PFLANZENSCHUTZ-BERICHTE

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BAND 57/HEFT 2
1998

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ISSN 0031-675 X

Abonnements laufen ganzjährig und verlängern sich automatisch, wenn nicht 1 Monat vor Jahresende die eingeschriebene Kündigung erfolgt.

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Verleger und Abonnementbetreuung: w. o.

Erscheinungsweise: 2mal jährlich – Bezugspreis öS 490,– p. a.

Hersteller: Druckerei Lischkar & Co., A-1120 Wien, Migazziplatz 4.

EINLEITUNG

Im Jahre 1992 wurde der Western Corn Rootworm (*Diabrotica virgifera virgifera* LeConte; Coleoptera: Chrysomelidae) erstmalig in Europa und zwar in der Nähe des Belgrader Flughafens Surcin in Serbien nachgewiesen. Nachhaltige Schäden und typische Schadsymptome hatte serbische Entomologen die Ursache dafür untersuchen lassen. Das Resultat, das von US-Amerikanischen Wissenschaftern bestätigt wurde, bewies das Vorhandensein dieses, in den USA gefährlichsten Maisschädlings auch in Europa.

Als Reaktion auf dieses Auftreten organisierte die Internationale Arbeitsgemeinschaft für Maisschädlinge (IWGO) im Rahmen der Global IOBC mit Unterstützung der Food and Agricultural Organisation der UN (FAO) ein 1. Workshop in Graz, Österreich, bei der diese Problematik von Kollegen aus Europa und den USA eingehend diskutiert wurde. Schon damals war an die FAO der Wusch herangetragen worden, ein staatenübergreifendes Forschungsprojekt zu unterstützen. In den Folgejahren wurde der Schädling auch in Ungarn, Kroatien, Bosnien-Herzegowina, Rumänien, seit 1997 in Bulgarien und seit 1998 auch in Italien (Prov. Venedig) gefunden. Wenngleich die wirtschaftlichen Schäden, die von diesem Schädling verursacht wurden, vorerst im wesentlichen auf Serbien beschränkt blieben, waren die Länder, in denen der Schädling mittels Pheromon- und Gelbfallen nachgewiesen werden konnte, aufs höchste alarmiert.

Weitere Tagungen in Gödöllö, Ungarn (1995), Agram, Kroatien (1996), wieder in Gödöllö (1997) und Rogaska Slatina, Slowenien (1998) zeigten, wie intensiv sich die betroffenen Staaten mit diesem Problem beschäftigten. Bis 1997 wurde in den Ländern Serbien, Ungarn, Kroatien, Bosnien-Herzegowina und Rumänien auf mehr als 500.000–600.000 ha der Schädling nachgewiesen.

In der Folge war auch die EPPO (European and Mediterranean Plant Protection Organisation) auf das Problem aufmerksam geworden. Der bisher in Europa nicht bekannte Schädling wurde auf die EPPO-A1-Liste für Quarantäneschädlinge gesetzt. EPPO beteiligte sich auch an den laufenden Tagungen von IWGO und FAO in Form eines „*Diabrotica* ad hoc Panels“ Fragen der Verschleppung dieses Schädlinge und der phytosanitären Maßnahmen im internationalen Handel wurde im Rahmen dieses Panels besprochen.

Nach einer gründlichen Vorbereitung bei einer Tagung in Wien (1997) entschloß sich die FAO, ein länderübergreifendes Forschungsprojekt zum Thema *Diabrotica virgifera virgifera* einzuleiten. Unter der wissenschaftlichen Leitung von Richard EDWARDS (Purdue University. LaFayette, Indiana, USA) mit Unterstützung eines „Trainingskoordinators“ (Josef KISS; Universität Gödöllö, Ungarn) und einem „Monitoring-Koordinator“ (H. K. BERGER; Bundesamt und Forschungszentrum für Landwirtschaft, Wien, Österreich) wurde das Projekt (TCP/RER/6712[A]) begonnen. Beteiligt waren Ungarn, Kroatien und Rumänien. (Jugoslawien/Serbien konnte an dem Projekt offiziell nicht beteiligt werden, da der Staat derzeit nicht Mitglied der FAO ist.) Mittels Pheromon-, Cucurbitacin- und Gelbfallen wurde in den gefährdeten Ländern ein Warndienst aufgebaut und in Ungarn auch erste Bekämpfungsversuche mit Flugzeugapplikation durchgeführt.

Bei der Tagung in Gödöllö, Oktober 1997, wurden von einer Reihe von Wissenschaftern die letzten Forschungs- und Untersuchungsergebnisse zu diesem Thema präsentiert. Auch die weiter vom ursprünglichen, ersten Auftreten in Belgrad entfernte Länder wie Deutschland und Frankreich präsentierten Untersuchungen, die auf eine potentielle Gefährdung auch dieser und anderer Länder Mittel- und Südeuropas hinweist. Mittlerweile (Sommer 1998) wurden auch einzelne Exemplare von *Diabrotica virgifera virgifera* in Italien, in der Nähe Venedigs nachgewiesen. Ein Punkt mehr, der auf die Gefährdung weiterer maisbauender Länder Europas hinweist und ein weiterer Grund, sich intensiv – auch innerhalb der EU – mit diesem Schädling, seiner Verbreitung und Möglichkeiten seiner Kontrolle zu beschäftigen.

Der Großteil der Vorträge, die im Rahmen dieser Tagung in Gödöllö gehalten wurden, sind in diesem Band der „PFLANZENSCHUTZBERICHTE“ enthalten. Als Convenor der IWGO und Mitarbeiter im FAO-Projekt bin ich dem Bundesamt und Forschungszentrum für Landwirtschaft, Institut für Phytomedizin, besonders dankbar, daß uns die Möglichkeit geboten wurde, die Vorträge in Form von „Proceedings“ einer breiteren wissenschaftlichen Öffentlichkeit vorzustellen und so zu einer Unterstützung unserer Bestrebungen, das weitere Vordringen des Schädlings zu verhindern bzw. eine erfolgreiche Kontrolle dieses Schädlings durchzuführen, beizutragen.

Harald K. BERGER
Convenor der INTERNATIONAL WORKING GROUP ON OSTRIRIE AND OTHER MAIL POSTS

Pflanzenschutzberichte
Band 57, Heft 2, 1998

Übersicht über das FAO-Western Corn Rootworm Maßnahmen-Paket für Zentraleuropa

Overview of the FAO Western Corn Rootworm management program for Central Europe

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Zusammenfassung

Die FAO (Food und Agriculture Organization) hat im Juni 1997 im Rahmen des UNO/TPC-Programms ihre Aktivitäten in Bosnien-Herzegowina, Kroatien, Ungarn und Rumänien aufgenommen, um den eingeschleppten Maisschädling Western Corn Rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, zu bekämpfen. Das WCR-Projekt umfaßte:

1. Aufbau eines ständigen Überwachungsnetzwerks,
2. Bekämpfung durch Fallen und Erstellung eines Pflanzenschutzprogramms und
3. Bewertung des semichemischen Insektizidköders SLAM® bei großflächigem Pflanzenschutzmitteleinsatz.

Im Rahmen des ständigen Überwachungsnetzwerks wurden im Jahr 1997 ungarische Lockstoffallen an fixen Kontrollpunkten angebracht; 10 davon in Kroatien, 47 in Ungarn und 27 in Rumänien. Die Fallen wurden von Juli bis Anfang Oktober wöchentlich bzw. monatlich kontrolliert, je nach Anzahl der gefangenen Käfer.

Bei der Eindämmung und Bekämpfung des Schädlings durch Fallen wurden ungarische Lockstoffallen und gelbe Multigard®-Fallen paarweise an 4–5 Standorten entlang der am stärksten befallenen Gebiete in Kroatien, Ungarn und Rumänien aufgestellt. Es wurden beide Fallentypen eingesetzt um sicherzustellen, daß sowohl Männchen als auch Weibchen gefangen werden konnten. Bei Verzeichnung eines WCR-Fangs an einer der beiden Fallen wurden sofort 12 Fallenpaare im Umkreis von 1 km aufgestellt. Nach jedem Fang wurden zusätzliche Fallenpaare im noch nicht abgedeckten Umkreis der betroffenen Falle aufgestellt. Das Aufstellen der Fallen hatte das Ziel, die Durchführbarkeit dieser Maßnahme zu testen und Auswirkungen der WCR-Bekämpfung auf einem Testgebiet zu beobachten.

Der dritte Schwerpunkt des Programms befaßte sich mit der Bewertung des großflächigen Einsatzes von SLAM gegen Adulte WCR in Ungarn. Für eine großflächige Pflanzenschutzaktion 1997 traf das Mittel SLAM leider zu spät ein. Immerhin konnte die Wirksamkeit des Produkts auf zwei Feldern festgestellt werden. Im Rahmen des Gesamtprojekts, wurde von der FAO (Agromet Group, Rom, Italien) eine Studie durchgeführt, die über die Möglichkeit des Befalls auch in anderen europäischen Regionen Auskunft geben sollte. Dabei wurden die Auswirkungen von Temperatur, Klima und Feuchtigkeit auf den WCR analysiert und in das Vorhersagekonzept eingebracht. Außerdem wurde Schulungsmaterial ausgearbeitet und in den Teilnehmerstaaten verteilt.

Stichwörter: Western Corn Rootworm, *Diabrotica virgifera virgifera* LeConte, Warndienst, Pheromonfalle, Multigard® Falle, Slam®, Mais, *Zea mays*

Summary

A Food and Agriculture Organization (FAO) of the United Nations Technical Cooperation Programme (TCP) activity was initiated in June 1997 in Bosnia-Herzegovina, Croatia, Hungary, and Romania against the introduced maize pest, western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte. WCR project field activities included: 1) establishment of a permanent monitoring network; 2) implementation of a trapping for containment and control program; and 3) evaluation of a Slam®-based areawide pest management program. In the 1997 permanent monitoring network, Hungarian-produced pheromone traps were placed in 10, 47, and 27 permanent locations in Croatia, Hungary, and Romania, respectively. Traps were monitored from July through early October at intervals from weekly to monthly, depending on WCR numbers. The trapping for containment and control activity used Hungarian pheromone and Multigard® yellow sticky traps placed in pairs at 4–5 sites along the leading edge of the infestation in Croatia, Hungary, and Romania. Both trap types were used to ensure the capture of both males and females. When WCR catches were recorded on either trap at any location, 12 sets of paired traps were placed at 1 km increments radiating out in 4 directions from the original pair. After each catch, additional paired traps were placed in one or more of the four directions from the trap registering the positive catch. This trapping activity was designed to determine the feasibility and effect of removing WCR beetles from an area. In the third field activity, Slam was to be tested against WCR adults in Hungary on an areawide basis. However, Slam was received too late for areawide management of beetles in 1997 However, the efficacy of the product was determined in tests conducted in two fields. Also, as part of the overall project, a study on the suitability for WCR establishment in other areas of Europe was conducted by the FAO Agromet Group, Rome, Italy. Data on the effects of temperature, continental climate, and moisture on WCR were incorporated into the predictive model. Additionally, educational materials were produced and distributed to participating countries.

Keywords: *Diabrotica virgifera virgifera* LeConte; western corn rootworm; pest monitoring; pheromone trap; Multigard® trap; areawide pest management; Slam®; *Zea mays* L.; maize

Introduction

The western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, is the most important insect pest introduction into Europe (EDWARDS, 1997) since the 1877 discovery of the Colorado potato beetle, *Leptinotarsa decemlineata* Say, in potato fields in Germany (JERMY and BALAZS, 1990). WCR beetles and damage from larval feeding were first observed in maize, *Zea mays* L., in Europe in 1992 at Surcin, Yugoslavia (i. e., Serbia) near the Belgrade International Airport (BACA, 1993). Although it has been reported that WCR probably arrived in Yugoslavia in 1989 or 1990 (SIVCEV ET AL., 1996), it is likely that the beetle was introduced into this area in the early to mid 1980's considering the first economic populations were noted in 1992. It is unknown as to its mode of transportation into Yugoslavia, but it is thought to have arrived by airplane (SIVCEV ET AL., 1996). By 1994, WCR had spread as far as 50 km from the initial point of infestation in Yugoslavia, with 60 ha of maize being economically damaged and approximately 200000 ha being populated by this pest. By 1995, WCR reached Croatia (BARCIC and MACELJSKI, 1996) and Hungary (PRINCZINGER, 1996).

In 1996, further spread within Yugoslavia, Croatia, and Hungary occurred while some WCR beetles were also trapped in Bosnia-Herzegovina (I. BARCIC, Croatia, personal communication) and Romania (I. VONICA, Romania, personal communication). As of the end of the 1997 growing season, a total of approximately 100000 km^2 were infested in Yugoslavia, Bosnia-Herzegovina, Croatia, Hungary, and Romania with 10000 km^2 in Yugoslavia supporting an economic population.

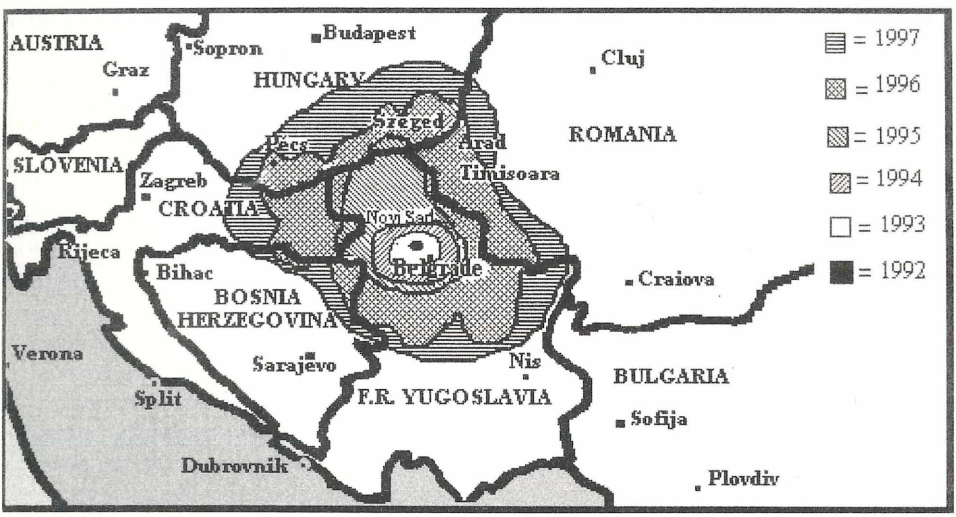

Fig. 1: Spread of western corn rootvorm in Europe from 1992–1997 (based on data provided by Barcic, Camprag, Festic, Ilovay, Maceljski, Princzinger and Vonica).

Although not confirmed, WCR is probably in the northwestern corner of Bulgaria based on reports of WCR trapped in 1997 near the Danube River bordering Bulgaria (I. VONICA, Romania, personal communication). WCR is likely to find its way into other areas of Europe based on the rate and direction of the spread through the infested countries, and based on initial results of studies on the suitability for WCR establishment in other areas of Europe by the FAO Agromet Group in Research, Extension and Training Division; Environmental and Natural Resources Service (SDRN) and Land and Water Development Division; Soils Resources Management and Conservation Service (AGLS).

In the midwestern USA, the WCR is the most important insect pest affecting continuous maize cultivation (EDWARDS, 1995). Yield losses of up to 2 t/ha have been reported. The cost for chemical control in this area, combined with the value of crop loss, have been estimated to reach approximately U. S. $ 1 billion per annum. Both adults and larvae of this univoltine insect can damage maize plants, although the most significant damage occurs from the larvae feeding on the roots. WCR eggs are laid in the soil from mid July through September, with peak egg laying normally occurring sometime in early to mid August. The eggs overwinter in a state of diapause in the soil and hatch over a period of about 6 weeks in late spring/early summer, depending on soil temperature. Upon hatching, the larvae search for maize roots. Larval feeding on roots may reduce the amount of water and nutrients supplied to developing plants, and extensive root damage makes plants more susceptible to lodging or "goosenecking." After completing their feeding, third instar larvae pupate in the soil.

Adults begin to emerge in late June or early July depending on the year. The males begin to emerge about one week before females. Adults may be present in maize fields from July until the occurrence of frost. The adults have a tendency to move out of maturing maize fields as the silks brown and the maize begins to dry down. They move to more attractive fields tc continue their feeding and oviposition activities. In maize, the adults feed on pollen, silk, exposed immature kernels, and leaf tissue. However, unless the adults are unusually abundant, only scattered plants are severely damaged. Therefore, farmers rarely need to apply insecticides to control adult feeding.

Yield losses approaching those seen in the USA have been reported in Yugoslavia (I. SIVCEV, Yugoslavia, personal communication). Although still small, this area of economic WCR activity is expanding. It is thought that WCR populations will reach levels that will cause economic losses in Bosnia-Herzegovina, Croatia, Hungary, and Romania within the next 2–4 years. Based on this threat and the need for a multi-country cooperative effort to address this emerging and expanding problem with WCR, the above mentioned countries requested and received a Technical Cooperation Program (TCP) project funded for 20 months through the Food and Agriculture Organization (FAO) of the United Nations. TCP/RER/6712 officially became a project in June 1997. A coordinating committee was established to direct the project. It consists of four National Coordinators, representing Bosnia-Herzegovina, Croatia, Hungary, and Romania; a Monitoring Coordinator, a Training Coordinator, an International Consultant on WCR, and an FAO Backstopping Officer.

Methods

In July 1997, the first TCP 6712 meeting of the coordinating committee was held in Szeged, Hungary. The three primary field activities of the WCR TCP were discussed and defined:

1) establishment of a permanent monitoring network,

2) implementation of a trapping for containment and control program, and

3) evaluation of a Slam®-based (BASF Corp., Research Triangle Park, North Carolina) area-wide pest management program for WCR (Slam is a semiochemical insecticide-bait which contains WCR feeding stimulants, cucurbitacins; a low dosage of carbaryl insecticide as the toxicant; and inert ingredients). As a result of this meeting, a permanent monitoring network using Hungarian-produced pheromone (8-methyl-2-decyl-propanoate) traps (TOTH ET AL., 1996) was established within the participating countries to determine WCR adult male population levels over time. The location of each permanent trap was to be recorded so that the same site could be used in subsequent years. The traps were to be numbered sequentially from left to right by each country as they faced their country's border from within Yugoslavia (e.g., Croatia 1 or C1 = trap closest to Bosnia-Herzegovina, etc.).

A trapping for containment and control activity using Hungarian pheromone and Multigard® (Scentry, Billings, Montana) yellow sticky traps (approximately 28 x 23.5 cm yellow sticky card that folds around an object, no pheromone) was established along the leading edge of the infestation in those countries bordering Yugoslavia from Croatia to Romania. This activity was designed to determine the feasibility and effect of removing WCR beetles from an area over time. The third field activity, the Slam-based areawide pest management program, was delayed until 1998 due to the late arrival of the Slam. However, Slam was tested late in the growing season in 1997 to determine efficacy against WCR adults under Hungarian conditions. Additionally, a study to determine the suitability for WCR establishment in other areas of Europe by the FAO Agromet Group in SDRN and AGLS was finalized. These data were to be provided in late 1997 At the October 1997 meeting of the coordinating committee in Gödöllö, Hungary, WCR slides and computer disks with digitized pictures of WCR and its damage were distributed to all the participating countries as part of the TCP.

