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# DIABR-ACT –Harmonise the strategies for fighting *Diabrotica virgifera virgifera*

## 1 Project Execution

### Major project objectives

The project **DIABR-ACT** intended to coordinate sustainable and environmentally embedded maize production systems among EC countries aimed at controlling the invasive maize pest Western Corn Rootworm (WCR), *Diabrotica v. Virgifera* LeConte ( Coleoptera: Chrysomelidae ) by using diversified approaches and control measures.

More specifically, **DIABR-ACT** proposed at the end of the project :

- a coordinated European Action Plan in order to harmonise and improve control and prevention measures against WCR populations in Europe,
- a coordinated European Research Plan that identifies priority research areas with regard to WCR as well as harmonises research activities .

### Methods

The long term goal of **DIABR-ACT** was to establish a harmonised and sustainable control strategy for WCR populations both in the areas of continuous establishment and in the areas of discontinuously emerging populations. At the same time **DIABR-ACT** aimed at minimizing the impact of these measures on biodiversity and the environment. These control strategies had to be adapted to the situation of each country involved and had to take into account the situation of the farmers and the economic chains built upon the maize crop. These control strategies include biological and integrated control, plant resistance traits, the adaptation of biotechnological approaches and cultural techniques.

Stakeholders participating in the Specific Support Action were members from organizations involved in potential problems caused by this insect pest, i.e. farmers organizations, national plant protection services, policy makers, European research groups, cooperatives, chemical and plant breeding companies, environmental groups, respectively.

The focus of **DIABR-ACT** was on coordination of already established activities concerning the control of WCR by means of sustainable control measures. However, knowledge concerning the economic impact of WCR on farm, food or feed chain level was still limited. Thus, and evaluation of short and long term costs and benefits of containment and eradication strategies at the micro or macroeconomic level (farms, regions, countries, Europe) seemed mandatory.

**DIABR-ACT** has been structured according to the deliverables issued from 6 workpackages :

- Workpackage 1 (WP01) " Basic Ecology and Integrated crop management" addresses the researches in the WCR, actually conducted within EU (months 1 to 15).
- By addressing administrative shortcomings or evaluating the impact of certain control strategies on farmer incomes and maize chain stakeholders, the workpackage (WP02) "Decision implementation of management strategies" will identify action to be taken by policy makers in the next years to control WCR populations or to avoid the establishment of introduction (months 1 to 15),
- Workpackage 3 (WP03) " Drafting of the action plan" will use the results of WP01 and WP02 to draft an action plan (months 16 to 21)
- Workpackage 4 (WP04) " Drafting of the research plan" will use also the results of these WP to draft a research plan (months 16 to 21).
- An international symposium on WCR management in Europe (workpackage 5 – WP05) "International Symposium on “WCR management in Europe: Future research and action needs”" will present the action and research plans (months 22 – 23).
- A workpackage 6 (WP06) "Project Management" is dedicated to the management (months 1 to 24).

## Expected results

The first two packages (WP01 and WP02) have been scheduled for the first 15 months (month 1 to month 15) with workshops organised by the specific tasks of WP01 and WP02. The workshops will strengthen the awareness of related research interests within European research group, will promote collaboration and will help to establish a network of research groups for the benefit of the European research area.

The package WP03 has been scheduled from month 16 to 21 with 2 workshops in order to propose adaptations to the current EC regulations according to various social, environmental, economical and technical characteristics encountered in the different European countries. A draft of an action plan aiming at a sustainable management of WCR in Europe has to be prepared at the end of this period.

The package WP04 scheduled from month 16 to 21 had the objectives to propose a draft of a research plan aiming at broadening the control options for a sustainable management of WCR in Europe.

The package WP05 scheduled from month 22 to 24 had the objectives to organize a scientific Symposium on all issues related to WCR and to discuss the findings and recommendations of the drafts of action and research plans proposed by **DIABR-ACT** consortium. Finally, final action and research plans have to be delivered at the end of the project to the European Commission.

