there has been no change in sensitivity to the Bt protein after five years of widespread use. In 2008, thousands of European farmers grew Bt maize in seven EU countries – a total of 109,913 hectares. The sale of 1507 maize, once regulatory approval is granted, will offer farmers increased choice and competition in the seeds market in Europe. Herculex™ I Insect Protection technology by Dow AgroSciences and Pioneer Hi-Bred.™ Herculex and the HX logo are registered trademarks of Dow AgroSciences LLC.

Poster 16

Western corn rootworm in confrontation mood: simultaneous geographic and host spectrum expansion in southeastern Slovenia and other European countries.

Hans E. Hummel*, S. Dinnesen, S. Modic, G. Urek & C. Ulrichs

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Diabrotica v. virgifera LeConte (Col.:Chrysomelidae), the Western corn rootworm (WCR), is a main competitor for cultivated food plants including maize, but also is dependent on man's help as a principle vector for hitchhiking between continents and European countries. WCR arrived in Europe from North America on at least 5

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discernable occasions and expanded its territory with amazing effectiveness and speed. Within about 15 years after first introduction at Belgrade airport, most of the Balkan countries and most of central Europe except Denmark had at least one documented infestation episode. Several areas are already suffering from economic losses in maize due to WCR beetles and their voracious root feeding larvae. Repeated new "jumping advances" into Germany, Eastern France and into the Ukraine have recently been observed. The natural and man assisted spreading of WCR all over Europe now seems unavoidable. *Zea mays* is the favorite host plant in Europe, in contrast to the Americas where WCR has several hosts including Cucurbitaceae. For the last nine years, we have searched for WCR expansion of its European host range. In August of 2006 we obtained first evidence of WCR visiting yellow blossoms of the regionally important oil pumpkin *C. pepo* in fields situated at Gaberje in southeastern Slovenia. In Ticino canton our search so far has been negative. The discovery in Slovenia provides one additional indicator for WCRs irreversible establishment and colonization of both new territory and hosts. This has consequences for the future effectiveness of crop rotation as a sustainable IPM option.

Poster 17

Distribution and abundance of *Agriotes ustulatus* in three regions in Croatia

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The wireworms are the major polyphagous pests in arable crop in Croatia. The most important is genus *Agriotes*. Species *A. lineatus* L., *A. sputator* L., *A. obscurus* L. i *A. brevis* Cand. and the most dangerous *A. ustulatus* Schall are numerous. According to literature the species *A. ustulatus* Schall. is dominant in east region while *A. lineatus* L. is dominant in west region. Recently conducted investigations indicated the changes in the distribution and abundance of these species. The study aimed at identifying the distribution and abundance of *A. ustulatus* in three different regions in Croatia regarding the crop type and climatic conditions during the year 2007 and 2008. Study was conducted in east, mid and west region. In order to determine the adult abundance individual YALTOR funnel traps were baited with the synthetic sex pheromones. Monitoring period started at the end of May and lasted till September. Specimens were collected weekly. Dominance was calculated by Balogh's formula. For each region the climatic data (average monthly temperatures and total amount of rainfall) was collected. In dry and hot 2007 dominance index in east region was 81.93%, 80.28% in mid and 55.87% in west region. In more humid and colder 2008

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dominance index was lower on all localities. In east region it was 54.89%, 53.36% in mid and 39.34% in west region. The dominance of the *A.ustulatus* has been increased in west region and now is eudominant species in all regions.

Poster 18

Emergence and the optimum time for scouting of western corn rootworm based on ovarian development and accumulated degree-days

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WCR (*Diabrotica virgifera virgifera*) is the most important perennial pest of maize in Croatia. The primary control measure is crop rotation, but it is necessary to incorporate alternative tactics. The objectives of this investigation were to develop model to predict beetle emergence, based on accumulated degree-days for air temperature, and to determine optimum time for scouting based on ovarian development of the gravid females. The research was conducted in 2005 in Slavonija County, Croatia. Cages and pheromone traps were placed in the field in order to estimate the first day of beetle emergence (biofix). Estimation of emergence was based on degree-days for air temperature post biofix. Ovarian development was determined by dissection of the gravid females and optimum time for scouting was determined upon degree-days post biofix. The average of accumulated degree-days was 5,5°C per a day. More than 50% of the total number of the adult WCR was recorded at the sum of 221 degree-days post biofix, while the total number of the adult population appeared at the sum of 393 degree-days. The first gravid females were detected at 30 degree-days, 50% appeared at 235 degree days. The gravid females were present in the field until 360 degree-days post biofix. Based on the dissection of gravid females, 10% of the females had the full gravidity (III. and IV. ovary stages) at 121 degree-days post biofix. The scouting of the WCR beetles should be between 121 and 360 degree-days, and the optimum is 221-235 degree days post biofix.