Field activities

1) Permanent monitoring network – Hungarian pheromone traps were placed in 10, 47, and 27 permanent locations in Croatia, Hungary, and Romania, respectively, to determine population levels over time (59 traps were established in Bosnia-Herzegovina in 1997 of which 10 will be designated as permanent traps for 1998). Traps were monitored at intervals from weekly to monthly, depending on the numbers of WCR caught (the more caught, the more often the traps were monitored). New pheromone traps were placed at each site after 30 days, and between the time of trap replacement WCR were removed from the sticky surface after counting. The traps were monitored from early July through the middle of September. In some instances, the traps were monitored until October. WCR counts were recorded for each trap, for each sampling period, and the location of the trap and date of monitoring noted.
2) Trapping for containment and control – In the second field activity, Hungarian pheromone and Multigard traps were placed in pairs at 4–5 sites along the leading edge of the infestation in Croatia, Hungary, and Romania (not feasible to establish this activity in Bosnia-Herzegovina in 1997). Both pheromone and Multigard traps were used so as to capture both males and females. The males are attracted to the pheromone, while both females and males are attracted to the yellow Multigard traps. When a catch was recorded on either type of trap at any location, 12 sets of paired pheromone and Multigard traps, the pair being placed within 5 meters of each other, were placed at 1 kilometer increments radiating out from the original pair in 4 directions (up, down, left, and right as one views the traps as if standing in Yugoslavia and looking toward the trap within their country). This arrangement allowed for three new pairs of traps over a distance of 3 kilometers beyond the original trap.

   If the second set of traps or any original set of traps that had not previously trapped adults record catches, additional pairs of traps were to be placed at 1 kilometer increments radiating out until no more WCR were caught or until the middle of September. Each trap pair was checked every 7–10 days and the results recorded on a standardized record form using a code developed for the project. All traps were changed at intervals of 30 days, except for traps placed out after August 9. These were not replaced, but were monitored until mid September. No trap pair was replaced more than 3 times during the trap-monitoring period. Additional traps were added using the same arrangement when catches were made on other traps within the trapping grid. Paired traps were only added in one or more of the four directions, if other traps were not already in place in that direction.

   The purpose of this trapping activity was to determine the feasibility of trapping out as many WCR beetles as possible. It was hoped that it would be possible to show that the buildup of a WCR population in a given area could be slowed or possibly stopped over

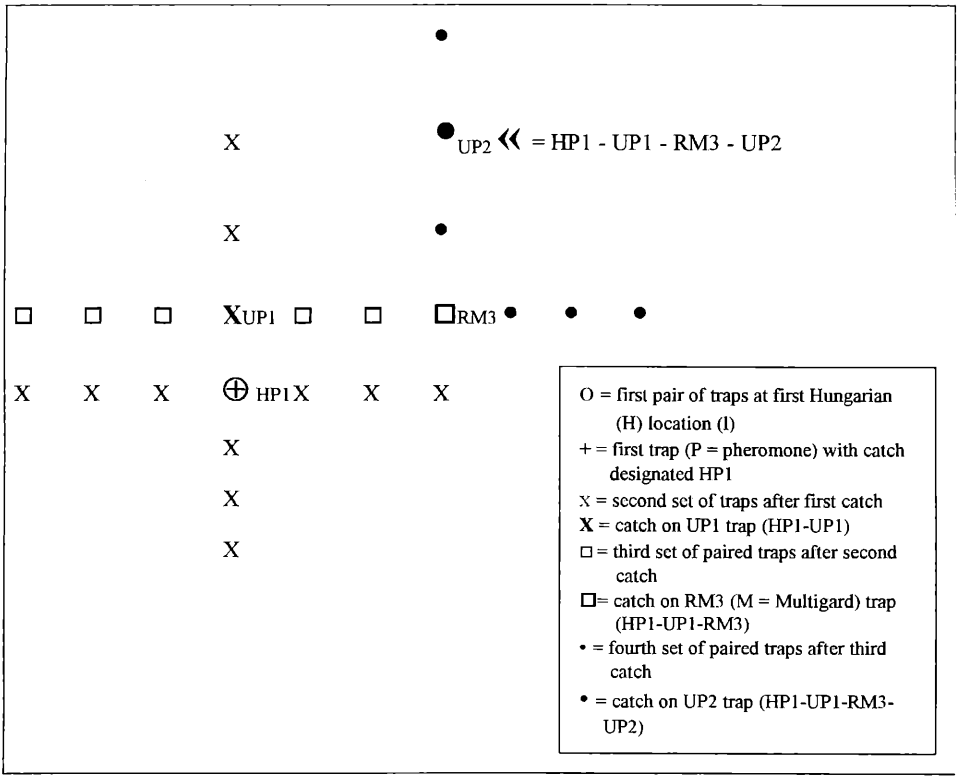

Fig. 2: Example of paired-trap (pheromone and Multigard®) arrangement in containment and control program, FAO TCP/RER/6712, Central Europe, 1997.

time using this trapping method. This management technique would have the greatest use in areas where the beetle is somewhat isolated, such as valleys, or where there are barriers to its movement, such as mountains. This management tool could be used in all participating countries, but would probably have the greatest application in the Croatian valleys leading to the western part of the country and the Cris, Maros, and Danube River valleys intersecting with the Carpathian mountains in Romania.

3) Slam-based areawide pest management program – Slam was received too late in the growing season (21 August) in 1997 to conduct the WCR areawide pest management study as originally planned. According to the areawide pest management concept, the idea was to initiate the program when economic populations of beetles were present, and before 10% of the females were gravid. Since this normally occurs in late July to early August, it was not possible to conduct the study as originally planned for 1997. Therefore, it was decided to conduct an abbreviated study to test application protocols and to obtain some preliminary data on efficacy of the product.

The study was conducted in 2 fields, 20 and 40 ha, in southern Hungary near Szeged and Csanadpalota, respectively. Before applying the Slam, the aircraft, a Cessna C-188, was modified based on the application protocol, and a trial application was made over water sensitive paper. This was done to determine spray pattern, droplets per cm², and droplet size in microns. The use of the Cessna allowed for USA application protocols to be used more easily. Also, the experience gained in the adaptation of this sprayplane was fully transferable to some other types of sprayplanes used in Central and Eastern Europe. The spray was applied at a rate of 9.7 l/ha, containing 420 g/ha Slam, and 0.1% by volume Windbrake® (Terra Corp., Sioux City, Iowa) drift retardant (used to improve deposition of spray on leaves). The final spray, when applied to the maize, registered approximately 1 droplet/ 5 cm^2.

WCR pre- and post-treatment counts on Hungarian pheromone and Multigard traps were taken according to the sampling protocol established for this activity. Approximately 1 day prior to and 8, 15, and 22 days following treatment, the traps were examined for beetles and the numbers recorded. Two fields, one within 1 km of each site was used as the untreated control.

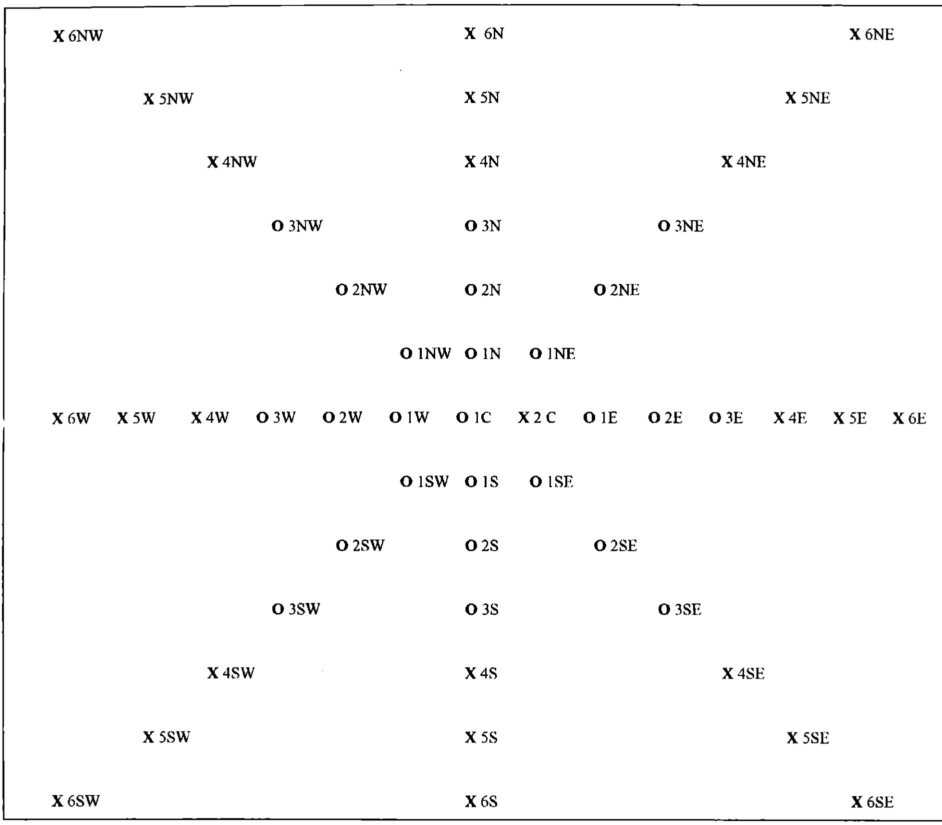

Fig. 3: Trap arrangement for Slam® – based areawide pest management program, FAO TCP/RER/6712, Central Europe, 1997. O = Pheromene trap; X = Multigard® yellow sticky trap; Number = Position of trap (from 1 to 6); Letter = Direction (N, NE, E, SE, S, SW, W, NW, C = Center).

Other activities

The risk assessment for potential spread and establishment of WCR in Europe was lead by the FAO Agromet Group in SDRN and AGLS. Their study was based on the following parameters: 1) WCR develops if April temperature exceeds 12.8 deg. C and average temperature for May, June, and July exceeds 17 deg. C; 2) diapausing WCR are assumed to be killed by temperatures below –10 deg. C; 3) WCR is assumed to prefer continental climates, Koeppen's D climate; 4) semi-arid and polar climate conditions, Koeppen's B and Koeppen's E climates, respectively, are deleterious to WCR; and 5) October temperatures above 12.8 deg. C are deemed to break diapause, resulting in death. Each parameter was evaluated as a single factor then combined with the other parameters, each carrying different weights based on their level of importance, to determine the overall effect.

As part of the TCP protocol, WCR educational materials were to be produced and/or assembled and distributed to the cooperating countries. This activity was the responsibility of the TCP Training Coordinator and was to be completed and the materials distributed by October 1997.

Results and Discussion

The detailed results of the first year of this study are either reported in individual papers/summaries submitted to *Pflanzenschutzberichte,* or in the Abstract Volume of *Western Corn Rootworm 97* published for the 2nd FAO WCR/TCP Meeting, EPPO Panel Discussion, and International IWGO Workshop held at Gödöllö University of Agricultural Sciences, Gödöllö, Hungary, 28–30 October 1997.

Field activities

A summary of the results for the various activities in 1997 are as follows:

1) Permanent monitoring network – In **Croatia,** the main flight of WCR beetles in 1997 occurred from 10 July to 20 September, with the first appearance on 4 July and the last on 3 October. A dense chain of traps was placed from the border with Yugoslavia toward the west. Additional traps were placed even further to the west along the road to Zagreb, as well as near the new WCR front line as new WCR trap catches were observed. Ten traps were designated as the permanent monitoring network traps. For all traps monitored in 1997, 3227 beetles were caught. Most were caught (2472) in Vukovarsko-Srijemska Zupanija. In the Vukovar region, an average of 13 beetles per trap was caught, while 6 per trap were caught in the Otok region. WCR trappings increased three fold from 1996 to 1997. WCR damaged roots, although not at economic levels, were noted in insecticide trials near Otok.

   In **Hungary** in 1997, the establishment of traps was based on "waiting" traps employing Hungarian pheromone traps and "linear" traps using the pheromone and Multigard traps. The waiting traps were established beyond the area of known infestation as part of a forecasting system. The linear traps were placed within and along the front line of the advancing WCR population and included the 47 permanent traps. WCR expanded 100–120 km from the southern border of the country through 1997. More than 3910 beetles were caught on the various traps. WCR was detected at 81, or 34%, of the 246 locations throughout Hungary. An average of 47 beetles were caught per trap countrywide.

   Of the traps in Csongrad, Bekes, Bacs, and Baranya Counties of the WCR infested area of southern Hungary, 92, 56, 65, and 76%, respectively, recorded catches. The traps in Csongrad County caught and average of 115 per trap. Of the three zones, 3864, 46, and 0 beetles were caught in the southern, middle, and northern zones. The permanent monitoring network traps caught and average of 9.3 beetles per trap, ranging from 1 to 67. These traps caught a total of 438 beetles. Within Hungary, about 10000 km^2 are infested with WCR. In the Szeged area, larval damage to roots was noted in 1997. This damage, however, was not at economic levels. While monitoring for beetles in 1997, WCR adults were observed on maize, sunflower, bean, soybean, alfalfa, squash, ragweed, and pigweed. Feeding damage, although not at economic levels, was noted on the first three.

WCR monitoring in **Romania** started on July 4, with 240 pheromone traps (both Romanian and Hungarian pheromone types) being placed in four districts (Arad, Timis, Caras-Severin, and Bihor, hereafter referred to as districts 1–4) of the western region. Starting in August, 316 Multigard traps were added to those of the expanded pheromone trapping network (355 pheromone traps), and four additional districts (Mehedinti, Alba, Hunedoara, and Dolj, hereafter referred to as districts 5–8) were included in the network. During the course of the trapping period, 39897 WCR beetles were trapped on pheromone (36161; or 91%) and Multigard traps (3736; or 9%).

In July, 2696 beetles were caught on the pheromone traps in districts 1–4. No Multigard traps were in place at this time, and no traps were in districts 5–8. The 296 pheromone traps monitored in August and 335 in September in districts 1–4 caught 15835 and 17494 beetles, respectively. During this same period, the 296 and 335 Multigard traps caught 2544 and 1192 beetles, respectively. In August, the first beetles were observed in Mehedinti, one of 5–8 districts. The 20 pheromone traps in this district caught 23 beetles. In September this increased to 113 beetles, but no beetles were caught on the other 39 pheromone traps in the other three districts of districts 5–8. The 20 Multigard traps, which were only placed in Mehedinti of districts 5–8 in August and September, did not catch any beetles.

In the permanent monitoring network, 27 Hungarian pheromone traps were included. The traps were placed in the following districts: Alba, Arad, Bihor, Caras-Severin, Hunedoara, Mehedinti, Timis, and Dolj. No beetles were captured on 10 of the traps. No captures were recorded in Alba, Bihor, Hunedoara, and Dolj districts, and 2 traps of 5 in Arad did not record captures. The highest average number of beetles caught per pheromone trap for a district over the trapping period July through September 15 was 880 in the Caras-Severin district. The pheromone trap at Naidas Vama caught the highest number overall for a single trap, 1681 beetles.

In **Bosnia-Herzegovina,** Hungarian pheromone traps were placed in the cantons (regions) of Tuzla-Posavina and Zenica-Doboj. WCR were caught only in the Tuzla-Posavina canton, which is the largest maize producing canton in Bosnia-Herzegovina. In this region, 59 traps caught approximately 300 beetles. Traps at two sites in this region, Dobo-Istok and Gracanica, did not record beetles. Also, beetles were not trapped in the Zenica-Doboj canton.

2) Trapping for containment and control program – In **Croatia,** all 5 site-traps recorded catches and additional traps were placed near the traps in the up, down, left, and right arrangement as originally agreed upon in Szeged. The Batrina, Pleternica, Kutjevo, Gornje Predrijevo, and Benicanci traps recorded catches of 1, 7, 2, 2, and 10 beetles, respectively. In 1998, Croatia intends to monitor traps at 4 of the 5 1997 trapping for containment and control sites.

In **Hungary,** 4 of 5 traps recorded catches. Additional traps were placed near those traps with positive catches in the up, down, left, and right arrangement. The original traps, H-1, H-2, H-3, and H-5 recorded catches of 78, 91, 234, and 52 beetles, respectively. Hungary will monitor traps at 4 of the 5 1997 trapping for containment and control sites in 1998.

The **Romanian** traps were located in the districts of Arad, Caras-Severin, and Mehedinti. All 4 traps recorded catches. Additional traps were placed near those traps with positive catches in the up, down, left, and right arrangement. The Arad, Caras-Severin, Mehedinti (Ostrovul Corbului area), and Mehedinti (Garla Mare area) traps recorded catches of 25, 5, 5, and 12 beetles, respectively. These same four sites will be used for the containment and control program in 1998.

3) Slam-based areawide pest management program – Since Slam was received too late in the growing season (21 August) in 1997 to conduct the areawide management study as originally planned, an abbreviated study to test application techniques and to obtain some preliminary data on efficacy of the product was conducted. WCR pre-treatment counts on Hungarian pheromone and Multigard traps at Szeged showed that 854 and 31 beetles were caught, respectively, on the two trap types. 8, 15, and 22 days following treatment, 1 and 1; 3 and 0; and 2 and 0 were caught on the two trap types, respectively, over the post-treatment time period. The untreated companion field was over 1 km from the treated field and was not as heavily infested as the Slam-treated field. Numbers of WCR beetles caught on traps in this field showed that numbers of beetles were the highest for the first 9 days (40 on 17 pheromone traps and 0 on 17 Multigard traps pre-treatment sampling date, and 30 on 17 pheromone traps and 1 on 17 Multigard traps 8 days post-treatment), but dropped off during the last two weeks (13 and 0, and 3 and 0 for the two trap types for the 15- and 22-day sampling periods).

Pre-treatment counts of WCR on pheromone and Multigard traps at Csanadpalota showed that 1822 and 88 beetles were caught, respectively, on the two trap types. 8, 15, and 22 days following treatment, 18 and 5; 6 and 1; and 0 and 1 were caught on the two trap types, respectively, over the post-treatment time period. As was observed at the other site, the untreated companion field was not as heavily infested as the treatment field. Numbers of WCR beetles caught on traps in this field showed that numbers of beetles only remained high for the first 9 days (116 on 9 pheromone traps and 0 on 9 Multigard traps pre-treatment sampling date, and 171 on 9 pheromone traps and 5 on 9 Multigard traps 8 days post-treatment), but dropped off during the last two weeks (17 and 0, and 5 and 1 for the two trap types for the 15 and 22-day sampling periods). From these data, it is apparent that Slam is highly efficacious against WCR beetles, and that under little to no rainfall the application should remain effective for 2 weeks.

Other activities

In the FAO Agromet Group risk assessment activity, a preliminary report was given to the coordinating committee based on Agromet's findings relative to the suitability for WCR establishment in Europe, and also for the USA, based on the parameters given in the "Methods" section. Overall, data output for several of the parameters was skewed slightly north of the actual WCR population in the USA (partially in the zone of the northern corn rootworm, *Diabrotica barberi* Smith & Lawrence). How this relates to what will actually happen in Europe is difficult to say. However, after further review by an expert on WCR population dynamics, W. D. Woodson, United States Department of Agriculture, Agriculture Research Service, Northern Grains Insect Research Laboratory, Brookings, South Dakota, it was determined that more relevant temperature parameters needed to be incorporated into the model so as to improve the predictions. Based on the inclusion of these new or updated temperature parameters, new maps were produced. Figure 4 shows one of the maps which indicates areas of potential spread and establishment of WCR in Europe based on suitability of climate.

As a part of the TCP activity, the Training Coordinator distributed to each country a folder containing slides, a picture sheet of the slides, and a computer disk with computer formatted pictures at the October 1997 meeting of the coordinating committee in Gödöllö, Hungary. These are to be used as the TCP member countries see fit.