## Partners

<i>Role</i>	<i>Number</i>	<i>Organisation name</i>	<i>Short name</i>	<i>Country</i>
CO	1	ARVALIS - Institut du végétal	ARVALIS	France
CS	2	Georg-August-Universität Göttingen	UNIGIPP	Germany
P	3	Università degli Studi di Padova	UNIVPAD	Italia
P	4	CAB International	CABI	UK
P	5	Praktijkonderzoek Plant & Omgeving B.V.	PPO	The Netherlands
P	6	Szent Istvan Universty	SZIE	Hungary
P	7	Wageningen Universiteit	WU	The Netherlands
P	8	Institut National de la Recherche Agronomique	INRA	France
P	9	Station de recherche Agroscope Changins-Wädenswil ACW	ACW	Switzerland
P	10	Csongrád Megyei Mezőgazdasági Szakigazgatási Hivatal	MSH	Hungary
P	11	Julius Kühn-Institut, Bundesforschungsinstitut für Kulturpflanzen	JKI	Germany
P	12	Poljoprivredni fakultet u Osijeku	PFOS	Croatia
P	13	Association Générale des Producteurs de Maïs	AGPM	France

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**Website of the project :** <http://www.diabtract.org/>

**Duration of the project :** 01/06/2006–31/07/2008

**Work performed from 01/06/2006 to 31/07/2008**

For the whole period, 8 tasks had been scheduled in the workpackage 1 (WP01) and 5 tasks in the workpackage 2 (WP02), 1 task in the workpackage 3 (WP03), 1 task in the workpackage 4 (WP04), 1 task in the workpackage 5 (WP05) and 1 task in the workpackage 6 (WP06)

1) The WP01 was dedicated to identify the main maize research needs with regard to WCR ecology and integrated maize management in Europe:



Task 01.01 – action of coordination: UNIGIPP coordinated the tasks within WP1. At the kick-off meeting, which all partners attended, and which has been hosted by ARVALIS, a poster session has been organized, where all partners of WP1 have presented their recent relevant activities in the area of Western Corn Rootworm (WCR) research, in order to give a brief state-of-the-art-report for all partners of the **DIABR-ACT**. This overview has helped to identify duplication of research activities. UNIGIPP has regularly updated (approximately every two months) all partners of WP1 with the progress made within each task over the previous months and has thus enhanced project cohesion and promoted co-operation between partners. UNIGIPP has also monitored the progress of the project in completing tasks and achieving deliverables and milestones within the fixed timetable of **DIABR-ACT**. Finally, UNIGIPP has prepared the first annual progress report and has communicated minutes of the workshops and meetings organised within WP1.

Task 01.02 – Western Corn Rootworm Ecology: A literature survey has been conducted by INRA on the ecology of the western corn rootworm, *Diabrotica virgifera virgifera*. This survey details a large part of the literature available on this subject as well as unpublished results of current research. A computer database has been build: it consists in a compilation of more than a thousand bibliographic references on the ecology of WCR and associated information such as the availability of the corresponding articles among the partners of the project. The database will be made available for interested research groups in case legal entities are not violated. An international expert group was invited in Nice, France, for a workshop on the topics of past and present research achievements on the ecology of WCR. Most importantly, this expert group outlined the research gaps that should be filled. A report detailing the research accomplished since the last comprehensive review on the subject of WCR ecology has been written. Four review articles have been submitted and were accepted for publication in a peer-reviewed international scientific journal.

Task 01.03 – Biological control including bio-pesticides: CABI conducted a worldwide survey for units dealing with or interested in dealing with biological control strategies in the maize agro-ecosystem. A global expert list was presented. A core group of institutions and experts focusing on the biological control of WCR was established. An international expert group was invited for a first workshop on the biological control of WCR and other maize pests in order to review research conducted on this subject, to show current developments, to analyse feasibility of biocontrol options, to inform about stakeholder needs, and finally to reveal knowledge gaps.

A survey was conducted on the integration of potential WCR biological control techniques with established biological control options against other maize pests and a literature and projects were reviewed on possible adoptions of newly developed bio-pesticides to the control of WCR in Europe.

A training manual was developed and published by CABI and international experts on possibilities to conserve and enhance natural enemies in the maize production system in order to reduce outbreaks of maize pests, particularly WCR.

An international expert group was invited for a second workshop on the biological control of WCR and other maize pests to further review natural enemies of Diabroticina, to identify a common agreement on the most promising biological control strategies against WCR in Europe, and to suggest possible objectives of a collaborative European research plan for suppressing WCR populations using biological control techniques within an integrated and/or organic management approach in European maize production systems.

A final report on the most promising biological control strategies that may be considered for the suppression of WCR populations in Europe has been published. This report proposes priority areas for a collaborative European research plan on the control of WCR, focusing on biological control as a valuable component within an integrated management approach in European maize production systems.

Task 01.04 – Chemical control: PPO prepared a literature study, preliminary to the first workshop entitled “Possibilities and gaps of knowledge in chemical control against WCR”. The group constituted has evaluated the gaps in knowledge in chemical control and has identified realistic and feasible chemical and control strategies for WCR. An overview of informations has been gathered from an additional literature study and e-mail correspondence with discussion by the experts group. Following this discussion a report has been realized. A report on the final overview of gaps and research plan has been prepared and published.