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Influence of weather conditions on the western corn rootworm adult population density in Bosnia and Herzegovina

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Western Corn Rootworm was noted in Bosnia and Herzegovina (B&H) for the first time in 1996. By the end of 2008 it had spread to almost half of the B&H territory. We estimate that 95% fields under corn are infested by WCR. Adult population

density of WCR has varied during the years. It has been clear from the beginning that adult population density is dependant on weather condition as well as corn cultivation practices. Monoculture is the main factor for increasing population densities in B&H. The effect of weather conditions in any year is also influenced by weather conditions in the previous years as this affects the biology of WCR. For example, drought in 2000 reduced the WCR population by half but the drought in 2003 had less influence on the WCR population. Drought in 2007 had, yet again, a significant influence. The relationship between adult population density and larval damage on roots is very specific to conditions of Bosnia and Herzegovina. Multiple factors: weather conditions, soil and cultivation practice; affect adult population density. Some locations, with over 10 adults/yellow sticky traps/week, do not exhibit larval damage the following year. Yet, some locations with lower populations densities (less than 5 adults/trap/week), during the same year and identical weather conditions, exhibit larval damage. Field research was conducted in the fields under same cultivation practices. Chemical treatment was done only against weeds. Key conclusion of this research is that weather conditions have a significant influence on the WCR adult population density. Conclusions about relationships between weather conditions, soil and cultivation practice are very important too, especially in cultivation conditions in Bosnia and Herzegovina.

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Incorporated from the rhizosphere – fungal communities in the gut of western corn rootworm larvae

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To understand whether root feeding insects take up microorganisms from their surrounding environment selectively, we investigated the fungal communities in the gut of western corn rootworm larvae (WCR). Maize plants were planted in the greenhouse in three different field soils harbouring different fungal communities. Eggs of WCR were artificially applied, root samples taken and larvae extracted using a high gradient Kempson extraction system. Guts of the larvae were removed, the DNA extracted and DGGE-ITS was used for analyses of the fungal communities. Furthermore, common bands from the ITS-analyses were cloned and sequenced to identify the fungi. Additionally guts were plated on different media, isolated and identified under the microscope. Thus it was possible to identify viable fungi. Here we compare the fungal communities that were found in the rhizosphere and in the guts of the larvae. Additionally a list of fungi identified to species level is presented found in the gut systems of western corn rootworm larvae. By combining a molecular approach and culturing of fungi this work gives a comprehensive insight into the complex interactions between fungi and western corn rootworm larvae.

Poster 21

How to make a bioassay about life history traits of *Diabrotica v. virgifera*?

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The maize pest *Diabrotica virgifera virgifera* LeConte is an example of a highly successful invader in North America and Europe. Although *D. v. virgifera* is a well-studied pest, basic knowledge on its behavioural ecology, phenotypic traits and fitness is limited; which is likely to be attributed to methodological e. We propose a methodology for investigating phenotypic traits or fitness of *D. v. virgifera* adults in the laboratory. The method includes how to set up small space-efficient bioassay containers that allow a controlled rearing of single beetle pairs whereby mimicking an environment for female egg laying and allowing an easy handling for observations, food replacements and trait measurements. The containers consist of two plastic

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urinalysis cups, stacked one inside the other. The upper cup has a lid with a mesh-covered hole to provide ventilation. The upper cup also has a 10-mm hole in the bottom to allow the female to gain access to the lower, soil-filled cup for egg-laying. The bottom and the lower 20 mm of the wall of both upper and lower cups are painted black to provide a dark environment for oviposition.

With the help of survival curves and age-specific oviposition curves we can moreover propose a shortened trial period instead of trials over the entire three to five months lifespan of *D. v. virgifera*. This research was funded by the French “l'Agence Nationale de la Recherche” (ANR-06-BDIV-008).