Acknowledgments

We are grateful to FAO and its supporting countries for providing the funds that made this project possible. We also appreciate the hard work and dedication of all the plant protection personnel in all the countries who helped accomplish the tasks of the TCP. A special thanks

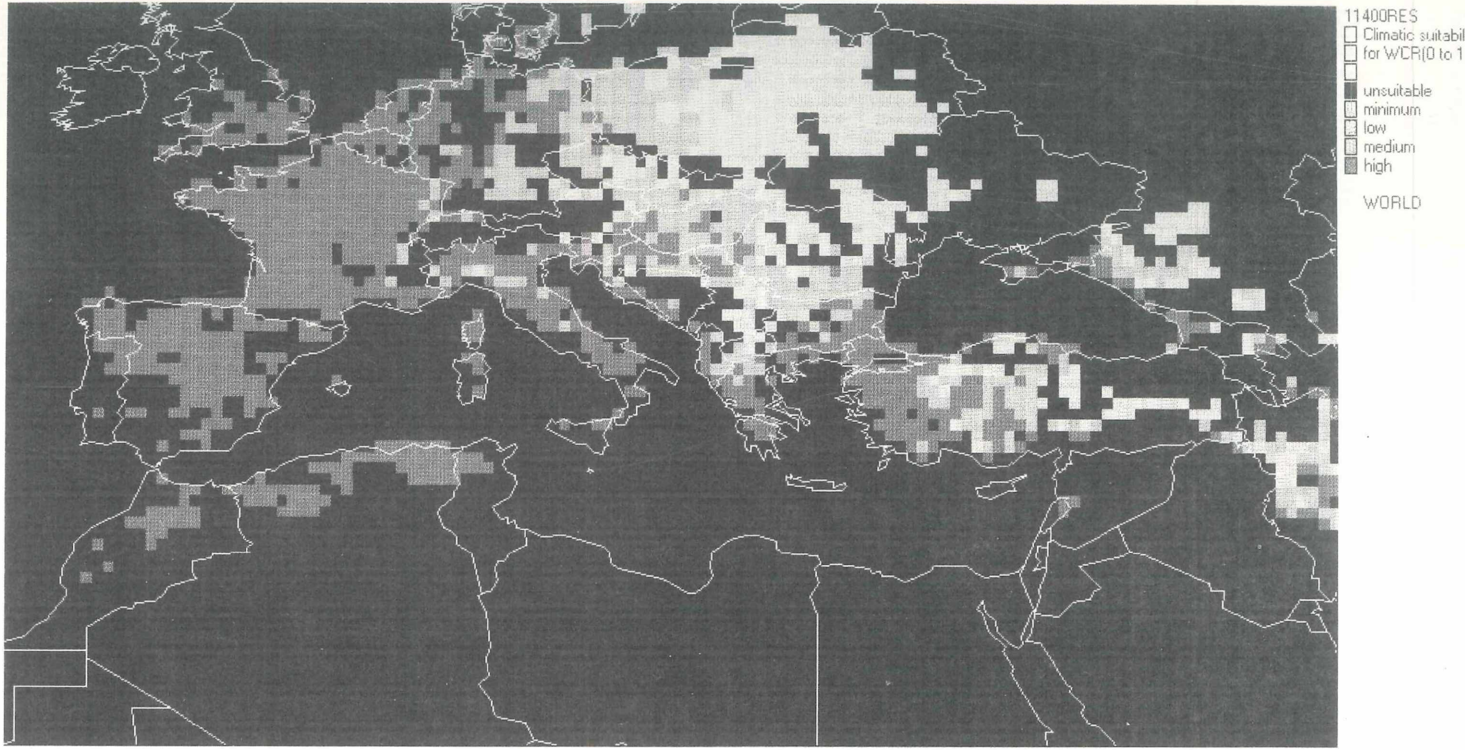

Fig. 4: Climatic suitability of areas in Europe for the establishment of the western corn rootworm, FAO TCP/RER/6712, 1997.

goes to the aerial application experts in Hungary who tested and carried out the application protocols for Slam. This is Purdue Agricultural Research Programs Paper No. 15694.

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(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Pflanzenschutzberichte
Band 57, Heft 2, 1998

Die Ergebnisse des Warndienstes bei *Diabrotica virgifera virgifera* LeConte (Cleoptera: Chrysomelidae) in Kroatien 1997

The results of monitoring *Diabrotica virgifera virgifera* LeConte (Cleoptera: Chrysomelidae) in Croatia in 1997

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Zusammenfassung

Der Western Corn Rootworm – WCR *Diabrotica virgifera virgifera* LeConte befiel Kroatien im Jahr 1995 und verbreitete sich bis 1997 über 100 km westlich der jugoslawischen Grenze. Der WCR wurde im Laufe des Jahres 1997 an 123 Standorten mit 650 Lockstoff- und Gelbfallen überwacht. Insgesamt wurden 3.906 Käfer gefangen, davon 97.6% mit Lockstoffallen.

Im Vergleich zu 1996 hat sich die Bevölkerungsdichte im Laufe des Jahres 1997 verdreifacht. In Kroatien läßt die Dichte von Osten nach Westen und von Süden nach Norden stark nach. In Tovarnik, das nahe der jugoslawischen Grenze liegt, wurde mit 13 Käfern pro Tag und Falle die höchste tägliche Dichte verzeichnet. Die Fangperiode erstreckt sich vom 4. Juli bis zum 3. Oktober. Trotz einiger Wurzelschäden wurden in Kroatien keine Ertragseinbußen verzeichnet.

Stichwörter: *Diabrotica virgifera virgifera,* Warndienst

Summary

The Western Corn Rootworm – WCR (*Diabrotica virgifera virgifera* LeConte) infested Croatia in 1995 and in 1997 spread about 100 km west of the Yugoslav border. By the use of 650 traps, the WCR was monitored during 1997 in 123 places. A total of 3906 beetles were caught, 97,6% by pheromone traps.

In comparison to 1996, the population density increased three times in 1997 The density decreased significantly from the east to the west and from the south to the north of Croatia. In Tovarnik, near the Yugoslav border, the maximal daily density was 13 beetles per trap, while the density during the whole period of appearance was 3.2 beetles per trap per day. The first beetle was caught on July 4th, and the last one on October 3rd. In spite of some damage to the roots, there were no yield losses recorded in Croatia.

Key words: *Diabrotica virgifera virgifera,* monitoring

A brief retrospect

We learned of the presence of the Western Corn Rootworm – WCR (*Diabrotica virgifera virgifera* LeConte) in Yugoslavia as late as 1994. Knowing about the potential danger of this pest, we informed Croatian agronomists about it in a review paper compiled from a number of American publications (Maceljski, Igirc Barcic, 1993). Subsequently, we compared biometeorological data on the acclimatisation and development of the WCR to the climatic data in

Croatia (MACELJSKI, IGRC BARCIC, 1994, 1995). We predicted that this insect would become established and propagate in Croatia (and in some other countries in Europe) very well, in fact, even better than in many infested parts of the U.S.A. We also calculated that the larvae would hatch between May 14th and June 15th, on the average May 29th–30th. These data are important for the control of the WCR.

Our prediction concerning the development of the WCR in Croatia and Europe was confirmed by BAUFELD ET AL., 1996, FURLAN, 1997 and REYNAUD, 1997 for Germany, Italy and France.

Recently (IGRC BARCIC, MACELJSKI, 1998), we have chosen five climatic criteria the fulfilment of which we consider necessary for the acclimatisation and development of the WCR and compared them to climatic data at four localities in Croatia. Four of the criteria are related to soil temperature (10 cm deep): (1) that it should never be lower than –10°C. (2) the April mean should be above 12.8°C; (3) the May/June mean should be above 17°C; (4) and (5) the October mean should be lower than 12.8°C. In addition, criteria (4) stated that the mean monthly air temperature in June, July and August should be above 17°C. This analysis confirmed the former prediction (MACELJSKI, IGRC BARCIC, 1994, 1995) that the WCR could develop strongly in the majority of the maize growing regions of Croatia although all the criteria were not fulfiled.

All these predictions for the establishment and strong development of the WCR in Europe are fully confirmed by the status of this pest in Europe: the only 0.06 km^2 of infested area in 1992 had become 100.000 km^2 by 1997.

Monitoring

Croatia started monitoring in 1995. American cucurbitacin (150) and yellow sticky traps (200) were used. Near the Yugoslav border and along the main roads, 70 monitors were set up. Only one beetle was caught by a cucurbitacin trap, 28 km away from the Yugoslav border. Knowing that these traps are arrestants rather than attractants, we assumed that the infested area was a lot larger. The large infested area in the following year confirmed this assumption. We are of the opinion that in 1995 a broad area between the Bosut and the Sava rivers, about 30 km from the Yugoslav border, was infested.

In 1996, 100 monitors were using 109 Hungarian pheromone traps, 50 Multigard traps and 68 cucurbitacin traps (ZLOF, 1996). During the monitoring, 788 beetles were caught. Together with beetles caught in some research in 1996 a total of 885 beetles were caught in Croatia. The pest spread 80 km from the border to the west and infested an area of about 6000 km^2.

In 1997 a dense chain of 34 monitors was organised along the borderline from which the WCR was spreading to the west. An additional 22 monitors were situated more westwardly, especially along the highway to Zagreb. As the infested area shifted to the west, 24 new monitors were placed near the new borderline. In the infested area, additional traps were placed by 43 monitors. Altogether 123 monitors were active in this year.

At least 10 monitors active in 1996 and 1997 will continue their activity in the next years. These monitors were placed in Nušar, Otok, Bošnjaci, Oprisavci, Dakovacki Selci, Pleternica, Gornji Bogicevci, Višnjica, Nemetin and Orahovica, but their number would probably be greater.

The map shows that the infested area extends now to about 100 km away from the Yugoslav border and amounts to about 9000 km^2. On the map the sites of all monitors, 10 permanent monitors and five rings are marked.

On July 13th 1997, one beetle was caught in Pleternica and an other one in Kutjevo. Both localities are about 40 km to the west of the borderline from the previous year. At these two localities, as later in Benicanci, Batrina and Gornje Predrijevo, rings around the active trap were established. In these rings 12 new traps were placed, three in each direction. After the first catch in one of these new traps, a new ring was established around this trap. Altogether in five rings 131 pherotraps together with 131 Multigard traps were placed. A total of 22 beetles was caught. These rings were agreed upon at the meeting of the FAO project in Vienna in order to try to slow down the spread to the west. As these rings are only useful before the mating process they should be placed as early as possible.

In the monitoring activities carried out in 1997, a total of 3227 beetles were caught. If we add to this number 22 beetles caught in the rings and 657 beetles caught in trials with various traps, in Croatia in 1997 a total of 3906 beetles were caught. Less than 2% were females. Altogether 123 monitors observed 400 pherotraps and 250 Multigard traps, not counting the traps used in trials.

During 1996 and 1997 some investigations on the attractiveness of various baits were carried out. The attractiveness of the pheromon trap was compared to the cucurbitacin trap, various yellow sticky traps and different traps consisting of 4-methoxycinnamaldehide (IGRC BARCIC, 1996; IGRC BARCIC, DOBRINCIC, 1997). Out of three trials with the pheromon trap, 84.5%, 93.8% and 97.2% of all the beetles were caught. With the Multigard trap 3.1%, 4.5% resp. 0 beetles were caught, and with the best MCA trap 4.1%, 1.5% resp. 2.1% of the beetles were attracted.

With the various traps used together during the monitoring in 1997, 97.6% of the beetles were caught in pheromon traps, 1.8% on Multigard and 0.6% in cucurbitacin traps.

We conclude that the share of the beetles caught in pheromon traps is negatively proportional to the population density.

The dynamics of the catch and density

The dynamics of the catch of the beetles during 1997 is shown in the graph. There was no maximum expressed. The main flight of the beetles occurred between July 10th and September 20th The first appearance was registered in July 4th and the last in October 3rd

As 32 monitors were placed in 1997 at the same localites as in 1996, it was possible to compare the beetle density for the two years. The increase factor varied from 0.7 to 20.0 but the average for the territory infested in 1996 was about 3.0. This means the population increased three times. The decrease in the density of the beetles is quite obvious from the east to the west and from the south to the north.

In the period of maximum appearance the catch in pherotraps in Tovarnik (Vukovar region) reached 13.0, in Vrbanja 10 and in Otok 7.6 beetles per trap per day. All of the three localities are in the southeast part of Croatia. In other regions the number of beetles rarely exceeded 2 beetles per trap per day. The average catch during the whole flight period was much smaller: during the period of 83 days in Tovarnik, the average was 3.2 beetles per trap per day.

In formerly occupied region of Baranya towards the border with Hungary, four monitors registered no beetles caught at all, while in the Hungary part of Baranya on the contrary many beetles were registered. This fact can only partly be explained by the natural barrier consisting of the 17.000 hectare of marshland, the national park called Kopacki rit.

Damage

In 1997, roots damaged by the WCR were registered at our insecticide trials in Otok where 4800 roots were examined. But the damage was small: evaluated on the 1 to 9 scale described by MUSICK and SUTTLE, 1972, the average damage on untreated plots was 3.04, while the maximum damage was 5.0. It should be noted that on the scale of 1 to 9, the marks 1–6 equal marks 1–3 on the 1 to 6 scale. Since the damage was low we will not, at the moment, report on the results of these trials. We can only state that in these conditions, 24 out of 25 treatments succeeded in decreasing the damage significantly.

No damage affecting the yield was registered either in this trial or anywhere else in Croatia. It is interesting to mention that during the search for the WCR, farmers in some regions found cobs heavily damaged by another insect: *Glischrophilus quadrisignatus* (Say). This insect does damage to the kernels on cobs. It can be identified by two dark red spots on each of its elitrae.

Programme for 1998

In 1998 we plan to continue intensive WCR monitoring along the borderline of the spread of the WCR and extensive monitoring along both sides of the borderline. Investigations on the biology and ecology of the WCR in Croatian conditions will be greatly expanded. We intend to continue trials with various traps, especially those attracting females. Trials with soil insecticides will be extended and trials against adults will be started. Big efforts will be made to educate farmers about the WCR and teach them how to recognise this insect and the damage it can do. The advantage of avoiding monoculture of maize will be strongly pointed out. Since in some infested regions more than 40% of the maize is grown in monoculture, it will be difficult to persuade the farmers to rotate maize unless they themselves experience the damage caused by the WCR. In cases where maize is still in monoculture, in the most infested regions the use of soil insecticides will be recommended.

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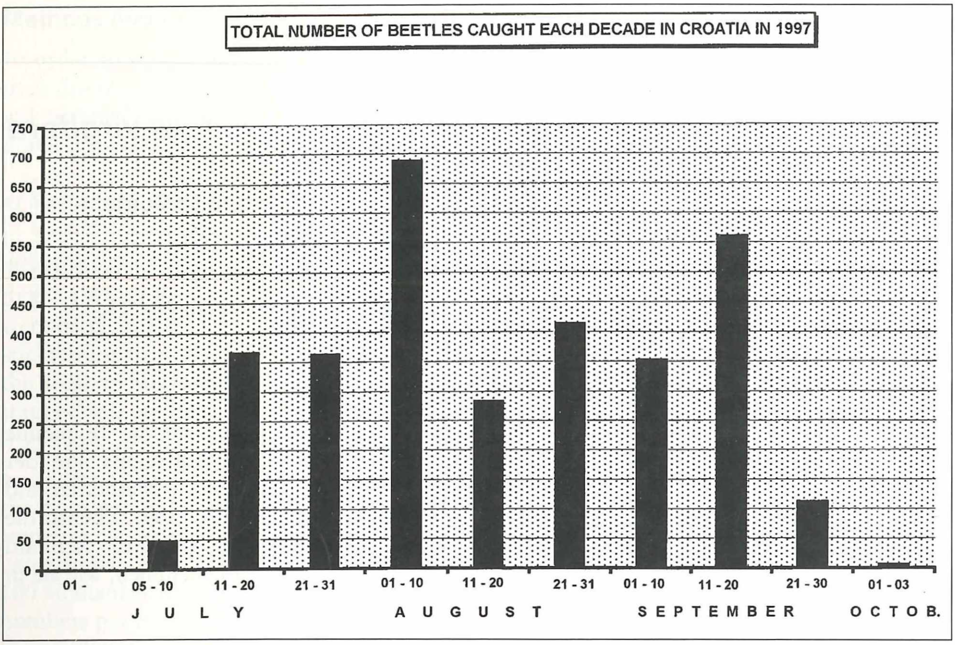
(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)


TOTAL NUMBER OF BEETLES CAUGHT EACH DECADE IN CROATIA IN 1997
750
700
650
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550
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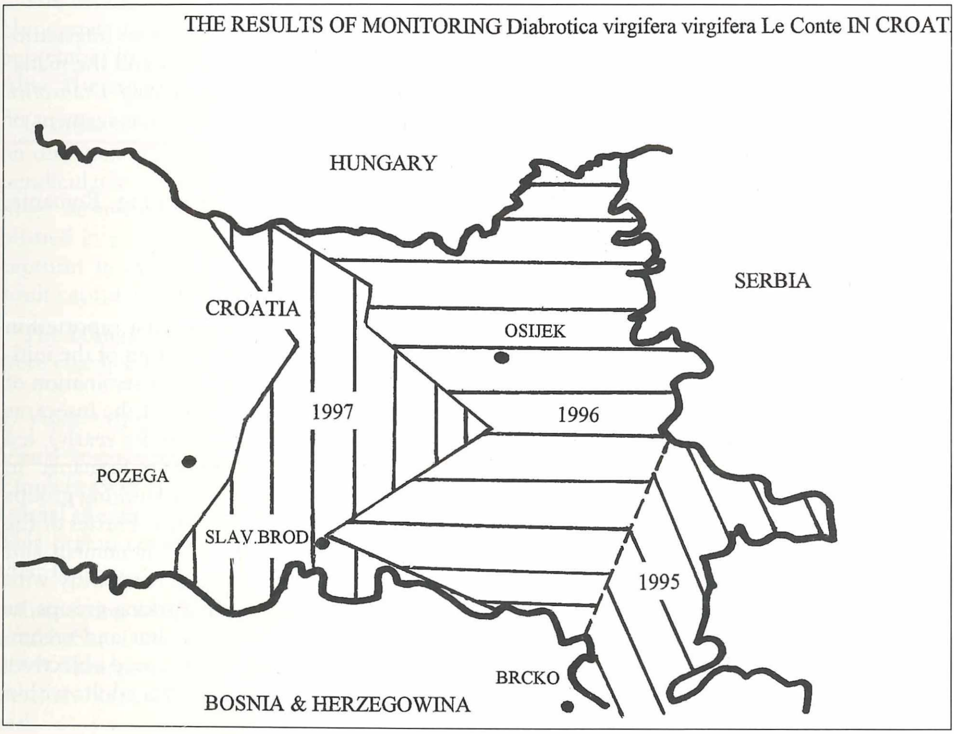
THE RESULTS OF MONITORING Diabrotica virgifera virgifera Le Conte IN CROAT
HUNGARY
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BOSNIA & HERZEGOWINA

Pflanzenschutzberichte
Band 57, Heft 2, 1998

Auftreten und Verbreitung von *Diabrotica virgifera virgifera* LeConte in Rumänien

The occurence and dissemination of *Diabrotica virgifera virgifera* LeConte populations in Romania

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Zusammenfassung

Der Beitrag beschäftigt sich mit den wichtigsten Maßnahmen in bezug auf die Teilnahme Rumäniens im Internationalen FAO Programm zur Vermeidung des Auftretens und der Verbreitung bzw. der Kontrolle von *Diabrotica* in Rumänien. Es werden die Methoden und Materialien vorgestellt, die für den *Diabrotica* – Warndienst verwendet wurden. Ebenso die Ergebnisse, die im Rahmen des *Diabrotica* – Warndienstes erzielt wurden, sein Auftreten und seine Verbreitung in Rumänien und die Ergebnisse von Bekämpfungsmaßnahmen, wie sie in Rumänien durchgeführt wurden.