Task 01.05 – Resistance breeding: PFOS realized a state of the art report on resistance and tolerance traits in European maize cultivars and a group of experts was constituted to work on a questionnaire on WCR breeding activities. More than 400 experts were contacted in order to answer to the questionnaire concerning corn rootworm maize resistance programs. Analysis of the questionnaires with regard to the resistance breeding against WCR were presented and described during a workshop and the participants to the workshop have tried to identify the gaps of knowledge on the genetic field. A final report on resistance breeding options targeting WCR in Europe has been prepared and published.

Task 01.06 – Cultural control: In the beginning LBC, leader of the task prepared a questionnaire for reviewing the maize production structure and prevailing agronomic practices in regions already continuously colonized by WCR. Data collection and evaluation have been made by experts during a workshop to identify the impact of different agronomic measures and cultural systems of maize growing on WCR incidence and damage. an expert group has prepared an overview on maize production systems in Europe and has made propositions on cultural control components. During a second workshop scheduled on July 2007, members of the expert group on cultural control have discussed an overview of maize seed production and on an outlook of maize grown as an energy plant. All the elements have been used to prepare the workshop report and a second report on some case studies on cultural measures concerning WCR control.

Task 01.07 – Integrated Pest Management: SZIE, leader of the group, established a European WCR IPM Group involving individual experts, institutes and representatives of key stakeholders. The first IPM Workshop was organized with 25 experts of this Group. Reports delivered by these experts gave an overview on the range of national and regional regulations for WCR management as well as tools applied in managing WCR. Case studies for WCR management in selected areas of Europe were identified. Specifically, this task compiled available national regulations that are closely related to WCR management; identified gaps in regulations for WCR management and made recommendations for adjusting regulations for sustainable WCR management. During the 2<sup>nd</sup> workshop, experts identified and discussed gaps of knowledge and missing tools and bottlenecks of IPM implementation. Risk management guidelines and the farmers’ training manual have been prepared with regard to recommendations and suggestions of the IPM experts group.



Task 01.08 – Drafting of a synthesis report: a synthesis report summarising the results elaborated in WP01 and WP02 has been prepared by UNIGIPP. The synthesis aims at specifically identifying gaps in knowledge, which need to be filled in, in order to establish more refined sustainable management approaches.

2) Objectives of WP2 aimed at helping decision makers to implement management strategies:

Task 02.01: Action of coordination: ACW coordinated the tasks within WP2. At the kick-off meeting, which all partners attended, and which has been hosted by ARVALIS, a session has been organized, where all partners of WP2 presented their recent relevant activities in the area of Western Corn Rootworm (WCR) research, in order to identify the elements of management strategies for all partners of the **DIABR-ACT**. The coordination was necessary to prevent overlaps and assure that the tasks receive the necessary information in due time. Regular updates of progress and principal decisions in individual tasks of WP2 has been sent to the task and work package leaders and thus has improved project cohesion, cooperation and minimise procrastination. Communication between task and work package leaders has been assured by exchanging minutes of workshops and other important informations. An intermediary progress report has been written in collaboration with task leaders of WP2 and a synthesis report on the different tasks (the state-of-the-art and gaps in knowledge) has been published. The leader of WP3 has taken an active responsibility in the drafting of the action plan.

Task 02.02: Monitoring: During the two workshops, the monitoring group of experts constituted by UNIVPAD has tried to make an overview and an evaluation of traps systems to monitor WCR and has worked on the standardisation of trapping at the level of a field or of a geographical area.. It was suggested that trapping results are centralised on the European level and maps of the current *Diabrotica* distribution are not elaborated in the USA but in Europe. Monitoring should be most strictly regulated in un-infested areas and around isolated foci and in border areas to the infested areas. A report on the statistical evaluation of data collected (standardisation of trapping at the level of a field or of a geographical area) has been published.

Task 02.03: Environmental and socio-economic analysis: The leader of the task was WU. During a first workshop, the experts have examined the costs/benefits comparison of different control mechanisms and their cost-benefit and environmental analysis, the available economic studies and the monitoring costs. During a second workshop, several economic analyses of different European countries were available and discussed. The assumed yield loss without control was estimated at 10-30% and the spread of *Diabrotica* trough Europe was estimated at 20-60 km per year depending on maize density. All the elements given by the experts permitted to prepare three reports: one report on environmental and socio-economic analysis, one report on a market analysis for the potential uses of biological control products in high value maize systems and one report on practical compatibility and economic competitiveness of each biological control option with chemical control and with cultural control of WCR.