Poster 22

The occurrence and damage of *Scotinophora horvathi* Distant in maize and its control considerations

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Historically, black stink bug *Scotinophora horvathi* Distant (Hemiptera: Pentatomidae) is a secondary insect pest on maize in China. More recently, severe infestations and damages have been often reported in the hilly maize region, especially in southwestern China. Both the adults and nymphs pierce and suck fluids from the plant. The highest crop losses are due to root, stem and growing point attacks before V5 stage, which cause wilting, yellowing, drying, and dead heart, or whorl leaves attacks at V5-V10 stages, which cause leaf-splitting, plant stunting, and twisting. Injured young plants produce side tillers. The average attack of 30% was observed during last 5 years, and 70% or even as high as 100% in the heavy infested fields in the basin and hilly areas of Sichuan Province. *Scotinophora horvathi* begins spring development when ambient temperature exceed 12°C. It was confirmed existence of 1 to 2 generations per year and usually generations overlapped. Pilot experiments showed that the most effective suppression measure among the treatments was the seed treatment with Gaucho® 600FS (Bayer AG) at a rate of 10ml/kg, which could reduce the damage from *Scotinophora horvathi* up to 85.0% , followed by Regent® 500FS (fipronil, Aventis). Phorate+Phoxim was less effective to reduce the damage from *Scotinophora horvathi*. Spraying of Imidacloprid (Admire®) 70%WG and/or Regent+Imidacloprid were the optimal solution for control from *Scotinophora horvathi* during the seedling stage.

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Poster 23

Similar hatching pattern of larvae of *Diabrotica v. virgifera* due to interruption of overwintering

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In the framework research of bionomics of *Diabrotica v. virgifera* (Dvv) the influence of environmental factors on the overwintering of its eggs was studied in central Slovenia in 2005. The Dvv eggs were recovered at 21-day-intervals and incubated at daily temperature of 24 °C and night temperature of 18 °C. The hatching pattern of Dvv larvae was observed. The hatching started three weeks after the rise in temperature regardless of different duration of overwintering conditions. It lasted 30 days and its peak occurred in the first week. Since the larvae had no food in the experimental design, 90 % of them died from starvation three days after hatching. Longer period of exposure to environmental factors resulted in smaller viability and hatching of the eggs. However, the environmental temperatures had influenced the hatching initiation. The eggs started to hatch when the sum of effective temperature reached 210 °C above temperature threshold of 11 °C or 174 °C above temperature threshold of 12,7 °C. In the years 2006-2008 the threshold temperature was reached earlier than in the years before 2005. Earlier onsets of high temperatures lead us to the conclusion that the population of Dvv could increase due to a longer period of egg deposition.

Poster 24

"The Stem Crusher": An new and innovative way to manage the European corn borer, *Ostrinia nubilais* (Hubner) (Lepidoptera:Crambidae) in potatoes

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The European corn borer (ECB) is an established pest of potatoes in Atlantic Canada. Severe damage can result in stem breakage and consequently reduced yield. The main method of control is the use of precisely timed insecticide applications aimed at the hatching larvae. However, inclement weather often restricts or delays insecticide application, resulting in poor control. ECB larvae are known to overwinter within the discarded stalks of potato plants. A device "the stem crusher", was developed which allows growers to harvest potatoes and control ECB larvae

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simultaneously, thereby reducing the number of times a grower has to enter the field to control this pest. The device is attached to the back of a potato harvester. As the potatoes are harvested, the stalks, before being discarded on the soil surface, are passed through the device which crushes the stalks and larvae within them. An eighty percent larval mortality was achieved in efficacy trials at harvest, with a further decrease over the winter months noted. A detailed description of the device and its workings will be displayed.

Poster 25

Susceptibility of Croatian maize hybrids to European corn borer

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European corn borer (ECB) tunnel and feed within vascular tissues of maize whereas disrupt water and nutrient transport within plants. Occurred injuries predispose plant to stalk breakage and ear droppage, and may result in serious maize yield losses. The aim of this work is to evaluate susceptibility of maize hybrids to ECB. Two years of field studies were conducted among seven maize hybrids at Croatian site. Susceptibility to ECB was assessed by measuring tunnel length and number of ECB larva in dissected maize stalks and grain yield. Intensity of ECB attack in both years was 100%. Number of larva detected in plants across years was similar. Significant difference was observed for tunnel length since in 2008 it was longer for 22 cm in average for all hybrids compared to 2007. The extent of tunneling injury ranged between hybrids from 13.70 to 29.20 cm in 2007, and from 40.84 to 64.42 cm in 2008. Significant differences for tunnel length and number of larva among hybrids were found in both years. One larva in average was found in each dissected stalk. A positive correlation between tunnel length and number of larva has been observed for all hybrids in both years with exception of one hybrid in 2008 year. Our results indicate substantial variability among hybrids, and hybrid OsSK 602 showed tolerant characteristics. However, all hybrids proved to be susceptible to ECB but able to produce high yields under severe ECB infestation.