Stichwörter: *Diabrotica virgifera virgifera* LeConte, Chrysomelidae, Warndienst, Rumänien, Western Corn Rootworm, Pheromonfallen, Mais, *Zea mays.*

Summary:

This paper summarizes the primary activities conducted by Romania as part of an international cooperative program on the prevention of the introduction/dissemination and the management of the pest *Diabrotica.* The methods and materials used for monitoring *Diabrotica* adults, as well as the results obtained on the occurrence, dissemination, and management of the pest's populations within the territory of Romania are presented.

Key words: *Diabrotica virgifera virgifera* LeConte, Chrysomelidae, Monitoring, Romania, Western Corn Rootworm, Pheromone traps, Maize, *Zea mays.*

Introduction

The attack of corn roots by *Diabrotica virgifera virgifera* LeConte larva was first reported in Europe in 1992 and occurred near the Belgrade, Yugoslavia airport. The location of the initial infestation is about 80 km from the western border of Romania. The rapid dissemination of adult *Diabrotica* throughout Serbia during the years following the first report of the insect, as well as the fact that Romania is a large producer of corn (more than 3 millions ha yearly), led to the inclusion of this pest in the "List of phytosanitary quarantine organisms of Romania" in January 1995. At the same time, Romania became a member of the *Diabrotica* working groups (IWGO – 1995 and EPPO – 1996), and since June 1997 she has been one of the Parties of the FAO Project TCP/RER/ 6712 (A) – Development and Implementation of Containment and Control of the Western Corn Rootworm in Europe. This project is conducted jointly with Bosnia-Herzegovina, Croatia, Hungary, and Yugoslavia. Meetings of these working groups, as well as the FAO Project, resulted in the establishment of joint action programs and recommendations for methods and materials to be used in order to achieve the proposed objectives of the studies and to report the first occurrence and dissemination of *Diabrotica* adults within the territories of the respective countries.

Methods and materials

In order to report the occurrence of the first *Diabrotica* adults, and afterwards to monitor their dissemination, in time and space, across Romanian territory, an adult monitoring method was established in 1995. Monitoring was accomplished by using different kinds of traps, visual inspection of corn plants, and inspection of transport means.

a) Monitoring using traps

In 1995 we used 120 "Cucurbitacin" bait type traps impregnated with carbaryl. In 1996, 30 "Cucurbitacin" traps and 80 Multigard yellow sticky traps furnished by Mr. Harald K. BERGER – IWGO President (International Working Group on *Ostrinia* and other Maize Pests) were used. In 1997 we received 1300 Hungarian pheromone traps and 1800 Multigard yellow sticky traps from the FAO Project for our use. Each year, a trap network was established in the areas within Romania most likely to be infested with *Diabrotica* adults. The area generally trapped was on the western side of the country, near the border with Yugoslavia and Hungary.

In 1997, the trap network was placed into operation on July 4th, with 240 Hungarian pheromone traps placed in 4 counties: Caras-Severin, Timis, Arad, and Bihor. The distance between the traps varied between 5 and 10 km, with the average distance being 7.5 km. Variations in trapping distances were based on land configuration and the location of the corn crops. In all cases, traps were placed within the corn crops, at corn cob height (1–1.5 m). At the same time, 100 Romanian pheromone traps were placed in corn fields within the same counties. Trap numbers per county were: Bihor (10), Arad (50), Timis (30) and Caras-Severin (10). Based on the results obtained during July and August, the trap network was extended in August and September in the counties where captures were reported (3) and into 4 neighboring counties, namely: Alba, Hunedoara, Mehedini, and Dolj.

The Multigard yellow sticky traps were set out on August 1, 1997 within 5–10 m from the Hungarian pheromone traps set up on July 4th, as well as from those added during August and September in order to extend the monitoring. Traps were not placed in the counties of Bihor, Alba, Hunedoara and Dolj, where no adult captures were observed.

In order to stop the dissemination of the adults, as well as to follow the adults' dissemination direction and speed, barrages of 3–4 Hungarian pheromones traps rows were placed perpendicularly in the valleys of the rivers Mures and Timis and on the left shore of the Danube River, at an interval 0.5–1 km. Three additional traps (up, down, left and right), were established in a crosswise pattern at intervals of 0.5–1 km immediately after the report of adult captures in marginal traps. This crosswise trap network was extended as more *Diabrotica* adult captures were reported.

The Hungarian pheromone traps were changed monthly, the Multigard yellow sticky traps were changed bimonthly, and the Romanian pheromone traps were not changed.

b) Visual inspection of corn crops and transportation means

Visual inspection of the corn crop grown throughout Romania was conducted in 1997 Emphasis was given to the most threatened south and southwestern areas of the country, with special attention provided during the flowering period of the corn plants (July 15th – August 15th). This period coincides with the greatest period of occurrence of Diabrotica adults and with their likely feeding on corn silk, where they can be easily counted.

Inspection of international transportation means that entered Romania from countries with established *Diabrotica* populations was conducted during the period from July to October 1997 Transports from Romanian areas infested with *Diabrotica* entering areas free from this pest, and especially those carrying corn plants for green forage or ensilage, were also inspected.

Results

The first *Diabrotica virgifera virgifera* adults (1 male and 2 females) were captured in Romania on July 15th, 1996 with a Multigard yellow sticky trap placed in a corn field near Nădlac in Arad county. This location is approximately 300 km from the Hungarian border.

In 1997 398 Hungarian pheromone traps and 359 Multigard yellow sticky traps were evaluated. From this initial number, 343 of both trap types were in the 4 counties (Arad, Timis, Caras-Severin and Mehedini) where adult captures were reported. A total of 39,897 adults (36,161 individuals in Hungarian pheromone traps and 3,736 on Multigard yellow sticky traps) were collected. In the counties of Bihor, Alba, Hunedoara and Dolj no *Diabrotica* were captured. (Table 1)

Table 1:

No.	County	Number of installed traps/Number of captures						Total captures	
		July		August		September			
		F	M	F	M	F	M	F	M
1	ARAD	104/313	-/-	125/1113	125/543	141/325	141/325	1751	605
2	TIMIS	90/1198	-/-	110/6627	115/792	124/5343	124/261	13168	1053
3	CARAS-SEVERIN	30/1185	-/-	45/8095	40/1209	54/11826	54/869	21106	2078
4	BIHOR	16/0	-/-	16/0	16/0	16/0	16/0	0	0
5	MEHEDINI	-/-	-/-	20/23	20/0	24/113	24/0	136	0
6	ALBA	-/-	-/-	10/0	-/-	10/0	-/-	0	-
7	HUNEDOARA	-/-	-/-	15/0	-/-	15/0	-/-	0	-
8	DOLJ	-/-	-/-	14/0	-/-	14/0	-/-		
	TOTAL	**240/2696**	**-/-**	**355/15858**	**316/2544**	**398/17607**	**359/1192**	**36161**	**3736**

Hungarian pheromone traps:

A comparison of the installed trap numbers per county, number of traps with reported captures, the average number of captured adults per installed trap and per installed trap with reported captures, in decreasing order of the total number of captured adults in per county, is presented in Table 2.

Out of the 343 Hungarian pheromone traps placed in the 4 counties where *Diabrotica* adults were captured, adults were reported in 200 traps (58% of those installed) (Table 2). The highest percent (78%) of traps collecting adults was recorded in Caras-Severin County, while the lowest rate (42%) was recorded in Mehedini County. The average number of captured adults/trap from the 343 installed traps was 105.4 (the highest average number of adults collected/trap was 390.8 in Caras-Severin County and the lowest average number of adults collected/trap was 5.6 in Mehedini County). The average number of adults captured from traps that collected beetles (200 traps) was 180.8 (the highest average number of adults collected/trap was 502.5 in Caras-Severin County and the lowest average number of adults collected/trap was 13.6 in Mehedini County).

In Table 3 it can be seen that the highest absolute number of adults captured from a single Hungarian pheromone trap during 1997 was 1,681 in Caras-Severin County (Naidas customs). Highest absolute numbers collected in other counties included 538 in Timis County

Table 2:

No.	County	Number of traps				Average number of captured adults	
		Installed	With captures		Total	By installed trap	By trap with captures
			No.	%			
1	Caras-Severin	54	42	78	21106	390.8	502.5
2	Timis	124	76	61	13168	106.2	173.3
3	Arad	141	72	51	1751	12.4	243.2
4	Mehedini	24	10	42	136	5.6	13.6
	Total/Average	343	200	58	36161	105.4	180.8

(Deta Puiu), 486 in Arad county (Nădlac customs), and 9 in Mehedini County (Ostrovul Corbului).

Multigard yellow sticky traps:

Multigard traps (Table 1) placed in the counties of Arad, Timis and Caras-Severin in August (280) and September (319) captured a total number of 3,736 *Diabrotica* adults (2,544 in August and 1,192 in September) compared to 36,025 adults with similar numbers of Hungarian pheromone traps. Of this total, 2,078 were captured in Caras-Severin, 1,053 in Timis, and 605 in Arad. The details are presented in Tables 1 and 2.

Romanian pheromones traps:

A total of 90 traps captured western corn rootworm adults. These traps were installed in July in 3 counties, and collected 1,845 adults. A total of 610 adults were collected in 10 traps in Caras-Severin, 728 in 30 traps in Timis County, and 507 in 50 traps in the Arad County. An average of 61.0, 24.6, and 10.1 *Diabrotica* adults, respectively, were collected per installed trap per county.

Direction and speed of *Diabrotica* adult dissemination in Romania during 1997:

The dynamics of the occurrence/dissemination of *Diabrotica* adults, in time and space, from west to east in Romania, can be best observed on map 1. Three lines delimit the infested areas: line 1 for July, line 2 for August, and line 3 for September. Line 4 delimits the 8 western counties of Romania that were monitored in 1997.

In map 2 an example of a system of additional traps placed crosswise around a terminal trap is presented. This location is in the Mures Valley where the deepest adult penetration occurred during 1997. In July adults were captured as far as Arad-Fîntînele. In August and September adults were collected as far as Ususau. These two localities are located 65 and 125 km, respectively, from Nădlac on the Hungarian border.

Observations, in time and space, of Diabrotica adults population dynamics (organized in 1997 through a 27 Hungarian pheromone fixed trap network integrated in the FAO/WCR/TCP permanent monitoring network) is presented on map 3. Number of captures in the network is presented in table 3. During the coming years, this permanent trap network shall be extended, depending of the evolution of *Diabrotica* populations within the territory of Romania.

Findings

I. The first *Diabrotica* adults (1 male and 2 females) were captured in Romania on July 15th, 1996 by a Multigard yellow sticky trap placed in a corn field located near Nădlac in Arad County. This location is 300 m from the Hungarian border. During 1996 there were no additional reports of *Diabrotica* adults captured within the territory of Romania.

II. In 1997, the mass appearance of Diabrotica adults occurred in 3 counties situated in the western portion of Romania which adjoins Yugoslavia and Hungary. The counties were: Caras-Severin, Timis and Arad. Sporadic collections occurred in Mehedini County which is adjacent to Yugoslavia and is northwest of Bulgaria. This phenomenon was due to the pressure exercised by *Diabrotica* populations from Yugoslavia and Hungary. It is not out of question that the possibility of some undiscovered *Diabrotica* hotbeds exist in the western border area of Romania.

III. Stopping the dissemination of *Diabrotica* populations by barrages of traps, including crosswise placed additional traps, inclusively on the Mures, Danube and other rivers valleys, did not have satisfactory results. In this respect, the dissemination of *Diabrotica* adults was most intense in Caras-Severin County, followed by Timis and Arad. This was especially true in the valleys of streams. For instance, in Arad County in the Mures Valley, *Diabrotica* adults covered about 65 km in July (from Nădlac to Fîntînele, a locality situated 10 km east of the city of Arad), and in August and September reached Ususau. Ususau is about 60 km east of Fîntînele and about 125 km from Nădlac. This represents the deepest penetration of the pest into the territory of Romania. The adults also infested over 100 km of the Romanian shore of the Danube River, extending as far as Gîrla Mare in Mehedini County. The mountain area which follows the Danube for over 80 km between Yugoslavia and Romania (Caras-Severin and Mehedini counties) seems to have offered no large obstacle for *Diabrotica* adult movement.

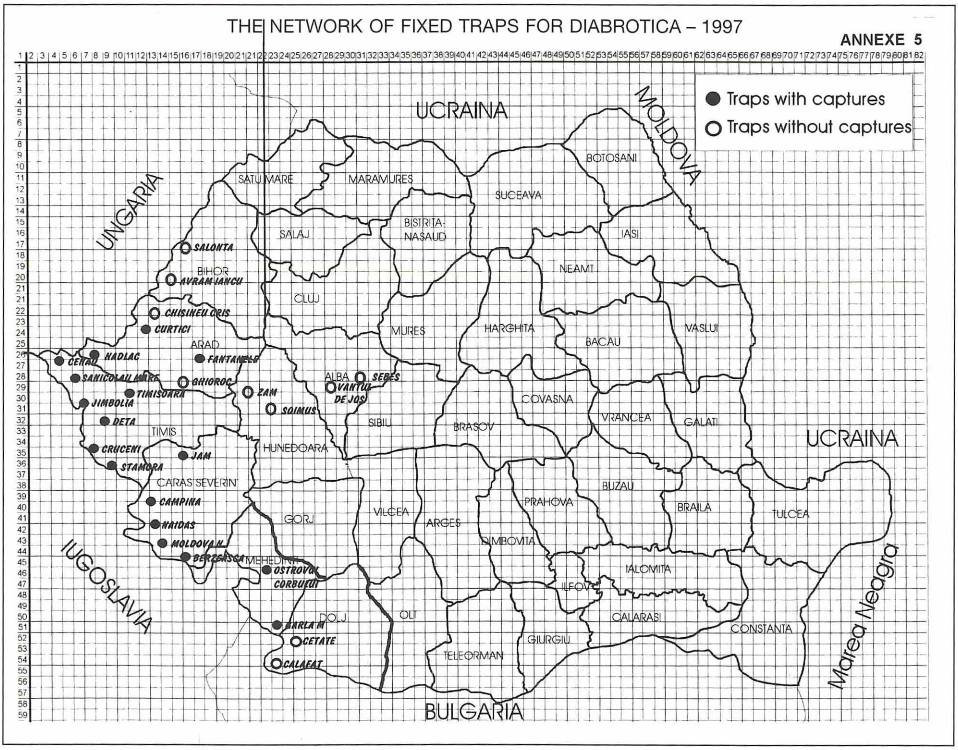
IV. From all the types of traps used, the best results were obtained with Hungarian pheromone and Romanian pheromone traps. Both types had a comparable trapping efficiency. The number of *Diabrotica* adults captured with Multigard yellow sticky traps was 9 times lower than that of the pheromone traps.

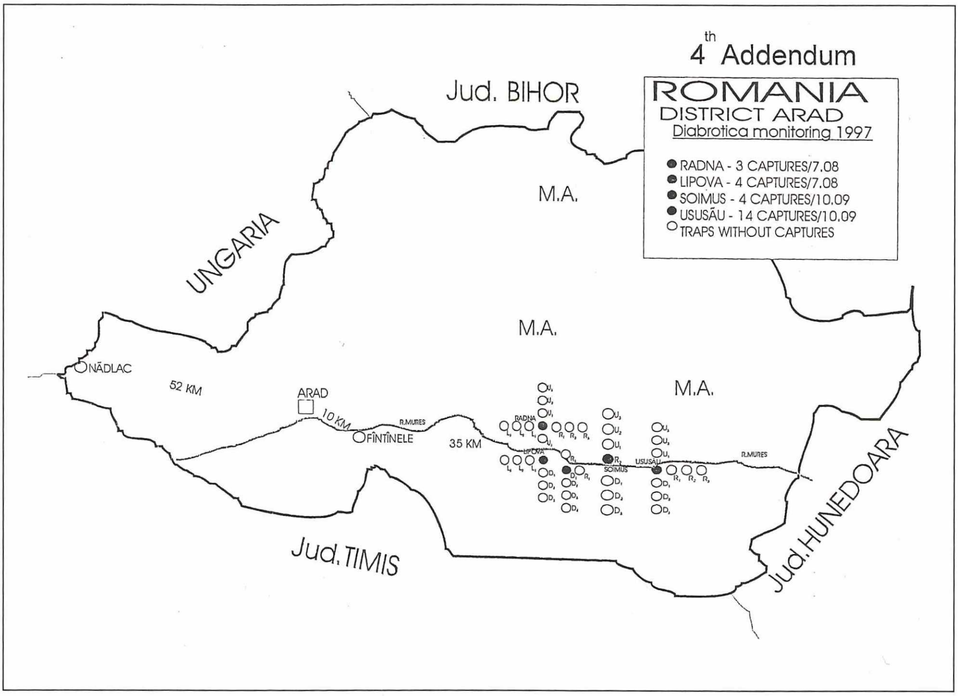
V. In 1998 monitoring of *Diabrotica* adults will be carried out according to the FAO/WCR/TCP Project provisions. Monitoring will be extended in the 8 counties monitored in 1997, and into 3 additional counties (Satu Mare, Gorj, and Olt), potentially threatened by the penetration and dissemination of *Diabrotica*.