Task 02.04 – Pest risk analysis: During the first workshop, the experts of this group, lead by JKI, tried to evaluate the different measures (containment, eradication, suppression) and made an analysis of integrated strategies combining all management options. The discussions dealt with dispersal, geographical distribution, host plants, potential of the pest for establishment,



transport of the pest and economic impact: the majority of countries consider eradication cost effective. Generally, the earlier eradication, the more cost effective it will be. Containment is difficult to apply and expensive. Incentives are necessary to convince farmers already affected by *Diabrotica* to apply containment measures. Suppression through rotation is feasible if maize production is not too intensive.

During the second workshop an analysis of the data for risk assessment and management of WCR has been discussed. This study has allowed preparing a report on the evaluation of effectiveness of eradication measures.

Task 02.05: Communication: The task leader (AGPM) developed and made available for distribution a poster and leaflets presenting the project **DIABR-ACT**.

During the unique workshop, experts agreed on the succession in disseminating information elaborated by **DIABR-ACT**: plant protection services - extension services – farmers. The dissemination in the different countries is based on the traditional means of communication: Internet, leaflets, presentations, field demonstrations. Experts proposed necessary elements of a PowerPoint presentation to be made available on [www.diabtract.org](http://www.diabtract.org) (biology, distribution, impact, monitoring, sampling, control measures, legal obligations). The presentation should be in English and the proprietors of pictures should agree on their availability on the Internet. Local disseminators should do translations and adaptations to local needs.

A report on the website visit statistics has also been published.

3) WP3 (ARVALIS) had the objectives to prepare a draft of an action plan. One workshop was held in order to define methods of actions according to various social, environmental and technical characteristics encountered in the different European countries. A second workshop allowed discussing the adaptations of current EC regulations. Following these two workshops their reports have been realized and a draft of an action plan has been published.

4) WP4 (UNIGIPP) had the objective to propose a draft of a research plan aiming at defining gaps of knowledge with regard to the ecology of WCR and control options for a sustainable management of WCR in Europe. This draft has been published.

5) WP5 (UNIGIPP) had the objective to organize a symposium at the end of the project. This symposium held in Germany (Goettingen) at the end of May 2008 aimed at bringing together colleagues from research groups, plant extension services, agroindustrial companies and administrative organizations involved in the problem of WCR in Europe to discuss the drafts of research and the action plans proposed by the EU consortium.

At the end of the project a preliminary action and the final research plans to be used by the European Commission have been published.

6) WP6 (ARVALIS) aimed at properly initiating, running and closing the procedures, tools and assistance to partners during the progress of the project. It also has the objective to prepare the technical and financial reports: annual and final publishable activity report, annual and final management and financial reports. These reports have been published at the end of the first year and at the end of the contract.

## 2 Dissemination and Use

The first two packages (WP01 and WP02) have been scheduled during the first 15 project months.

In the frame of the WP01, all the partners involved in the different tasks organized one or two workshops to bring together worldwide European experts involved in scientific and legislative aspects of WCR ecology and management in Europe. The workshops organized by these partners intended to give a forum for an in-depth discussion of the research and knowledge gaps with regard to WCR control in Europe and to foster cooperation with regard to future activities. The workshops strengthened the awareness of related research interests within European research groups, promoted collaboration and helped to establish a network of research groups for the benefit of the European research area.

In the frame of the WP02, under the responsibility of the partners involved in this part, many of the experts in decision implementation of management strategies of WCR in Europe gathered at least twice to get to know each other, compare approaches applied in their respective countries and learn from each other. This workpackage provided a unique opportunity to discuss practical aspects of monitoring and management and consider the costs of fighting WCR.

The objectives of the package WP03 were to prepare a draft of an action plan. The purposes of the workshops realized in the frame of the WP03 were to define methods of actions according to various social, environmental and technical characteristics encountered in the different European countries and to propose adaptations to current EC regulations. The draft has been focused on actions including monitoring, eradication and containment in non-infested and low infested areas, respectively and on actions in well established WCR population areas.

The objective of the package WP04 was to prepare a draft of a research plan aiming at broadening the control options for a sustainable management of WCR in Europe. The purpose of this draft is (1) to address gaps of knowledge (2) to propose funding directions needed to fully understand the ecology of WCR in Europe (3) to develop and to make use of adjusted and improved control measures against WCR to be implemented at a regional scale.

Therefore, these drafts of action and research plans have been discussed during the International Symposium on "WCR management in Europe: future research and action needs", organized at the end of the project in Göttingen (Germany) from 25<sup>th</sup> to 29<sup>th</sup> of May 2008. This Symposium aimed at bringing together colleagues from research groups, plant extension services agroindustrial companies and administrations involved in the problem of WCR in Europe. All these participants were invited to present their recent research and management activities and to discuss the drafts of the research and action plans prepared by the consortium. This procedure has allowed to prepare for the end of the project the final action and research plans intended for the European Commission.