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Noninvasive methods for evaluating western corn rootworm larval behaviour and maize root growth

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Distribution and behaviour of belowground herbivores and root damage generated by the larvae are difficult to evaluate without using invasive methods. A better understanding of their behaviour, such as larval feeding preferences or larval movement would help to develop more efficient management systems of belowground pests such as the western corn rootworm. Different methods helping in directly observing larvae and roots and their developmental parameters have been evaluated: i) an artificial transparent gel matrix, ii) glass bead layers, both allowed

observing neonate larvae but with young plant roots only, iii) thin soil layers allowed observation of larvae and roots within older plant root systems but reduced visualization of larvae. For the latter method larvae during their 2nd and 3rd larval stage need to be used, iv) nuclear magnetic resonance (NMR) is used to scan maize root systems, helping to evaluate damage to root systems entailed by larval feeding at any stage during root and larval development.

Poster 27

Insect communities on the *Bt* and control maize plants

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Field trials were performed in Southern Bohemia (300 m a.s.l.) vicinity with České Budějovice in 2002 – 2004. Ten plots 0.5 ha were set within the field of 7.6 ha (2002) and 14 ha (2003 and 2004) and seeded either with the Bt or the isogenic non-Bt cultivars. The occurrence of plant dwelling insects was recorded visually in the field every week and examined in detail on 10 randomly selected plants taken to the laboratory from each plot every 2 weeks. Enzyme-linked immunosorbent assay (ELISA) was used to detect the amount of Bt toxin Cry 1Ab in the plants during the whole vegetation season. No larvae of the target insect *Ostrinia nubilalis* were found on the Bt maize (although adults and eggs were commonly observed). In contrary, larval infestation of the control maize reached from 10% (2002) to 15% (2003).

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Population density of this pest was considerably lower in 2004. The non-target species included aphids (*Rhopalosiphum padi*, *Metopolophium dirhodum*, *Sitobion avenae*) that peaked at the end of June, thrips (*Franklinella occidentalis*) that were most abundant at the beginning of August. The most common predator of non-target insects was *Orius* sp. In 2004, we found on maize some caterpillars of *Helicoverpa armigera* that had been unknown in the region. Statistical analysis revealed no significant negative effect of *Bt* maize on the non-target insects. This work was supported by grant No. QH91093 from the Ministry of the Agriculture CZ.

Poster 28

Biological control of *Diabrotica* larvae using nematodes

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A three-year project aimed to develop a nematode-based biological control product against the larvae of the Western Corn Rootworm, *Diabrotica virgifera virgifera* for Europe. All three nematode species tested in field experiments in Hungary significantly reduced the number of *D. v. virgifera*. Particularly the nematode species *Heterorhabditis bacteriophora* showed a promising reduction of damages on maize roots, no matter whether applied at sowing time of maize or later in June. The nematode survived longer than two months in field soils which is long enough to control *D. v. virgifera*, and it effectively killed all three larval instars and pupae. At rates of ca 1×10^9 nematodes/ha, economic losses were reduced by 40 to 60 % when using fluid solid stream sprays into soil at sowing, or fluid narrow flat sprays applied later over small maize plants. Both application techniques reduced the average root damage by 70 to 96 %. Results and knowledge from this project are currently taken further by industry partners and implemented. The CTI Innovation and Technology Fund of Switzerland financed this work (CTI P-No. 7485.1 LSPP-LS).

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Is the invasive alien western corn rootworm attacked by indigenous natural enemies in Europe?

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As part of a sustainable pest management, knowledge pertaining to the community of indigenous natural enemies of *Diabrotica virgifera virgifera* was required from its areas of introduction in Europe. Natural enemy surveys were conducted on different life stages of *D. v. virgifera* in Hungary, Romania, Serbia, Croatia, Slovenia and Italy between 2000 and 2006.