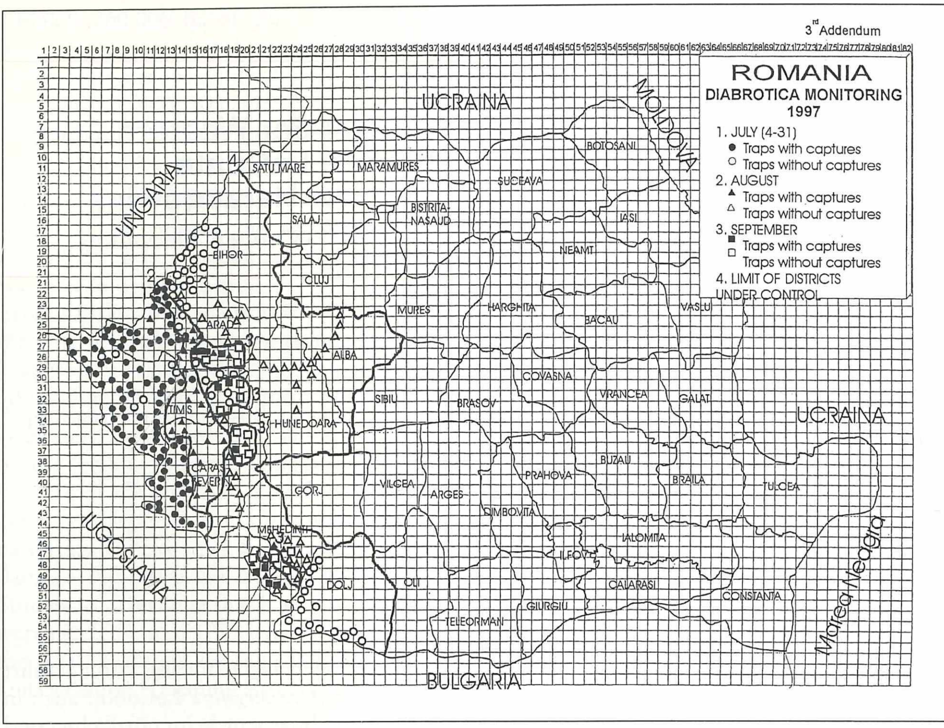
Tabel 3:

THE NETWORK OF FIXED TRAPS FOR *DIABROTICA* – 1997

No.	DISTRICT	LOCALITY	NO. CAPTURES
	ALBA		
1.		1. VANTUL DE JOS	0
2.		2. SEBES	0
	ARAD		
3.		1. NĂDLAC VAMA	486
4.		2. FÎNTÎNELE	17
5.		3. CURTICI	5
6.		4. GHIOROC	0
7.		5. CHIŞINEU CRIŞ	0
	BIHOR		
8.		1. SALONTA	0
9.		2. AVRAM IANCU	0
	CARAS SEVERIN		
10.		1. IARU	783
11.		2. NAIDAS VAMA	1681
12.		3. CAMPINA	948
13.		4. MOLDOVA NOUA	568
14.		5. BERZEASCA	420
	HUNEDOARA		
15.		1. SOIMUS	0
16.		2. ZAM	0
	MEHEDINTI		
17.		1. OSTROVUL CORBULUI	9
18.		2. GÎRLA MARE	3
	TIMIS		
19.		1. CENAD	7
20.		2. SÎNNICOLAU M.	39
21.		3. JIMBOLIA	55
22.		4. STAMORA MORAVITA	170
23.		5. CRUCENI	232
24.		6. DETA PUIU	538
25.		7. TIMIŞOARA	39
	DOLJ		
26.		1. CETATE	0
27.		2. CALAFAT	0


THE NETWORK OF FIXED TRAPS FOR DIABROTICA - 1997
ANNEXE 5
Traps with captures
Traps without captures
UCRAINA
MOLDOVA
UNGARIA
IUGOSLAVIA
BULGARIA
Marea Neagra
SATU MARE
MARAMURES
BOTOSANI
SUCEAVA
BISTRITA-NASAUD
SALAJ
IASI
BIHOR
NEAMT
CLUJ
MURES
HARGHITA
BACAU
VASLUI
ARAD
ALBA
SIBIU
BRASOV
COVASNA
VRANCEA
GALATI
TIMIS
HUNEDOARA
CARAS SEVERIN
BUZAU
PRAHOVA
BRAILA
TULCEA
GORJ
VILCEA
ARGES
DIMBOVITA
MEHEDINTI
IALOMITA
ILFOV
DOLJ
OLT
CALARASI
CONSTANTA
GIURGIU
TELEORMAN
SALONTA
AVRAM IANCU
CHISINEU CRIS
CURTICI
NADLAC
CENAD
FANTANELE
SANICOLAU MARE
GHIOROC
TIMISOARA
ZAM
SEBES
VANTUL DE JOS
JIMBOLIA
SOIMUS
DETA
CRUCENI
JAM
STAMORA
CAMPINA
NAIDAS
MOLDOVA N.
BERZEASCA
OSTROVUL CORBULUI
BARLA M
CETATE
CALAFAT


4th Addendum
ROMANIA
DISTRICT ARAD
Diabrotica monitoring 1997
RADNA - 3 CAPTURES/7.08
LIPOVA - 4 CAPTURES/7.08
SOIMUS - 4 CAPTURES/10.09
USUSĂU - 14 CAPTURES/10.09
TRAPS WITHOUT CAPTURES
Jud. BIHOR
UNGARIA
M.A.
M.A.
M.A.
NĂDLAC
52 KM
ARAD
10 KM
FÎNTÎNELE
R.MURES
35 KM
RADNA
LIPOVA
SOIMUS
USUSĂU
R.MURES
Jud. TIMIS
Jud. HUNEDOARA



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(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Pflanzenschutzberichte
Band 57, Heft 2, 1998

Die Ergebnisse des Warndienstes beim der Western Corn Rootworm *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae) in Bosnien-Herzegowina

The results of monitoring *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae) in Bosnia and Herzegovina in 1997

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Zusammenfassung

Auf Grund von Untersuchungen, die im Jahre 1997 in Bosnien-Herzegowina durchgeführt wurden, wurde der Western Corn Rootworm (*Diabrotica virgifera virgifera* LeConte) auch in Bosnien-Herzegowina nachgewiesen. Das Auftreten des Schädlings wurde im nördlichen und nordöstlichen Teil Bosnien-Herzegowinas nachgewiesen. Das erstmalige Auftreten kann nicht genau festgelegt werden, es ist aber anzunehmen, daß der Schädling 1995 von der Region Bijeljina nach dem Westen vorgedrungen ist. Der Schädling breitet sich sehr rasch aus, und sollten keine effektiven Maßnahmen zu seiner Bekämpfung getroffen werden, ist innerhalb weniger Jahre mit einer Verbreitung in ganz Bosnien-Herzegowina zu rechnen.

Stichwörter: *Diabrotica virgifera virgifera,* Western Corn Rootworm, Warndienst, Bosnien-Herzegowina

Abstract

Based on monitoring conducted in 1997, the occurrence of western corn rootworm, *Diabrotica virgifera virgifera* LeConte, in Bosnia and Herzegovina was first documented. The pest is distributed throughout the northeastern and northern parts of the country. An accurate estimate of the first time the pest entered the country is not known, but it is assumed that it appeared in 1995 in the area of Bijeljina from where it has spread towards the western part of Bosnia and Herzegovina. Currently the pest is spreading rapidly, and if effective measures for eradication are not taken within a short time period it will have spread throughout all of Bosnia and Herzegovina.

Keys Words: *Diabrotica virgifera virgifera,* Western Corn Rootworm, Monitoring, Bosnia-Herzegovina

Introduction

Corn (*Zea mays* L.) is an important crop in Bosnia and Herzegovina. It ranks first in number of planted hectares among all cereal crops. Since 1990 it is estimated that from

140.000–260.000 ha of corn is grown yearly throughout Bosnia and Herzegovina. In the mountainous areas of the country FAO corn maturity groups 200, 300 and 400 are primarily grown for grain, while the 400–600 maturity group is used for silage. The hybrids of FAO maturity groups 400, 500 and 600 are primarily grown in the plains area. Various varieties of domestic corn with white and/or yellow kernels and a small cob are grown to a lesser extent and are used in different processing forms.

In Bosnia and Herzegovina corn is attacked by many different pests. Recently a very dangerous pest, the western corn rootworm (*Diabrotica virgifera virgifera* LeConte), has been observed inflicting serious damage to corn throughout northern portions of the country. This pest was first noticed in Europe in 1993 near the Surcin airport which is located close to Belgrade. From this location the pest has spread concentrically within a short time through Serbia and into the neighboring countries of Bosnia and Herzegovina, Croatia, Hungary and Romania. This pest causes significant feeding damage to corn during the larval stage and periodically as adults. Larvae feeding on roots significantly reduce the yield and the profitability of the crop.

Western corn rootworm larvae develop in the soil and feed on and damage corn roots. Severe feeding causes lodging of corn stalks. Beetles (imagos) damage corn by feeding on leaves, tassel, silk and cob. This damage can also be significant. The area of infestation expands every year depending on dissemination intensity. Surveys conducted in Bosnia and Herzegovina during 1997 did not find any lodged corn plants. However, this does not mean that severe damage will not occur in the future with an increase in the number of rootworms present. Studies to determine the dissemination of western corn rootworm in Bosnia and Herzegovina were carried out in 1997 within the Federation at the boundary with the Republic of Srpska in the Tuzla-Podrinje canton and at the boundary of the Republic of Croatia in the Zenica-Doboj canton. Trapping also occurred at locations within these cantons away from the borders.

Material and Methods

Studies to determine the occurrence and spread of western corn rootworm throughout Bosnia and Herzegovina were conducted during the growing season of 1997. These studies were not initiated earlier due to known wartime circumstances occurring over the past 4–5 years. Surveys were made in Tuzla-Posavina and Zenica-Doboj cantons on the boundaries with the Republic of Srpska, the Republic of Croatia, respectively. In the locations where studies on pest dissemination were made 33.000 ha of corn were grown in 1997. Corn rootworm monitoring was initiated in early July with Hungarian pheromone traps which were provided by FAO via Budapest. Pheromone traps were placed at defined distances from the edge of each field. Male corn rootworm adults, which are easily differentiated from females by the use of several morphological characteristics, were mainly caught in the pheromone traps. At locations where pest populations were severe, there were even females on pheromone traps. Traps were collected during fixed portions of the day when nice weather occurred. Within the Tuzla-Podrinje canton the pheromone traps were set at the following places: Celic, Gornji Rahic, Brka, Srebrenik, Orasje, Gradacac, Doboj-Istok and Gracanica. In the Zenica-Doboj canton the pheromone traps were set at the following places: Maglaj, Zavidovici and Tesanj. During pheromone trap monitoring, data were also collected on hybrids and domestic variants of corn, soil constituents, one-crop seeding and manure and mineral fertilizer use.

Results and Discussion

In the Tuzla-Podrinje canton corn rootworms of different population intensities were observed at each trapping location. In the Celic area, 10 pheromone traps were set up near Celic and Pukis. All traps were set up on individual producer fields. The first corn rootworm adult was found on August 12th. Monitoring continued until September 20th. On September 2nd the pheromone traps were moved to neighbouring plants. Out of the 10 traps, adult rootworms were caught in 7. The largest number of pests caught per trap was 10 which occurred in two fields. Total number of adults caught was 36, all of which were males. The last catch of an imago took place on September 30rd.

Seven pheromone traps were set up in the Gornji Rahic area. Trap were monitored daily. Male imagos were caught on 2 traps. No imagos were caught on the remaining 5 traps.

In the Brčka area 6 pheromone traps were set up in government owned fields. Monitoring was performed every three days. The first adult rootworm was collected on August 15th. Imagos were caught in all traps. The largest number of adult rootworms caught on one pheromone trap was 163. This trap was located in a 50 ha field where corn had not been grown in 1996. All imagos caught were males. The last adult catch occurred on September 14th.

In the Brčko-Ravne municipality 7 pheromone traps were established at the following places: Seonjaci, Skakava and Poljaci. A total number of 30 male beetles were caught in 6 of the 7 traps. The last imago was caught on September 3rd. 5 pheromone traps were set up in Srebrenik, 3 were set up in the Spionica area, and 2 in Sladina. Corn rootworms were found in only one location. In the Orasje municipality 2 pheromone traps were established. A total of 67 males were caught. The last imago was caught on September 9th. Within the Gradacac municipality a total of 10 traps were set up; 5 each in Ledenice and Okanovici. One imago was found at a single trap site. In the Doboj-Istok municipality 6 pheromone traps were established; 3 each in Klokotnica and Velika Brijesnica. No corn rootworms were caught. 6 pheromone traps were established in the Gracanica municipality. No trap was found to contain an imago corn rootworm.

In the Tesanj municipality, which is located in the Zenica-Doboj canton, pheromone traps were set up at the following localities: Radusa, Kalosevic, Miljanovci Stari, Miljanovci, Jelah, Matuzici, Silje and Tesanjka. Pheromone traps were also set up at the following places in the Maglaj municipality: Bijela Ploca, Donja Bocina, Kosova, Mosevci and Lijesanica; and at Vozuca and Misaradija-Vozuca in the Zavidovici municipality. No corn rootworms were detected at any location.

It is evident from the above data that western corn rootworm occurs in only in the Tuzla-Podrinje canton of Bosnia and Herzegovina. This canton is one of the greatest corn production areas in Bosnia and Herzegovina, with 25.000–30.000 ha of corn planted every year. Infestation in this canton occurs in areas along the border of the Republic of Srpska and along the Sava river northward towards the Republic of Croatia. The pest has invaded this area from the eastern part of the country which is located closest to Serbia where the pest was initially established. Less movement of the pest into the northern part of Bosnia and Herzegovina was observed although Croatia, where the pest is also expanding its range, is on the northern border.

In the years to come it is expected that the range of western corn rootworm will expand out towards western and southern parts of Bosnia and Herzegovina. Faster spreading will occur in northern and central parts of our country since larger areas of corn are cultivated in these regions.

Individual producers usually produce corn as the only crop (no crop rotations); this phenomena will facilitate faster range expansion of this dangerous pest. Based on annual observations it was noted that there was a difference in rootworm susceptibility between hybrids and domestic variants of corn to which attention will be paid in the future.

Conclusion

Monitoring the occurrence and dissemination of corn rootworms in Bosnia and Herzegovina commenced in 1997. Studies were established only in the Federation of Bosnia and Herzegovina. Based on experiments conducted with pheromone traps produced in Hungary it was found that the western corn rootworm occurs only in some municipalities in the eastern part of Bosnia and Herzegovina. Based on trap catches it can be concluded that this pest does not yet occur with severe intensity. Substantial numbers of rootworm adults were collected in corn fields around Brčko. This is understandable since the pest is spreading from Bijeljina, where according to some available information, the corn rootworm has become more numerous. Spreading out of the pest from Brcko towards Gradacac was also noticed. Gradacac grows large amounts of corn every year. In the Republic of Croatia the pest is spreading quite rapidly and now has covered large areas in Slavonia. Based on this fact the occurrence of corn rootworms can be expected in the areas of Banja Luka, Bosanska Dubica, Bosanska Gradiska and Prijedor during 1998.

Summary

Corn is an important crop in Bosnia and Herzegovina. Each year it is grown on 140.000–260.000 ha. Various hybrids, primarily from FAO hybrid groups of various maturity lengths, are planted. Corn yields, considering all the various conditions, have been satisfactory.

It is known that the corn pest *Diabotica virgifera virgifera* LeConte was first observed in 1993 in Serbia. The pest was concentrically distributed from the place of origin and eventually spread to Bosnia and Herzegovina. The exact time of infestation of the pest into our country could not be determined because of wartime circumstances. We confirmed its existence in 1997 However, based on the extent of the infestation within the country, the pest certainly infested corn in Bosnia and Herzegovina much earlier than previously thought. At present, the pest has been found to exist in the eastern and northern parts of our country, which makes sense when we consider the severe infestation occurring in Serbia and Croatia. The spread of the pest is expected to be even more severe in 1998, especially in northern parts of the country where corn is widely present. It appears that the occurence of corn rootworm depends on the size of the corn production areas. The spread of the pest will be monitored in future years and appropriate management measures will be taken against it.

Distribution of *Diabrotica virgifera virgifera* in die Federation of Bosnia & Herzegovina, 1998

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(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Pflanzenschutzberichte
Band 57, Heft 2, 1998

Verteilung und Populationsdynamik von *Diabrotica virgifera virgifera* LeConte (*Coleoptera: Chrysomelidae*) in den südlichen Backa, (Serbien, Jugoslawien) 1997

Distribution and population dynamics of *Diabrotica virgifera virgifera* LeConte (*Coleoptera: Chrysomelidae*) in southern Backa (Serbia, Yugoslavia) in 1997

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Zusammenfassung:

Die Flugüberwachung von *Diabrotica virgifera virgifera* mit diversen Fallentypen in der südlichen Backa (mittlerer Teil des nördlichen Jugoslawiens) ergab folgende Ergebnisse:

Die Verbreitung des Western Corn Rootworm (WCR) und die Populationsdichte des Schädlings nahmen weiter zu, allerdings waren große Unterschiede zwischen dem östlichen und westlichen Teil der Backa zu beobachten. Visuelle Untersuchungen ergaben einen 100%igen Befall der Felder und einen 41%igen Befall der Pflanzen im östlichen Landesteil. Im Westen waren 34% der Felder befallen und 2% der Pflanzen. Lagerung der Pflanzen (8,7%) wurde nur im östlichen Teil angetroffen.

Eine Untersuchung mittels Fallen zeigte, daß im östlichen Teil alle Felder befallen waren und eine wesentliche höhere Populationsdichte aufwiesen als im westlichen. Für das Auffinden von Käfern waren Pheromonfallen wesentlich wirkungsvoller als Gelbfallen.

Die Populationsdynamik des adulten WCR zeigte zwei Flughöhepunkte, einen ersten, höheren am 24. Juli und einen zweiten am 13. August. Zur Bestimmung der Populationsdynamik erwiesen sich Gelbfallen wirkungsvoller als Pheromon- und Cucurbitacin-Fallen.

Im Jahre 1998 ist mit einem weiteren Ansteigen der Population von WCR zu rechnen. In Abhängigkeit von der Witterung ist daher auch mit einem Anstieg der Larvenschäden vor allem in Maismonokulturen (im privaten Sektor) im Ostteil der Backa zu rechnen.

Stichwörter: *Diabrotica virgifera virgifera* LeConte, Mais, Populationsdynamik, südliche Backa (Jugoslawien)

Summary

The monitoring of the occurrence of *Diabrotica virgifera virgifera* LeConte in the southern Backa region (the central part of northern Yugoslavia) in 1997 gave the following results:

The geographic distribution and population density of the Western corn rootworm (WCR) was found to have continued increasing. As in the year before, however, there was a large difference between the eastern and western parts of the region in question. In the eastern part, using the visual evaluation method, WCR adults were found in all of the surveyed fields and on 41% of the plants, whereas in the western part they were present in 34% of the fields and on 2% of the plants. Plant lodging caused by WCR larvae was recorded only in the eastern part (8.7%).

When sampling was done using traps, however, the beetles were found in all the surveyed fields (5 in the west and 7 in the east), but population density in the eastern part was significantly greater. Pheromone trap proved more effective than the yellow sticky ones, especially for WCR detection in the western part.

In the focus of the epidemic (the Temerin area), the WCR flight dynamics had two peaks: July 24th and August 13th. The total WCR imago catch was the largest with yellow trap, followed by pheromone and then cucurbitacin ones.

In 1998, a further increase in *Diabrotica virgifera virgifera* population density is expected. Also, depending on the weather conditions, an increase in damage caused by the insect's larvae can be expected for continuous maize (mostly in the private sector) in the eastern part of southern Backa.

Key words: *Diabrotica virgifera virgifera* LeConte, maize, distribution, population dynamics, southern Backa (Yu).

Introduction

The Western corn rootworm (WCR) first appeared in Yugoslavia in 1992, in the vicinity of Belgrade airport. During the next several years, it spread through the northern plains, the main maize-growing region of the country. In 1996, using a network comprised of a total of 160 pheromone traps, it was found out that WCR adults already occupied almost 60% of localities in the Republic of Serbia, mostly in Vojvodina Province and the regions of Macva and Stig. The area on which damage by larvae was recorded had grown from 0.5 ha in 1992 to about 11,000 hectares in 1996 (SIVCEV, DRAGANIC, 1996), so the WCR must now be considered as a major maize pest in Yugoslavia.

In the Backa region, although maize is grown across large areas, with more than 40% in monoculture (especially in the private sector), this new pest was detected not before 1995. That year in late August/early September, several WCR individuals were discovered 60–80 km to the nortwest of Belgrade using cucurbitacin traps and visual inspection.

More detailed monitoring of the WCR and its geographic distribution in Backa began in 1996 and continued in 1997. One of the objectives was to compare the efficacy of three trapping techniques in monitoring the flight dynamics of WCR beetles and predicting the extent of next year's damage from the insect's larvae.