However, **DIABR-ACT** has generated a high amount of information and documents (synthesis, manuals, guidelines, proceedings of the Symposium) which are of great interest for the different stakeholders. These documents are now available on the website of the project.

**Website of the project:** <http://www.diabRACT.org/>

## Section 3 - Published results:

### 3-1 Results now available on the website and open to the public:

(<http://www.diabRACT.org/>)

#### **D01.01 Global list of experts and units interested in the biological control of WCR and other maize pests (WP 1 Task 3.1)**

The outcome of a survey for units dealing with or interested in dealing with biological control strategies in the maize agro-ecosystem is reported. A global expert list is presented which may be used when developing IPM strategies or biological control products.

#### **D 01.02 Review on chemical control against WCR including historical and current pest control strategies (WP1 Task 4.1)**

A literature study was carried out preliminary to a workshop organized by PPO-agv in Lelystad, 22 – 25 November 2006, entitled “the possibilities and gaps of chemical control against WCR”. This meeting was part of the European Union project “Harmonise the strategies for fighting WCR”, a Specific Support Action (SSA), workpackage 1 “Basic Ecology and Integrated crop management”, task 4 “chemical control”. This report shows relevant historical and current chemical control strategies worldwide against WCR, basically used for an advanced literature study and the workshop in Lelystad. Data is mainly available from the USA and the Eastern European countries where active chemical crop protection is conducted. Lists of insecticides are included, as well as tasks for discussion at the chemical workshop in Lelystad.

#### **D01.08 State-of-the-art report on resistance and tolerance in European maize cultivars to WCR (WP1 Task 5.1)**

A detailed literature survey was conducted in order to prepare a review of the state-of-the-art regarding resistance of maize cultivars against WCR, including the recent developments of maize breeding related to WCR maize resistance. The data provided in the report include information on the genetic background of European WCR population. Scientists, research institutions and companies that are improving resistance mechanisms in maize cultivars are recognized.

#### **D01.09 Literature survey on WCR ecology finalised (WP1 Task 2.1)**

This Deliverable D01.09 intends to present a literature survey that has been conducted on the ecology of WCR. This survey details a large part of the literature available on this subject as well as unpublished results of current research.

#### **D01.11 Report on diversity and specificity of the two most important maize production systems in Europe (WP1 Task 6.2)**

Main data of maize production of European countries are summarized. Based on answers of questionnaire formed in cooperation of experts of the 1<sup>st</sup> international workshop on Cultural Control Options against the Western corn rootworm (WCR) (*Diabrotica virgifera virgifera* LeConte) characteristics of cultivation procedures of regions with established and economic population of western corn rootworm were evaluated.

### **D01.13 – Survey report on the integration of potential biological control techniques against WCR among established biological control techniques against other maize pests in Europe WP1 Task 3.3).**

The integration of potential biological control techniques against WCR among established biological control techniques against other maize pests in Europe was considered achievable. With the exception of *Trichogramma* wasps (Hymenoptera: Trichogrammatidae) against eggs of Lepidopteran maize pest, no major other biological control strategy is widely used in maize production. Most promising biological control approaches against WCR are currently (a) the inoculative release of specific natural enemies of *Diabrotica* pests, like the adult parasitoids or viruses from Central America or Mexico into Europe; and (b) the inundative releases of mass-produced and commercially available entomopathogenic fungi or nematodes against WCR larvae. Both control strategies and agents would fit well to the established biological control techniques in maize. No conflicts will appear as agents are either highly specific or used against different life stages of WCR, i.e. either below ground or above ground. Crop rotation is compatible with adult parasitoids as long as infested fields remain in a region. Crop rotation is compatible with fungi and nematodes as they can be / must be applied preventively or curatively each year. When using nematode or fungi products against WCR, synergies are expected in terms of marketing, farmer training and application if the biological control products are produced and / or marketed by the same companies. Moreover, farmers that use biological control agents like *Trichogramma* already have a capacity for such applications.