The entomopathogenic fungal species *Metarhizium anisopliae* and *Beauveria bassiana* were found to naturally attack about 1.4% of larvae, 0.2% of pupae and 0.05% of adults (Hungary, Romania, Serbia). Eggs have never been found infected by those two fungi; instead, infestations with *Fusarium verticillioides*, *Clonostachys rosea f. catenulata*, *Volutella cf. ciliata*, *Lecanicillium longisporum* and *Paecilomyces*

lilacinus were found (Slovenia). The entomopathogenic nematodes *Heterorhabditis* sp. and *Steinernema* sp. were rarely found, but infected about 1.8% of larvae collected from four maize fields (Hungary). Protista, viruses, and bacteria have never been identified from field-collected *D. v. virgifera*; however, surveys may have missed such diseases. Entomophilous nematodes of the genus *Micoletzkyia* and *Panagrolaimus* infested 3.3% of larvae collected from two fields (Hungary). Aranae (*Agelena* sp., *Argiope bruennichi*, *Theridion impressum*, *Theridion pictum*, *Enoplognatha latimana*, *Achaearanea tepidariorum*, *Xysticus* sp.), Asilidae and *Tettigonia viridissima* were found to prey on *D. v. virgifera* adults. Aranae (*Lepthyphantes* sp. *Oedothorax apicatus*, *Pardosa* sp., *Trochosa spinipalpis*), Carabidae (*Amara similata*, *Brachinus crepitans*, *Pseudoophonus (=Harpalus) rufipes*, *Trechus quadristiatus*), several Formicidae, and *Gryllus campestris* were found to prey on larvae. In contrast to studies from Central and North America, parasitoids have never been found from field-collected *D. v. virgifera* during our surveys.

It can be concluded that specific indigenous natural enemies do not significantly affect the generational mortality of *D. v. virgifera* in Europe. This suggests that the search for effective and specific classical biological control agents in the area of origin is merited with the aim to potentially import selected natural enemies following thorough assessment of the non-target host range.

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Galerucid beetle, *Monolepta hieroglyphica* (Motschulsky), a potential major insect pest of maize in North China

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Monolepta hieroglyphica (Motschulsky) (Coleoptera: Chrysomelidae) distributes in Japan, Korea, the Philippines, Malaysia, Vietnam, Myanmar, Indonesia, and the Far East of Russia. It has a wide host range, which belong to 14 families, including Graminae, Cruciferae, Leguminosae, Solicaceae, Convolvulaceae and Malvaceae. It was first reported that adult of *Monolepta hieroglyphica* fed on silks and young kernels of maize in Zhangjiakou of Hebei Province in 1979. It has become more serious in some maize planting areas of North China, such as Shaanxi, Ningxia, Hebei, Jilin and Inner Mongolia since 2001. The infested area reached 270000 ha and 366800 ha only in Shaanxi Province in 2007 and 2008, respectively. It was estimate that the damage of the adult feeding resulted in 6-10% yield losses. *Monolepta hieroglyphica* has a single generation per year. Eggs are laid in the top of

soil in the ridge of field or at the base of maize plants and other host; they are the overwintering stage. They hatch over a prolonged period. The larvae develop in and/or on the roots, feed on fine rootlets of maize and other host plants. Pupation takes place in the soil. The emerging adults move to the maize plant, feeding on the leaves before pollination, and additionally move on pollen and silk as they become available. *Monolepta hieroglyphica* reduce the grain yield by eating pollen to levels insufficient to fertilize all available ovules and by clipping silks to lengths insufficient to intercept pollen as well as by the eating foliage.

Poster 31

Natural mortalities of western corn rootworm populations in Europe

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In order to successfully combat the invading western corn rootworm, *Diabrotica virgifera virgifera* LeConte, we need to understand the population dynamics of this alien pest species. This study focused on details of most of the natural mortalities acting on each of the life stages of *D. v. virgifera*. Life-table studies were conducted

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in Hungary in 2001 and 2002 in order to rank the mortality factors regarding their intensity in reducing *D. v. virgifera* populations, and to discover key mortalities acting on *D. v. virgifera* life stages and thereby influencing population growth.

In summary, a total mortality of over 95 % during the life cycle of *D. v. virgifera* appears to be typical for this maize pest; however, its populations are still able to grow. Populations of *D. v. virgifera* were mainly reduced by mortality factors acting on the first instars and by the un-realisation of the potential fecundity. Nonetheless, large variations in the realisation of fecundity, in the overwintering mortality, and in mortality of late larval instars resulted in a high impact on changes in population growth rates.

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