Materials and methods

1) In order to study the distribution and population density of WCR imago's, 113 maize fields were inspected visually (100 plants per field) in southern Backa (44 in the western and 69 in the eastern part) et the end of July 1997. At the same time, survey of 200 plants per field was used to record the damage caused by the larvae (expressed as plant lodging percentage).
2) During August and September 1997, pheromone and yellow sticky traps were used in the same area to compare their efficacy with that of the visual observation method. The yellow sticky traps Multigard, manufactured in the USA (Ecogen Inc., 610 Central Avenue, Billings, MT 59105), are made of yellowish green cardboard and have an adhesive area of 20x16 cm. The pheromone traps "Csalomone", manufactured in Hungary (Institute for Plant Protection, Budapest, Pf 102, 1525), are made of two-sided transparent foil, with a total adhesive area of 40x16 cm. We used "panel" type, as it had proven to be better than the triangular ones (TOTH ET AL., 1996).

On August 6th, one yellow sticky and one pheromone trap was placed 15 m apart in 12 maize fields (5 in the eastern and 7 in the western part of the region) in southern Backa. The WCR catch was determined on two dates (August 28th and September 17th), i. e., at three-week intervals. On the first of the two dates, old yellow traps were replaced with new ones because of their short durability.

3) The population dynamics of WCR beetles were monitored in the Temerin area (20 km to the North of Novi Sad), namely in a 0.28 hectare's field of continuous maize that was the site of the first major infestation by this pest in Backa, which was recorded in 1996. The flight dynamics of WCR adults were monitored from July 3rd till October 10th using three types of traps: yellow sticky trap (Multigard); pheromone trap (Csalomone), and cucurbitacin trap (amber plastic cylinders 7x2.5 cm in size, similar to those described by SHAW ET AL., 1984 in the USA). Three traps in total were placed in the field, one of each type. They were positioned about 15 m from each other and wrapped around the maize stalks at ear height. The yellow one was exchanged in two week's intervals, the pheromone after six weeks, while the pads in the cucurbitacin trap were changed on each collection date. The trapped beetles were counted in 1–2 week intervals during the first two months and after 3–4 weeks in the last two months. The data were considered in terms of the average catch per trap per day.

Results

1) After visual evaluation of maize fields in southern Backa, at the end of July 1997, it was determined that the distribution and population density of the WCR were on the increase. Just as the year before (1996), there were large differences between the western and eastern parts of the region (Tab. 1).

In the eastern part, imagoes of the WCR were found in all the locations and fields surveyed (compared with 83% in 1996) and on 41% of the plants on average (compared with 19% in 1996). The largest infestation percentage (55–80% of plants) was recorded in the focus of infestation (a circle around the town of Temerin about 10-km in diameter), whereas in the rest of the eastern part the average proportion of infested plants was 27%. In the center of the epidemic (Temerin area), population density ranged from 3 to 5 insects per plant, although a number of fields had as many as 10–15 individuals per plant. At the other sites in the eastern part of southern Backa, the population density was 1–2 beetles per plant. "Gooseneck" plants (damaged by larvae) were found only in the eastern part of the region. The percentage of "Gooseneck" plants were 8.7% overall, 20–35% in the focus of infestation, and over 70% on a smaller number of sites.

In the western part of southern Backa, the WCR adults were found on 36% of the sites (closer to the eastern part), 34% of the fields (18% in 1996), and 2.2% of the plants (0.3% in 1996). On the affected corn fields, between 2 and 10% of the plants were infested, mostly with one beetle per plant. Plant damage from the larvae was not observed.

2) Between August 6th and September 17th, 1997, the distribution and incidence of WCR adults were also monitored using pheromone and yellow traps. Using the traps, WCR imago's were found on all of the fields studied (Fig. 1), including several localities (Tovarisevo, Deronje, Ratkovo) in the western part of southern Backa in which this insect was not detected by visual observation. Still, in agreement with the results of visual evaluation, the population density determined by both kinds of traps was significantly larger in the eastern part of the region.

During the first three weeks (August 6th–28th), the average number of WCR beetles caught in a single pheromone trap was 339 for the eastern and 206 for the western part of the surveyed area. For yellow traps, the average was 101 specimens in the eastern and only 0.2 in the western part of the area. During the next three weeks (August 28th–September 17th), the number of trapped beetles dropped considerably, especially in the western part. Overall, the number of adults caught per pheromone trap was 544 in the eastern and 216 in the western part of the area studied. For yellow traps, the numbers were 122 WCR adults in the East and 1.2 in the West.

The efficacy of pheromone traps was several times larger on all the fields (in the East and West alike) and in both the first and the second period as well as overall. In the eastern part, the number of beetles caught with pheromone traps was 3.4–9.7 times (4.5 on average) larger than that caught by the yellow ones. This can be attributed partly to the fact that the adhesive area of the former is twice as large as that of the latter. Another likely reason may be the greater attractiveness of pheromones in comparison with the color yellow. In the western part, however, pheromone traps were 180 times (9.8–1,032) more effective than yellow traps, meaning that the former are much more suitable for WCR detection in areas with a low population density.

3) In the Temerin area, the focus of the first major occurrence of WCR imago's and larvae in Backa, the number of adults per plant in mid-July, 1997 was determined by visual observation to be 4–12. This was slightly less than in the year before (5–15), and the reason was probably the previous use of insecticides for controlling WCR larvae on the plot in question.

   In 1997, the monitoring of the WCR adult's flight dynamics on the said plot using three different types of traps revealed two peaks in terms of the average adult catch (Fig. 2). The first, significantly higher one came in late July, namely on July 21st for yellow trap (76.8 adults per trap per day) and July 24th for pheromone trap (68.3 adults/trap/day). The second peak was recorded on August 13th (42.2 adults/trap/day for yellow trap and 5.5 a/t/d for cucurbitacin ones).

   As shown in Fig. 2, the number of WCR individuals caught in Temerin was the largest with yellow trap, both at the two peaks and overall (1,256 imago's in total). The total WCR catch was considerably lower using pheromone trap (704) and much lower using cucurbitacin ones (123).

Discussion

1) The results obtained through visual inspection of maize fields in southern Backa, in late July 1997, showed that the geographical distribution and population density of the WCR imago's had increased relative to 1996. However, the differences between the eastern and western parts of the region were still evident. CAMPRAG ET AL. (1997) argue that they are due to the presence of several major roads in the eastern part (the old and new Belgrade-Subotica roads as well as the Novi Sad-Senta and Novi Sad-Zrenjanin ones). The heavy passenger and freight traffic on them probably contribute to the passive dispersal of this pest and hence to its larger presence in the area. Also, it seems that the Fruska Gora Mountain, although relatively low, may have slowed down, at least for a while, the spread of the WCR to the western part of southern Backa.

   The Temerin area was where economic damage from the WCR larvae was first recorded in the region of Backa in 1996 (on over 20 private fields). The rainy summer of 1997 (especially July and early August) caused favorable conditions for the regeneration of roots damaged by the larvae. For that reason the damage in 1997 was considerably smaller than expected and was manifested mostly as "Gooseneck" plants, as opposed to yield losses, which were less common.

2) Use of pheromone and yellow traps during the six weeks of August and September provided us with an even more detailed picture of the distribution of WCR imago's in the region. It was determined that this pest was present throughout southern Backa, including

some fields in the western part in which no WCR adults were found using the visual observation method. The number of insects caught was again significantly larger in the eastern part, confirming the results of visual evaluation. Pheromone traps proved much more effective than the yellow ones, especially in the West. These data are similar to the results of some studies carried out in Hungary (PRINCZINGER, 1996) and Croatia (ZLOF, 1996), which have also led to the conclusion that pheromone traps are more suitable for the detection of WCR imago's than the yellow or cucurbitacin ones.

3) The flight dynamics of the WCR beetles in Temerin were different in 1997 than in 1996, although the same field was surveyed and the same trapping techniques were used. In 1996, the number of insects caught started increasing in early July, peaked on August 6th, and then decreased until October (KERESI ET AL., 1997). In 1997, on the other hand, two peaks were recorded, and the first (July 21st–24th) was higher than the second (August 13th). A similar population dynamics of WCR adults was reported for some sites in Hungary in 1997 (ZSELLER ET AL., 1997).

The largest number of specimens in Temerin was caught with yellow trap, followed by pheromone and then cucurbitacin ones, which is in complete agreement with the results for 1996 (KERESI ET AL., 1997). It seems that, in areas with a high WCR population density, yellow trap exchanged two-weekly is more effective than pheromone ones (changed at six weeks) in monitoring the flight dynamics of this pest. Cucurbitacin trap had very low, unsatisfactory effectiveness and, contrary to SHAW ET AL. (1984), we do not suggest this trap type for monitoring the population density of WCR. The reason for low effectiveness is may be its small size that makes it less visible for WCR adults than other traps.

In the USA, where the WCR is one of the major pests of continuous grown maize, various techniques and programs have been developed to prevent economic damage from this insect. Sampling of adults to predict subsequent larval damage seems to be the most promising technique. HEIN & TOLLEFSON (1985) recommended yellow Pherocon AM sticky trap as the practical choice for sampling work due to compactness, easy installation and use, commercial availability, and low cost. The threshold of economic damage for Pherocon AM traps has been found to be six adults per trap per day, during a period of one week.

Our average daily catch on yellow trap, in the Temerin area in 1997, was much larger than mentioned threshold, especially during the peaks of infestation. That great difference may be partly due to our use of Multigard traps. The pest density determined in our study by visual inspection in July was also much larger than the damage threshold of one imago per plant that is widely used in the USA in the past. In view of this, damage from the WCR larvae is expected on the plot in question next year as well. Therefore, in case maize will be sown on it again, use of insecticides for the control of soil pests is recommended.

On the basis of our previous experiences and the overall results for 1997, in 1998 we expect a further increase of the geographical distribution and, especially, population density of the WCR in southern Backa. Depending on the weather conditions, furthermore, an increase in larval damage can be expected as well, primarily in the private sector, where continuous growing of maize is more common.

Acknowledgment

This study was partially supported by contract funds granted by the Ministry of Sciences and Technologies of Republic of Serbia (Project 12M17). Special thanks are due to Dr. HARALD K. BERGER (Institute for Phytomedicine, Vienna, Austria) and Dr. FRANJA BACA (Maize Research Institute, Zemun-Polje, Belgrade-Zemun, Yugoslavia), who made our experiments possible by supplying us with pheromone and yellow traps.

Tab. 1: Occurrence of *Diabrotica virgifera virgifera* LeConte adults on corn fields in southern Backa during late July 1997.

Site	Infested by adults in % fields	Infested by adults in % plants	Lodged plants in %	Site	Infested by adults in % fields	Infested by adults in % plants	Lodged plants in %
Eastern part				**Western part**			
Backi Jarak	100	80,2	32,5	**Rumenka**	100	10,5	0
Temerin	100	62,0	21,8	**Futog**	100	6,0	0
Rimski Sancevi	100	54,8	35,1	**Begec**	100	4,3	0
Sirig	100	76,7	19,5	**Glozan**	100	5,0	0
Kac	100	43,2	2,1	**Backa Palanka**	75	2,0	0
Budisava	100	40,5	1,0	**Obrovac**	0,0	0,0	0
Sajkas	100	48,7	0,6	**Tovarisevo**	0,0	0,0	0
Djurdjevo	100	21,5	0,0	**Bac**	0,0	0,0	0
Zabalj	100	45,4	0,2	**Deronje**	0,0	0,0	0
Gospodjinci	100	57,7	4,5	**Odzaci**	0,0	0,0	0
Curug	100	16,2	0,0	**Ratkovo**	0,0	0,0	0
Backo Gradiste	100	6,7	0,0	**Parage**	0,0	0,0	0
Nadalj	100	4,3	0,0	**Silbas**	0,0	0,0	0
Srbobran	100	15,7	4,0	**Backi Petrovac**	0,0	0,0	0
Average	100	41,0	8,7	**Average**	33,9	2,1	0,0

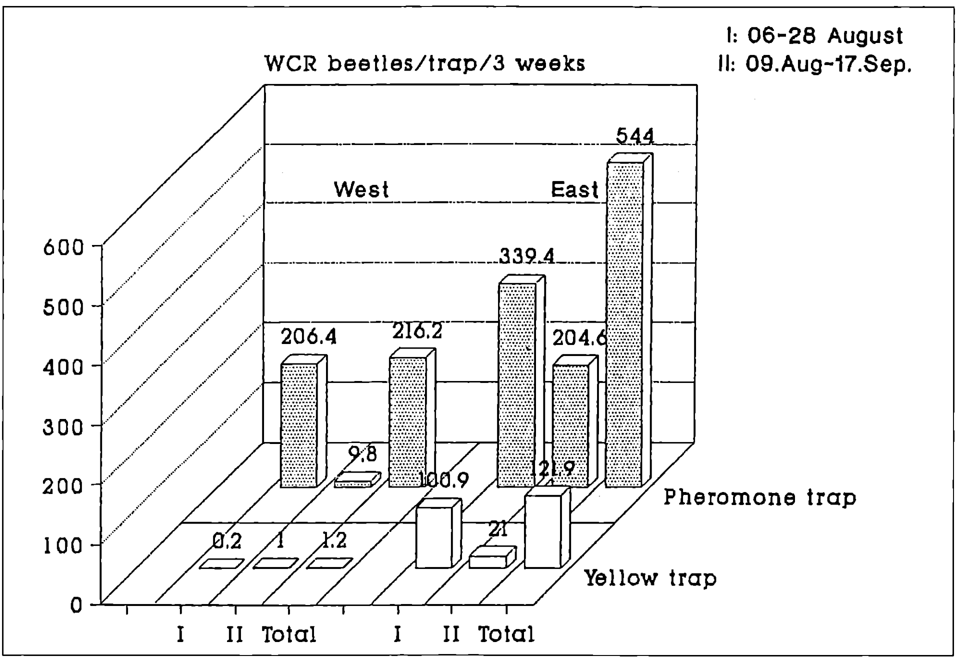
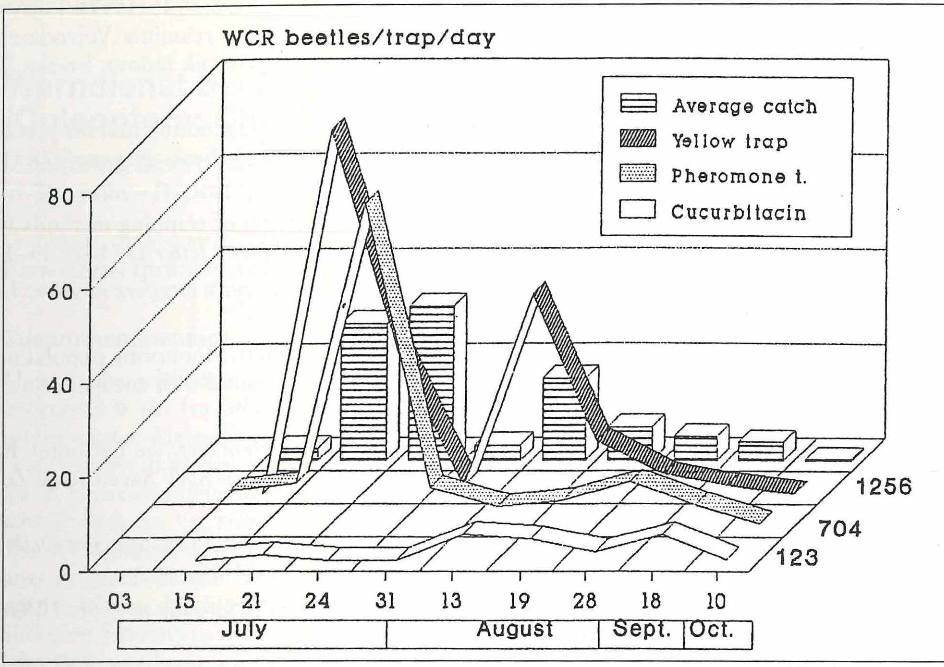


Fig. 1: Efficacy of yellow and pheromone traps in monitoring WCR adults in southern Backa



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(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Pflanzenschutzberichte,
Band 57, Heft 2, 1998

Warndienst bei *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae) in Slowenien – Bericht 1997

Monitoring *Diabrotica virgifera virgifera* LeConte Coleoptera: Chrysomelidae) in Slovenia – Report for 1997

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Zusammenfassung:

Mais ist die wichtigste ackerbauliche Kultur in Slowenien. Insgesamt 94.000 ha Mais bedecken 40% der fruchtbaren Ackerfläche. Seit Anfang der neunziger Jahre wurde einer der gefährlichsten Maisschädlinge, *Diabrotica virgifera virgifera,* nach Europa eingeschleppt, wo er sich zuerst in umliegenden und dann auch in ferneren Gebieten verbreitet hat. Da das Klima in Slowenien dem von Serbien, wo der Schädling erstmalig auftrat, in weiten Bereichen sehr ähnlich ist, hat sich Slowenien der internationalen EPPO/IWGO Arbeitsgruppe über den WCR angeschlossen, um mittels Warndienstbeobachtungen das Vordringen des Schädlings zu beaufsichtigen. In den Jahren 1995 und 1996 wurde die Überwachung hauptsächlich mit Gelbfallen durchgeführt, die in Gebieten mit intensivem Maisanbau im Nordosten und Südosten Sloweniens, nahe der ungarischen und kroatischen Grenze, aufgestellt wurden. Im Jahr 1997 wurde die Überwachung mit ungarischen Pheromonfallen ergänzt. Die geographische Lage der Kontrollpunkte wurde entsprechend dem UTM Netzwerk (WL38, WL48, WL58, WL57, WM97, WM95, WM54, WM64, WM74, WM84, WM94, XM08, XM07, XM06, XM16, XM05, XM15) festgelegt. Die Ergebnisse der Verbreitungsüberwachung bei *Diabrotica virgifera virgifera* sind von großer Wichtigkeit, da dieser Schädling in Slowenien bisher überhaupt nicht nachgewiesen werden konnte.

Stichwörter: *Diabrotica virgifera virgifera,* Mais, Warndienst in Slowenien

Summary

Maize is one of the major crops in Slovenia as 94.000 ha were sown with it in the year 1996, covering about 40% of all arable fields. Since at the beginning of nineties one of the most dangerous maize pests (*Diabrotica vifgifera virgifera*) has been brought to Europe where it has been spreading from areas in which it was first observed to the neighbouring and more distant ones, and in view of the fact that climate conditions in Slovenia are relatively favourable for its development, in 1995, we have joined a project team which is active in frame of EPPO by monitoring the spreading of western corn rootworm. In 1995 and 1996, monitoring of *Diabrotica virgifera virgifera* based on the use of yellow sticky traps was set up in the north-eastern and south-eastern Slovenia, two intensive maize growing areas bordering on Hungary and Croatia. In 1997, this monitoring was enriched by using pheromone traps manufactured in Hungary. The control monitoring checkpoints were geographically determined using UTM network (WL38, WL48, WL58, WL57, WM97, WM95, WM54, WM64, WM74, WM84, WM94, XM08, XM07, XM06, XM16, XM05, XM15). The results of monitoring the spreading of *Diabrotica virgifera virgifera* in Slovenia are very positive since the presence of this pest has not been recorded so far.