### **D01.14 – Review on adapting bio-pesticides for the control of WCR in Europe (WP1 Task 3.3)**

The practice of managing the WCR with bio-pesticides is absent from recent and current European research activities on biological control of WCR. As European researchers and ecologists wish to approach a management strategy using environmentally friendly bio-pesticides, such possibilities were reviewed. The role of entomopathogenic fungi in *Diabrotica* population suppression is still largely unknown. Although there are numerous records of individual infections, these fungi do not seem to be providing significant natural suppression of WCR in North America or Europe and thus, surveys for highly virulent fungi in the area of beetle's origin are suggested. Comparing the virulence of isolates from the area of origin and from North America with locally adapted European isolates may help to find the most effective strain. The influence of management practices on indigenous fungus populations in maize agro-ecosystem is unknown and should be revised in order to enhance or conserve their populations. To date there is still a lack of protozoan and virus candidates for development as a microbial pesticide against *Diabrotica* and thus, future surveys for pathogenic viruses and protozoa should be focused on the area of origin of *Diabrotica*. Transgenic maize that express the genes of *B. thuringiensis* toxins are the prominent strategy for *Diabrotica* control in North America. However, there is still a need for screening soils in the area of beetle's origin as well as in European regions for new indigenous *Bt* strains with specific activity against *Diabrotica*. The taxonomy of bacterial species associated with *Diabrotica* guts requires an update and newly developed molecular screening methods may help to discover additional species. Recently described *Chromobacteria* as well as *Wolbachia* may offer new directions for research in biological control of *Diabrotica*.

### **D01.15 - Training manual on enhancing natural enemies for sustainable maize management (WP 1 Task 3.3)**

This manual addresses possibilities to conserve and enhance natural enemies in the maize production system in order to reduce outbreaks of maize pests, particularly the WCR. The



training manual consists of five instructive sections dealing with (1) the identification of pests and their associated damage, (2) pest management strategies available to farmers, (3) descriptions of the types of natural enemies involved in maize pest reduction, (4) tools for finding and identifying those natural enemies and (5) methods for enhancing the efficacy of natural enemies in maize cropping systems.

#### **D01.18 Overview and report on IPM tools, options and practices in regions differing in intensity of maize production (WP1 Task 7.2)**

Maize is cultivated in almost Member States but acreages (intensity of production) are different from region to region. Feasibility of rotation (primary control method of WCR) depends on share of maize within arable land and on production purposes. In this case study IPM tools, options and practices against WCR are overviewed and compared in regions with high and low maize acreages. Suggestions of this case study are applicable for development of IPM against WCR in other regions.

#### **D01.24 Final report on biological control options of WCR in Europe (WP 1 Task 3.5)**

This report presents the most promising biological control strategies that may be considered for the suppression of *D. v. virgifera* populations in Europe. The conclusions presented in this document were derived from discussions and work carried out by international experts at two workshops. As an initial step, natural enemies of beetles in the subtribe Diabroticina were reviewed and subsequently, the most promising biological control strategies against *D. v. virgifera* for European maize production areas were determined. Based on these conclusions an action plan for harmonised and more efficient *Diabrotica* biological control in Europe was developed. Finally, this report proposes priority areas for a collaborative European research plan on the control of *D. v. virgifera*, focusing on biological control as a valuable component within an integrated management approach in European maize production systems.

#### **D01.25 Final report on resistance breeding options targeting WCR in Europe (WP1 Task 5.5)**

Investigations in Europe on the development of plant resistant mechanisms against WCR are just beginning. In 2003 the European Commission made decisions on certain measures aimed at slowing down the spread of the WCR in Europe. Nevertheless, this pest has already been found in 18 countries of the European region. Recently, European experts reported several European maize cultivars with WCR tolerance. PFOS coordinated one part of the **DIABR-ACT** project concerning “Resistance breeding” and reveal the latest research achievements regarding resistance breeding against corn rootworm. In order to carry out this task we utilized various methods and the results were presented through four deliverables. This report comprises the most important information regarding maize resistance breeding accomplishments against WCR and emphasize challenges for the scientists in future research activities

#### **D01.26 Case studies on cultural control measures on WCR control (WP1 Task 6.3)**

Case studies deal with maize cultivation in two different regions of Europe. Lombardy (Northern Italy) has very favourable conditions for maize production; irrigation is possibility because water sources are available, allowing different planting times. In spite of the high ratio of continuous maize no economical damage was observed since 2003. On the other hand Csongrád county (Southern Hungary) has much less favourable economic conditions for maize production: irrigation is limited and crop rotation is the main management option



against WCR; a reduced area of monoculture resulted in reduced population levels in the past years.

#### **D01.27 Farmers' Training Manual on WCR (WP1 Task 7.5)**

Western Corn Rootworm (WCR) is a new element of maize ecosystem in Europe, thus has both direct and indirect impacts on the former maize ecosystem and requires a response by farmers. Farmers should be prepared and their knowledge constantly updated so that they will find their most sustainable management option in the case of WCR and other pests as well. This manual contributes to this process.

#### **D01.28 Risk Management Guidelines (WP1 Task 7.5)**

Western Corn Rootworm (WCR) has spread over many areas in Europe. In regions where it has been established, farmers should manage it as one of the maize pests.

Based on our experiences and that of cooperating scientists, of FAO IPM for WCR Project we compiled Guidelines for WCR Management.

#### **D01.29 Possibilities and gaps and draft of a research plan on chemical control WCR in Europe (WP1 Task 4.4)**

Final overview of gaps and a research plan regarding chemical control of the Western corn rootworm *Diabrotica virgifera virgifera* LeConte. Priorities of research needs for identification of realistic and feasible Western corn rootworm chemical control strategies are described for the three topics seed treatment, adult control, and soil insecticides. The main research questions regarding seed treatment are factors influencing the efficiency and the responsible factors considering inconsistency of seed treatments. Main research points considering adult and larval control comprehends attraction availabilities and baiting techniques, consequently needing insecticides as well. Research to the behavior of *D. v. virgifera* larvae in different soil habitats is required.

#### **D01.30 Synthesis Report of the Different Tasks in WP1 and WP2 and state of the art report identifying gaps in knowledge of WCR ecology and management (WP01 Task 08)**

This synthesis report covers the whole period of work package 1 (01 June 2006 – 31 September 2007). The main achievement of the work package 1 *Basic Ecology and crop management* during this period was to describe the state of the art in WCR ecology and management and to identify gaps of knowledge. Six task groups of 10-20 experts from several European countries and the USA met once or twice to discuss these topics.

The European conditions with regard to the knowledge of the basic ecology of the Western Corn Rootworm (WCR) and the potential management options and control strategy are somewhat different from conditions in the USA and need to be adjusted to meet the specific conditions found in the overall more diverse maize cropping conditions in Europe. Although the European community may draw on rich information with regard to the biology of the pest, control measures so far implemented are to some extent based on deficient knowledge regarding the biology of the pest. Specifically, the lack of field experiments in most European member states, data on pest incidence / yield loss, and the lack of evaluation of alternatives with regard to pest control, including biological control options, chemical control options, or transgenic plants have to be considered before a comprehensive recommendation could be forwarded to plant protection services.

**D02.05 Leaflets introducing the project (WP2 Task 5)**

This leaflet presents the aims of the project and the information it should produce. An edition of 5000 copies will be distributed by the consortium partners in each country to a large agricultural public: technical institutes, agricultural organizations, maize users, farmers, scientists etc...

**D02.06 A poster introducing the project (WP2 Task 6)**

The objective of this poster is to present **DIABR-ACT** and the Consortium partners (countries, partners and stakeholders).

**D02.12 Synthesis Report of the Different Tasks on the State of the Art and Gaps of Knowledge (WP2 Task 1)**

This synthesis report covers the whole period of the work package (01 June 2006 – 31 September 2007). The main achievement of the work package 2 *Decision implementation of management strategies* during this period was to describe the state of the art in monitoring, environmental and socioeconomic analysis, pest risk analysis, and communication regarding Diabrotica and to define the lack of knowledge. Four task groups of 10-15 experts from about 5 countries met twice to discuss these topics.

The in Europe applied monitoring and control strategy is sound, yet needs improvement in specific areas. Decisions are often based on scarce knowledge regarding the biology of the pest, possible pathways of introduction and the economic impact of the control measures. Monitoring results could be of greater value if they would be shared and centralized across countries. An information package is in preparation helping disseminators to train European farmers.

**D02.14 Report on Environmental and Socio-Economic Analysis (WP 2 Task 3)**

The potential damage costs assessment indicates substantial economic benefits can be gained by controlling WCR. The economic benefits of the Wageningen workshop scenario are about 472 million Euro per year. The economic benefits of control justify eradication and containment strategies of the EU. The environmental and socio-economic analysis of Diabrotica control programs undertaken in this report gives a global idea of what are the benefits and the inconvenient of each possible control strategy (chemical, biological, transgenic) in terms of economic, environmental and health impacts for the different stakeholders involved in such management program.

**D02.15 Report on market analyses for the potential use of biological control products in high value maize systems in Europe (WP 2 Task 3)**

The potential market for biological control products against Diabrotica is assessed for high value maize systems such as sweet corn, seed corn and organic corn. The factors that determine the market potential of possible biological products are analyzed, in particular, the relative efficacy of bio-products compared with the efficacy of alternative control methods, the cost-competitiveness of bio-control products and the size of the market for bio-control products in high value maize systems. A market for potential biological control products against Diabrotica does exist in the current European situation for high value maize systems. The acreages currently used for producing sweet corn, seed corn and organic corn are largely higher than the current capacity of production of biological agents by the industry within the EU. The volume of the market size for potential bio-control products for Diabrotica for high value maize systems is estimated to be about 10 million€ and much higher in case possibilities for usage in grain and silage maize production are considered.