Key words: *Diabrotica virgifera virgifera,* maize, monitoring in Slovenia

Introduction

Due to natural conditions prevailing in Slovenia its agriculture is directed mainly towards animal husbandry, of which maize production represents the basis if considered from the nutritional point of view. In the last years maize as the most widely spread field crop in Slovenia has been produced on 40% of fields. In 1996, it was harvested on 94,000 ha of which half were devoted to grain maize. Last year, the yield was 334,000 tons of grain and approximately 1.912,000 tons of silage maize (STATISTICAL OFFICE OF SLOVENIA, 1997).

The use of phytopharmaceutical products in maize, except for herbicides and sometimes soil insecticides, has not been spread very much in Slovenia. The incidence of such a pest would therefore mean a certain stress for this area and the introduction of a new production technology which would include the use of appropriate phytopharmaceutical products. All this would be strongly reflected on the organization and economic calculations of maize production.

Material and methods

With regard to economic damage which could be caused by western corn rootworm in Slovenia it was decided, similar to southeastern and central Europe, to get as prepared as possible for this pest. For this purpose we started to monitor its eventual incidence in Slovenia already in the years 1995 and 1996. Its possible presence was monitored using yellow sticky traps distributed on intensive maize growing fields along the border with Hungary and Croatia (the regions of Prekmurje, Dravsko polje, Krško-Breciško polje). 30 control points were set up (Fig. 1 and Table 1). In 1997, the existing monitoring was enriched by 40 pheromone traps manufactured in Hungary.

Fig. 1: Distribution of monitoring checkpoints for *Diabrotica virgifera virgifera* in Slovenia in 1997

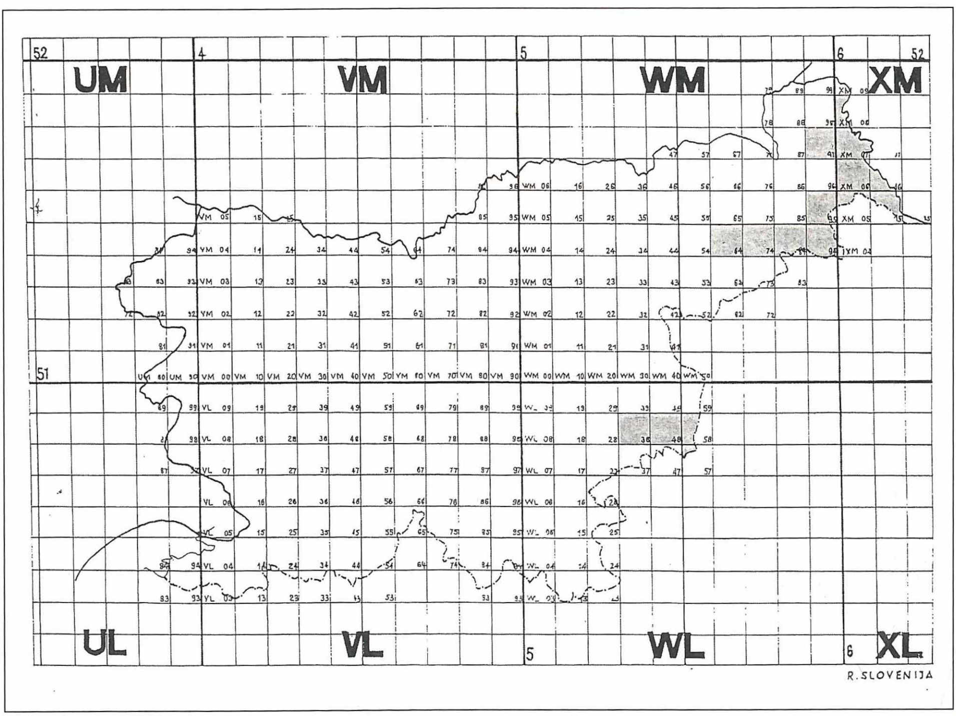


Table 1: An overview and geographic definition of control points used for monitoring of *Diabrotica virgifera virgifera* in Slovenia

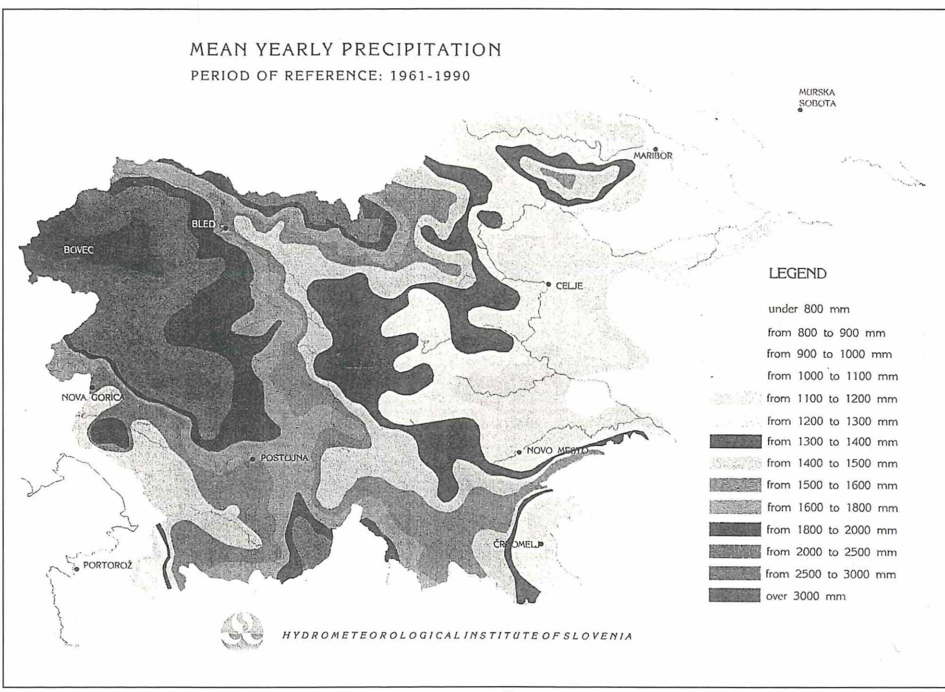
Area	UTM code	Location	Microlocation of plots
Prekmurje	WM-97	Martjanci	along the road M. Sobota – Dobrovnik
	WM-97	Tešanovci	along the road M. Sobota – Dobrovnik
	XM-07	Bukovnica	near the shooting range
	XM-07	Motvarjevci	near sugarbeet deposit
	XM-08	Prosenjakovci	near elementary school
	XM-08	Domanjševci	along the state border
	WM-95	Mota	along the road Razkrizje-Mota-Krapje
	WM-95	Pristava	at the end of the village
	XM-06	Kobilje	at the state border, near old military check-point
	XM-06	Kamovci	along the road Lendava – Dobrovnik
	XM-06	Genterovci	at the wooden cross by the road Lendava – Dobrovnik
	XM-16	Dolga vas	along the road Dolga vas – Lendava
	XM-16	Dolga vas	along the road Dolga vas – Lendava
	XM-05	Kot	at the end of the village near the state border with Croatia
	XM-15	Benica	along the river Lendava
	XM-15	Benica	along the river Lendava
Dravsko polje	WM-54	Pragersko	at the traffic sign for Sp. Polskava
	WM-54	Šikole	at the linden-tree
	WM-64	Ptuj	at the thermal springs
	WM-64	Turnišèe	avenue
	WM-74	Borovci	near football ground
	WM-74	Moškanjci	along the road
	WM-84	Mihovci	at hunting cottage
	WM-94	Središèe ob Dravi	passing Droga 1
	WM-94	Središèe ob Dravi	passing Droga 2
Krško polje	WL-57	Obrezje	near the border-crossing Obrezje
	WL-58	Dobova	between Sava and regional road of the border-crossing Rigonce
	WL-58	Gregovce	along Sava, border-crossing Obrezje
	WL-48	Dol. Skopice	along the motor-way Ljubljana – Zagreb
	WL-48	Velika vas	along the motor-way Ljubljana – Zagreb

Control points for monitoring western corn rootworm in Slovenia were set up on July 2nd 1997 and the monitoring lasted two months. Pheromone traps and yellow sticky traps were controlled once a week. The monitoring was established by Agricultural Institute of Slovenia with the cooperation of the Inspectorate of the Republic Slovenia for Agriculture, Forestry, Huntsmanship and Fishery (Margareta Dancs, Ludvik Lazar) and Agricultural Advisory Service (Smilja Tomše).

Results and discussion

Climate conditions are one of the most important factors for the population development or population growth of particular harmful organisms. Soil temperature and moisture are two major limiting factors influencing the overwintering of western corn rootworm eggs. Since the females lay their eggs in soil at different depths they are variously exposed to negative environmental effects. Those that are nearer to soil surface during unfavourable conditions perish earlier due to low temperatures or drying out of the upper layer of soil, especially when the precipitation is low over the winter. In winter, about 40 to 50 mm monthly precipitation fall on areas intensively grown with maize in Slovenia. Yearly average precipitation (Fig. 2) in these areas is 800 to 1200 mm (HYDROMETEOROLOGICAL INSTITUTE OF SLOVENIA, 1995). According to CHIANG (1973) the temperature threshold for the development of this pest is 12,8°C and the development of larvae lasts 71 days at 15°C, 38 days at 22°C and 27 days at 29°C. In summer months (July, August) the average air temperatures in intensive maize growing areas in Slovenia are 18 to 20°C. (CEGNAR, 1996) presents the average air temperatures in Slovenia in the month of July. Average temperatures of the remaining summer months do not deviate relevantly from July temperatures. In the coldest month of the year, in January, the average air temperatures in the area situated in the north-eastern Slovenia are about –2°C (CEGNAR, 1996). The limiting factor for the overwintering of the pest mentioned above is soil temperature. Temperatures below –8°C are fatal for the overwintering eggs (CAMPRAG ET AL., 1994). If minimum soil temperature data in the area of Murska Sobota, i. e. where north-eastern Slovenia is potentially most exposed to the intrusion of western corn rootworm from the neighbouring countries of Hungary or Croatia, are examined, it can be seen that in the period 1977–91 the minimum soil temperature in the depth of 10 cm never fell below –8°C. As the females lay their eggs 10 cm and deeper it can be concluded that soil temperatures in the north-eastern Slovenia are not the limiting factor for the species *Diabrotica virgifera virgifera.*

Fig. 2:



If the production intensity of maize in Slovenia (40% of fields under maize) and the existing climate conditions are considered, it can be expected that with its possible incidence or spreading in Slovenia this pest will cause great changes in the sense of economic efficiency of maize production.

If the movement or the spreading of western corn rootworm over Europe is considered, its incidence in Slovenia is not expected as yet. The results of the monitoring confirm our expectations since the above mentioned pest has not been discovered at any of the control points.

Next year we intend to continue the monitoring that will be designed to a similar extent as this year. At an eventual geographic move of *Diabrotica virgifera virgifera* towards the eastern or southern border of Slovenia we will set up a thicker network of control points and intensify such monitoring as necessary.

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(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Pflanzenschutzberichte
Band 57, Heft 2, 1998

Risiko-Bewertung von *Diabrotica virgifera virgifera* LeConte in Frankreich

Risk Assessment of *Diabrotica virgifera virgifera* LeConte in France

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Zusammenfassung:

Diabrotica virgifera virgifera LeConte (Coleoptera: Chrysomelidae) ist in Europa seit 1992 heimisch. Auf Grund des stetigen Ausbreitens des Schädlings nach Westen hat das französische Landwirtschaftsministerium sich entschlossen, eine Risiko-Bewertung des Schädlings in bezug auf die klimatischen und agronomischen Verhältnisse in Frankreich durchführen zu lassen. Mais, die wichtigste Wirtspflanze von *Diabrotica virgifera virgifera,* steht mit 1,7 Millionen Hektar (1996) an dritter Stelle in der französischen Pflanzenproduktion. Darüber hinaus sind mindesten 7 weitere wild wachsende Gramineen für die komplette Entwicklung des Schädlings geeignet. Vergleiche der klimatischen Bedingungen (Temperatur und Niederschlag) in Ungarn und den USA mit denen in Frankreich ergaben, daß sich *Diabrotica virgifera virgifera* auf dem gesamten französischen Staatsgebiet in allen Stadien entwickeln kann. Die phytosanitären Maßnahmen, die derzeit von den Landwirten gegen andere Schädlinge (Heerwurm, Maiszünsler) durchgeführt werden, könnten bestenfalls das Fortschreiten des Schädlings verlangsamen, seine Einwanderung nach Frankreich keinesfalls verhindern. Das Heimischwerden des Schädlings in Frankreich wird zu signifikanten Ertragsreduktionen führen.

Schlüsselwörter: *Diabrotica virgifera virgifera*, Chrysomelidae, Risiko-Bewertung, Mais, Frankreich

Summary

Diabrotica virgifera virgifera LeConte is established in the European continent since 1992. Because of its regular progress towards the West, the French Ministry of Agriculture decided to carry out a pest risk analysis in relation with climatic and agronomic conditions prevailing in France. Maize which is the main host of *Diabrotica virgifera virgifera,* is the third French production with 1.7 million ha in 1996. Monoculture is very frequent. Moreover, at least 7 species of wild graminaceous plants are suitable for a complete development of the immature stages. Comparison of climatic conditions (rainfall and temperature) in Hungary, USA and France indicates that *Diabrotica virgifera virgifera* will be able to survive on the whole territory at all stages of its development. The phytosanitary practices currently implemented by farmers against other pests (Armyworms and European corn borer) may limit its progress but will undoubtedly be insufficient to prevent its spreading. The pest establishment will have a significant economic impact by decreasing yields.

Key words: *Diabrotica virgifera virgifera*; Chrysomelidae; Pest Risk Assessment; maize; France

Introduction

Diabrotica virgifera virgifera LeConte, which is a serious North American pest, was discovered in Yugoslavia in 1992. Since that time, its progress was continuous in neighbouring countries of Yugoslavia. The presence of maize cultures in the French border areas will certainly facilitate the crossing of *Diabrotica virgifera virgifera* in the country under its own steam.

All these observations led the French Ministry of Agriculture to carry out an evaluation of the risk of introduction and establishment of this insect.

Three parameters were taken into account in this study: potential pathways of introduction, availability of host plants and evaluation of climatic conditions.

Material and Methods

Statistical informations on maize distribution in France were provided by the Ministry for Agriculture (Statistical Service). Data concerning the potential host range other than maize were deduced from North American lists, by comparison with a french flora (BONNIER & DONIN 1911–1935). The climatic data for Europe and North America were obtained from an American server (http://www.worldclimate.com) and biological data from a synthesis of North American studies (CHIANG, 1973).

Results

Maize in France

Maize, which is the main host of *Diabrotica virgifera virgifera,* is largely cultivated in France (FIG. 1 and 2). In 1996, 1,682,579 hectares of maize for grain were produced, 1,577,531 hectares for silage and 42,218 hectares for seed. France is the leading maize-growing country in Europe. The highest concentration of maize for grain and seed is located in the southwestern region (Aquitaine and Midi-Pyrénées) and represents more than a third of the French production (ANONYMUS, 1996).

The center-west (Pays de Loire and Poitou-Charentes) provides a little less than 20% of the national production. The eastern side of the country (Rhône-Alpes and Alsace), with good yields these last years, produces approximately 20 p.cent of the French maize. Surfaces in monoculture which are most concerned with the Western corn rootworm are ignored by French statistical surveys and so, are difficult to estimate. However, maize comes first in irrigated cultures (703,000 hectares) and irrigation, especially when it is fixed, is very often synonymous of continuous maize. Such a practice is mainly localized in the southwestern region. So, an introduction of *Diabrotica virgifera virgifera* in this area would be very worrying.

Potential pathways of introduction.

France exclusively imports maize in the form of grains. There are no importation of whole plants or soil containing (or having contained) roots.

The risk of introduction through importations is thus very weak. Moreover, the insect was never intercepted in France. The most important risk remains an introduction by natural ways.

The maize importation in the form of grains has two destinations: for industrial transformation on particular pathways (150,000 to 350,000 tons varying from year to year) or for the production of seeds (200,000 to 300,000 tons originating from about twenty countries).

Host range

An American study (BRANSON & ORTMAN, 1970) reported that apart from the maize, the Western corn rootworm can survive in laboratory for at least 10 days on 18 species of grasses and can even complete its immature stages in field test on 13 species. BRANSON & ORTMAN (1967) underlined that these plants are inadequate for an important multiplication of the pest. Nevertheless, they make it possible to maintain a residual population within the framework of rotations.

Seven potential host plants occure in France:

Agropyron elongatum	(Tall wheatgrass)
Hordeum vulgare	(Barley)
Oryza sativa	(Rice)
Setaria italica	(Foxtail millet)
Setaria viridis	(Green foxtail)
Triticum aestivum	(Wheat)
Triticum spelta	(Spelt)

However, this list is not exhaustive: some graminaceous, frequent in France, were not studied (*Echinochloa crus-galli* for instance). Foxtails are also very common weeds in maize culture.

Evaluation of the climatic conditions

To estimate if French agro-climatic conditions are compatible with ecological requirements, we have compared the climatic conditions of two areas where the insect is already established (USA and Yugoslavia) with several French situations. FIG. 3 indicates the location of the selected climatic stations.

Rainfall in USA and Yugoslavia is quite variable (FIG. 4) and fluctuates between 400 and 1000 mm per year. This climatic parameter will not limit the development of *Diabrotica virgifera virgifera* in France because French pluviometry lies between these boundaries.

As a matter of fact, the distribution area is controlled by thermal conditions.

FIG. 4 shows that annual mean temperatures lie between 9.6°C and 12.7°C in the French stations. A more accurate study by using monthly data (FIG. 5) shows that average temperatures are higher in winter and lower in summer than for the reference stations (USA and Belgrade). The French climate has a continental temperate influence with a more or less degraded oceanic tendency. It is characterized by moderate temperatures, scarcely lower than 10°C (and always transient), and rains more abundant in spring and autumn.

Discussion

The maize, which is the main host plant of *Diabrotica virgifera virgifera,* is largely cultivated in France.

With regard to temperatures, the egg must undergo a virtually compulsory overwintering with an optimal temperature of 4 to 5°C in the laboratory. CHIANG ET AL. (1973). These temperatures are compatible with the French climate. The same study evaluates the mortality level at 50% after a one week exposure to –10°C in the soil, and 100% after an exposure to 15°C. These extreme temperatures are almost never reached in France.

The larvae have a complete development for temperature higher than 11.7°C. (KUHLMAN ET AL., 1970). This threshold temperature is reached from April (Bordeaux) or May (most of the French stations).

The adult does not lay on days with minimum temperature below 10°C, and evening temperatures of 16 to 18°C are optimal for oviposition. A survival is possible after exposure to a temperature of –10°C.

An accidental introduction of *Diabrotica virgifera virgifera* will lead to its final establishment in France for the following reasons:

- Early planting and continuous cropping are frequent;
- The host plant is available during egg hatching (from May 15th, in USA as well as in Eastern Europe and probably the same in France).
- The agro-climatic conditions necessary to the larval development and the adult reproduction are close to those encountered in France.

The maize culture in France relies on high yields (70 to more than 100 quintals per hectare). This productivity is obtained by using powerful varieties and intensive pesticide protection. Soil insecticides are very often applied at planting to control soil insects as Wireworms (*Agriotes sp., Athous sp.*, etc. ...) and more rarely *Oscinella sp.* and *Geomyza sp.* Ten pesticides are officially authorized for these uses in France. Among them, several soil insecticides are known to be effective on Western corn rootworm larvae (carbofuran, chloropyrifos, fonofos, phorate or terbufos for instance).