### **D02.16 Practical compatibility and economic competitiveness of each biological control option with chemical control and with cultural control of WCR (WP 2 Task 3)**

Four main control options can be distinguished for controlling Western corn rootworm, *Diabrotica virgifera virgifera* LeConte, in Europe: 1) chemical control, 2) WCR-resistant transgenic maize, 3) biological control and 4) cultural control. These control options are not equally available in the EU and thus do not yield the same benefits for farmers. WCR-resistant transgenic maize yields the highest benefits, even if the biological control option is a promising control option for *Diabrotica* in EU.

### **D02.17 Report on evaluations of effectiveness of eradication measures (WP 2 Task 4)**

This deliverable D02.17 intends to present the objective, results and conclusions of the evaluation of the effectiveness of eradication measures in accordance with the Commission decision of 24 October 2003 on emergency measures to prevent the spread within the Community of *Diabrotica virgifera* Le Conte (2003/766/EC) and the Commission decision of 11 August 2006 amending Decision 2003/766/EC on emergency measures to prevent the spread within the Community of *Diabrotica virgifera* Le Conte (2006/564/EU) (see annexes). In both workshops on the “Pest Risk Analysis” in Kleinmachnow on 20 November 2006 and from 23 to 24 April 2007, it was intended to make an analysis of the data for risk management of *Diabrotica virgifera virgifera* by discussing several topics relevant to the evaluations of the effectiveness of eradication measures in different EU member states and the Switzerland by selected experts (see the reports of the workshops concerning the deliverables D02.03 and D02.10). The results of all the data presented by the experts at both workshops, additional information submitted by experts to support the evaluation and the reports of surveys for *Diabrotica virgifera virgifera* according to the Commission Decision 2003/766/EC, Article 2 and Article 5, have been evaluated so as to give conclusions as to the effectiveness of the eradication measures applied since the beginning of the enforcement of the Commission regulation 2003/766/EC in year 2003.

### **D02.19 – Information package (WP3 Task 5)**

This document presents essential parts to know about *Diabrotica virgifera virgifera* Le Conte ranging from biological aspect to regulation via possibilities to control and economic impacts. This presentation will be available to a large agricultural public: technical institutes, agricultural organizations, maize users, farmers, scientists etc..

### **D03.03 - Draft of action plan (WP03 Task 1)**

This report presents the synthesis of the work realized in the frame of WP03 in the objective to propose a draft of an Action Plan aiming at a sustainable management of the western corn rootworm (WCR) in Europe. The purpose was to propose adaptations to the current EC regulations according to various social, environmental, economical and technical characteristics encountered in the different European countries.

This report is focused on actions including monitoring, eradication and containment in non-infested and low infested areas, respectively, and on actions in well established WCR population areas.

### **D04.01 - Draft of research plan (WP04 Task 1)**

This report summarizes the work realized within the frame of WP04 with the objective to propose a draft of a research plan aiming at broadening the control options for a sustainable management the western corn rootworm (WCR) in Europe.



The purpose of this research plan is to address gaps of knowledge and to propose funding directions needed to fully understand the ecology of WCR in Europe to develop and to make use of adjusted and improved control measures against WCR to be implemented at a regional scale.

#### **D05.01- Final action and research plans (WP5 Task2)**

The final research and action plan addresses the main actions to be taken by the EU to improve control strategies against WCR by addressing the research and harmonise needs

#### **D05.02 Proceedings on international Symposium on “WCR management in Europe: Future research and action needs” (WP5 Task 2)**

This symposium report covers the content of closing symposium meeting, organized at the end of the project in Goettingen from 25th to 29th of May, 2008. This symposium aimed at bringing together colleagues from research groups, plant extension services, agroindustrial companies and administrative organizations involved in the problem of WCR in Europe. By inviting keynote speakers from the USA, the colleagues of European countries intended to exchange recent research results and to benefit from the long standing experiences in managing WCR populations in these areas. Current activities in Europe and the USA aiming at finding strategies to reduce WCR populations have been discussed. Specifically within the EU there is an urgent need for harmonising and concentrating these activities both on a scientific and administrative level to establish a community-scale action and research plan. The **DIABR-ACT** EU project, addressing these shortcomings during the past two years presented and discussed the first drafts of research and action plans.