The economic impact of this pest, on the assumption of an installation in France, may be decreased by existing cultivation methods (tillage practices, use of rotational crops ...) and soil insecticides. The control of the European corn borer (*Ostrinia nubilalis*) may contribute to a reduction of adult number (at least at the beginning of flight) and minimize larval damage.

Nevertheless, this Pest Risk Assessment reveals that France is an endangered area and *Diabrotica virgifera virgifera* is likely to become a major pest. Consequently, a monitoring survey should be realized in all the affected countries and phytosanitary measures should be taken to counteract the current outbreaks and to prevent spreading in pest-free areas.

Fig. 1. Maize for grain by region (1996)

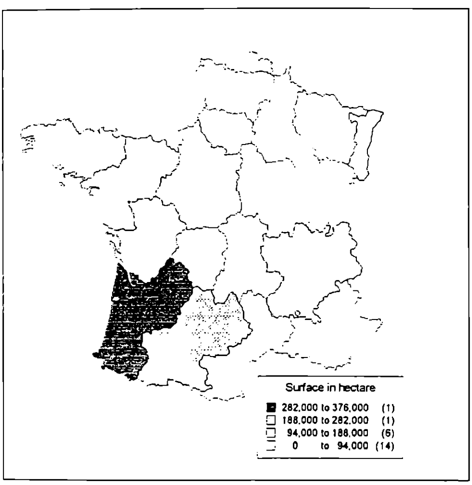


Fig. 2. Silage maize by region (1996)

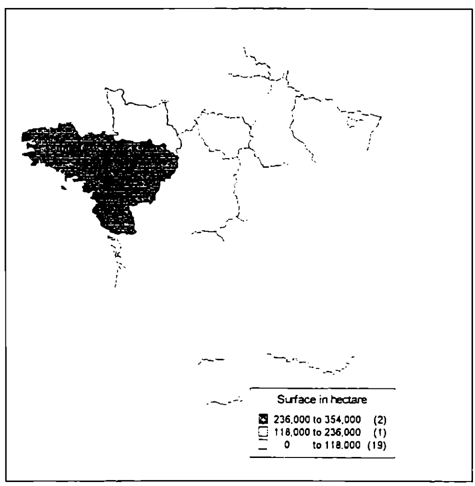


Fig. 3. Distribution of climatic stations

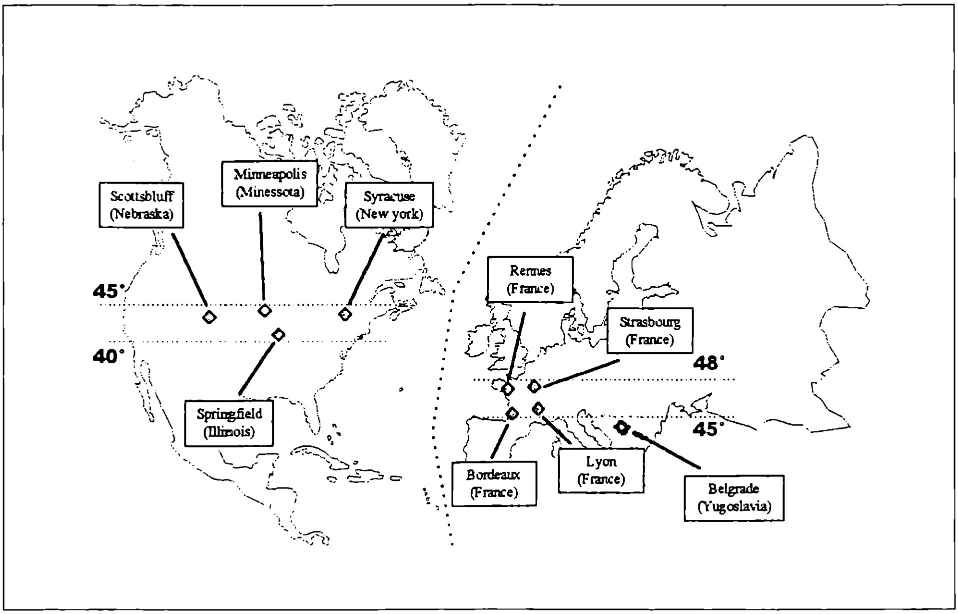


Fig. 4. Annual rainfall and temperature

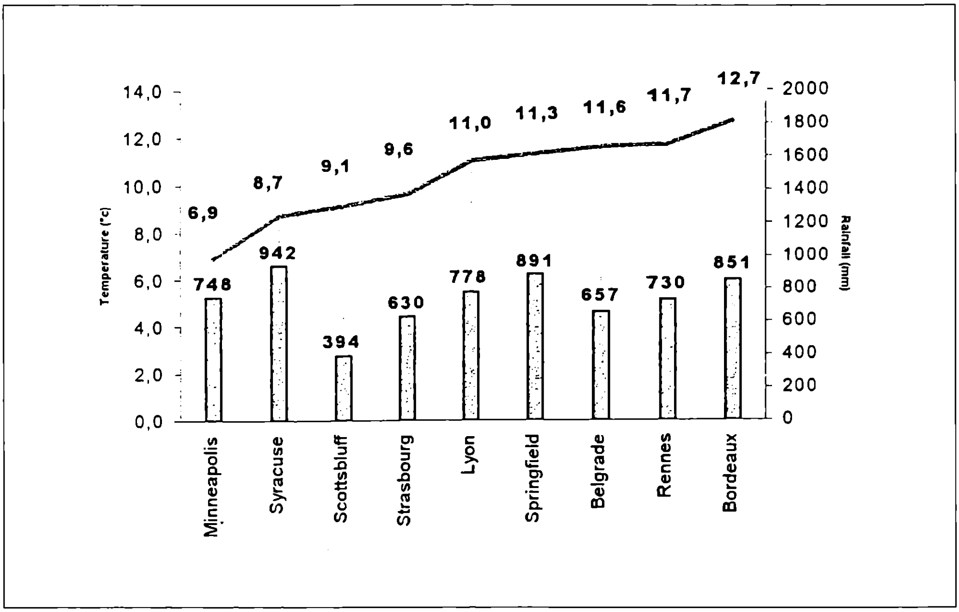
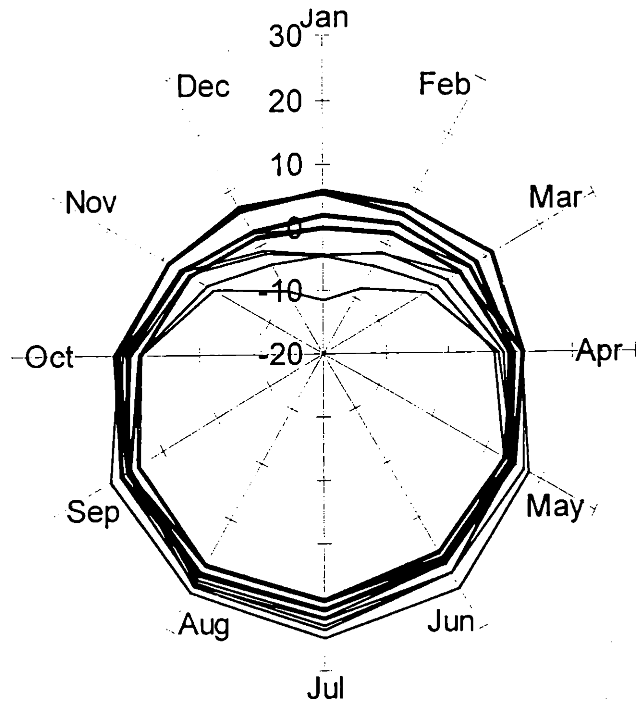


Fig. 5. Mean monthly temperatures



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(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Pflanzenschutzberichte,
Band 57, Heft 2, 1998

Vergleich zwischen den ungarischen Pheromon- und den Pherocon AM® Fallen bei wirtschaftlich bedeutenden WCR-Populationen in Indiana, USA

Comparisons of Hungarian Pheromone and Pherocon AM® traps under economic Western Corn Rootworm populations in Indiana, USA

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Zusammenfassung

In Zentraleuropa ist die ungarische Pheromonfalle die geeignetste Vorrichtung für die frühzeitige Überwachung des Western Corn Rootworm (WCR), *Diabrotica virgifera virgifera* LeConte. Im Vergleich zur ungarischen Pheromonfalle erreichten die Pherocon AM® (PAM), Multigard® (MG) und Insektizidköderfallen nur einen Bruchteil der Fangzahl. Die ungarische Pheromonfalle lockt WCR-Männchen aus mehr als 1 km Entfernung an. Die gelben, klebrigen PAM- und MG-Fallen müssen sich im Sichtbereich des Männchens befinden, um es anzuziehen, bei den Insektizidködern muß das Männchen mit der Falle in Berührung kommen, um gefangen zu werden. Die Fangvergleiche in Osteuropa wurden bei Adulten mit einer Dichte unter der Schadensschwelle durchgeführt. Um die ungarische Pheromonfalle unter rentablen Bedingungen mit der PAM-Falle (ohne Lockstoff) vergleichen zu können, wurde 1997 in Indiana (USA) ein Versuch auf mehreren Feldern gestartet. Die Ergebnisse in den Maisfeldern beweisen, daß die ungarische Pheromonfalle wesentlich mehr erwachsene Schädlinge fängt als die PAM-Falle. Trotzdem waren die Fangergebnisse der PAM-Falle aussagekräftig genug, um die Dichte der Schädlingsbevölkerung zu bestimmen. Außerdem spiegelt sie, durch die mit der Zeit zurückgehende Zahl der gefangenen erwachsenen Schädlinge, besser die Bevölkerungsfluktuationen innerhalb eines Feldes wider als die ungarische Pheromonfalle. Der Wirkungsbereich der ungarischen Pheromonfalle erstreckt sich weit über ein einziges Feld und macht deshalb Schätzungen der erwachsenen Schädlingsbevölkerung in einem Feld unmöglich. Die ungarische Pheromonfalle ist bei weitem die beste Falle für die Erfassung der WCR-Verbreitung und ihre frühe Vermehrung in einem Gebiet. Sobald jedoch eine bekämpfungswürdige Dichte erreicht ist, sind Nicht-Pheromonfallen besser für die Feldprognose geeignet.

Stichwörter: Western Corn Rootworm, *Diabrotica virgifera virgifera* LeConte, Pheromonfalle, Pherocon AM® Mais, *Zea mays*

Summary

In Central Europe, the Hungarian pheromone trap (HP) is the trap of choice for detection and early monitoring of adults of the western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte. Only a fraction of the number of adults observed on the HP trap have been noted in this region on the Pherocon AM® (PAM), Multigard® (MG), and cucurbitacin/insecticide-baited (CB) traps. The HP trap has the ability to attract WCR adult males over distances greater than 1 km. PAM and MG yellow sticky traps must be in visual sight of adults to be attractive, while adults must come in contact with the carbaryl-laced cucurbitacin in the CB trap to be captured. Trap comparisons made in Eastern Europe have been conducted on adult populations at non-economic levels. In order to compare the HP trap under known economic adult populations to one non-pheromone trap type, the PAM trap, a study was initiated in several fields in Indiana, USA, in 1997 Results show that in maize fields the HP trap catches significantly more adults than the PAM trap. However, the numbers caught in the PAM trap are sufficient to indicate the presence of an economic WCR population. Also the declining numbers of adults caught over time on the PAM trap are a better indicator of the normal fluctuation of a population within a field than those seen on the HP trap. The range of the HP trap goes beyond a single field, thus making dependable estimates of adult abundance within a field near impossible. The HP trap is by far the best trap for detecting the spread of a WCR population and its early buildup within an area. However, once economic WCR populations are present, non-pheromone type traps are better predictors of economic populations within a field.

Key Words: Western Corn Rootworm, *Diabrotica virgifera virgifera* LeConte, pheromone trap, Pherocon AM®, Maize, *Zea mays*

Introduction

The western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, is emerging as a major pest of maize, *Zea mays* L., in Europe (FURLAN, 1997). WCR was first observed in maize in 1992 at Surcin, Yugoslavia (i.e., Serbia), near the Belgrade International Airport (BACA, 1993). Since its first discovery in Yugoslavia, it has spread to Bosnia-Herzegovina, Croatia, Hungary, and Romania (EDWARDS, 1997). It is likely that WCR has also spread into the extreme northwest corner of Bulgaria based on WCR trap results on the Romanian side of the Danube River (I. VONICA, Romania, personal communication).

The primary means foı detecting WCR in Central Europe has been through the use of the Hungarian pheromone (HP) trap as described by TOTH ET AL. (1996). Other types of traps have been tested and used in the infested region. Some types were used in conjunction with the use of the HP trap while others have been used alone. These other traps include the cucurbitacins insecticide-bait trap [the first record of a beetle catch outside Yugoslavia was on this trap type, PRINCZINGER (1996), Pherocon® AM (Tre'ce' Inc., Salinas, California) trap, Multigard® (Scentry, Billings, Montana) trap, and Romanian pheromone trap (Romanian Ministry of Agriculture, Bucharest, Romania). It was evident from the data on the numbers of WCR beetles trapped in the infested countries that the HP trap was the trap of choice for WCR detection (EDWARDS, 1997).

Other trap types have caught only a fraction of the number of beetles observed on HP traps in Central Europe. As expected, the HP trap has the ability to attract male beetles from outside a field. The range of attractancy can vary greatly depending on the concentration of the pheromone and environmental conditions, but may range over several kilometers. Pherocon AM and Multigard traps are attractive to WCR adults that are within sight of these yellow-colored traps. Although one might expect that the cucurbitacins insecticide-bait trap attracts beetles, the cucurbitacins actually do not attract WCR beetles, but only stimulate them to feed. Therefore, beetles find the cucurbitacins insecticide-bait trap through random movement.

In the USA, Pherocon AM and Multigard traps are occasionally used to monitor beetle populations to estimate if economic levels of rootworm larvae are likely to occur the following year. Cucurbitacins insecticide-bait traps have only been tested for this purpose, but have not been sold commercially. Pheromone baited traps are not used for this purpose in the USA. Although pheromone traps may collect large numbers of male beetles, it is very difficult to know what the numbers mean in a given field since their range of attractiveness goes beyond individual fields. Thus when trapping with pheromones, one must ask the question "What do the numbers really mean for a given field?" Research has shown that yellow sticky traps can be good predictors of rootworm beetle populations when trap counts are compared to visual counts (HEIN and TOLLEFSON, 1984), and can be correlated with subsequent larval populations to predict damage the following season (HEIN and TOLLEFSON, 1985).

Because of the many questions related to the selection, use, and results obtained from these various traps under varying WCR beetle population levels in Central Europe, we designed an experiment to look at the HP trap versus the Pherocon AM trap. Testing these traps under known economic WCR populations could possibly help determine how each can best be utilized in detecting and monitoring of populations within an area, and predicting the presence of an economic larval population in a field. The first test was designed to look at the two trap types in both maize and soybean, *Glycine max* (L.). Soybean were added since WCR beetles are now flying to this crop in high numbers in parts of Indiana, Illinois, and Ohio, USA, to feed and lay eggs, and the attractiveness of other crops could become of importance with WCR infestations in Central Europe. This behavioral change has not been seen in other areas of the midwestern USA, but the area of the infestation of this WCR "variant" is expanding (SAMMONS ET AL., 1997). This could be important information for Europe, as it is not known where the beetle in Central Europe originated from in the USA. A second study was conducted to look at the two trap types in maize only.

Methods

The trap catch comparison study was divided into two parts, a comparison of trap catches for HP and Pherocon AM traps over time in maize and soybean (Test 1), and a comparison of the two trap types in maize (Test 2). The later study was added because of the results obtained in the initial stages of Test 1, and to better simulate the WCR situation in maize in Central Europe. In Test 1, HP traps were placed in soybean fields between the Pherocon AM trap locations in soybean and maize. Therefore, the 3 treatments in Test 1 were 1) HP traps placed in soybean, 2) Pherocon AM traps in soybean, and 3) Pherocon AM traps in maize. This study was conducted in 6 fields (from 14 to 31 ha) with 6 replications per treatment per field. The treatments were placed in a row for each trap type. The fields in Test 1 were sampled over a four-week period, from 11 August through 9 September 1997. The traps were collected weekly and replaced with new traps, and the numbers of WCR beetles per trap were counted and recorded.

In Test 2, a similar arrangement was used as in Test 1. The treatments were placed in maize in a trapping row for each trap type. The 2 treatments were 1) HP traps and 2) Pherocon AM traps. This study was conducted in 2 fields (32 and 71 ha) with 6 replications of each treatment per field. The test was conducted over a 3-week period, 2 September to 23 September. As with Test 1, the traps were collected weekly and replaced with new traps at each trapping site. Numbers of WCR adults on each trap were counted and recorded weekly.

Results and Discussion

In Test 1, for the first 3 weeks beetle trap catch numbers were not significantly different (LSD 0.05) between the HP traps in soybean and Pherocon AM traps in maize (HP traps had an average of 181, 222, and 325 beetles/trap/week for weeks 1, 2, and 3, respectively; Pherocon AM traps in maize had an average of 205, 243, and 341 beetles/trap/week for weeks 1, 2, and 3, respectively). They were, however, significantly different (LSD 0.05) from the Pherocon AM traps in soybean on week 1 and 3 (Pherocon AM traps in soybean had an average of 118 and 217 beetles/trap/week for weeks 1 and 3, respectively). In week 2, the HP trap catch was not significantly different (LSD 0.05) from the Pherocon AM traps in soybean (HP traps had an average of 222 beetles/trap for week 2; Pherocon AM traps in soybean had an average of 189 beetles/trap for week 2). By week 4, all traps were statistically different (LSD 0.05) from each other with the HP traps in soybean catching the highest numbers (233 beetles/trap for week 4), the Pherocon AM traps in maize catching the next highest (178 beetles/trap for week 4), and the Pherocon AM traps in soybean the lowest (94 beetles/trap for week 4).

When the data from Test 1 were combined and evaluated over the four-week period, the Pherocon AM traps in maize and the HP traps in soybean were not statistically different (LSD 0.05) from each other (HP traps had an average of 240 beetles/trap/week; Pherocon AM traps in maize had an average of 242 beetles/trap/week). The data show that the HP traps in soybean, although catching significantly (LSD 0.05) more WCR beetles than the Pherocon AM traps in soybean in 3 of the 4 weeks of the study, only caught significantly (LSD 0.05) more WCR beetles than the Pherocon AM traps in maize on week 4 (Fig. 1). The results therefore indicated that each trap type should be evaluated in each crop to get a true picture of trap performance in that crop. Since the HP and Pherocon AM traps were compared in Test 1 in soybean, but only the Pherocon AM trap was placed in maize, a similar study was set up in maize to evaluate the two trap types (Test 2).

In Test 2, the HP traps caught significantly (LSD 0.05) more beetles than the Pherocon AM traps over the 3-week trapping period (Fig. 2). The HP traps caught 324, 386, and 336 beetles/trap/week for weeks 1, 2, and 3, respectively, while the Pherocon AM traps caught 185, 80, and 32 beetles/trap/week for weeks 1, 2, and 3, respectively. Therefore, the HP traps in maize caught significantly (LSD 0.05) more beetles than the Pherocon AM traps in maize. However, based on the numbers of WCR beetles caught on the Pherocon AM traps, the numbers were sufficient to indicate the presence of an economic WCR population. Also, the declining numbers of beetles caught on the Pherocon AM traps in maize, as shown in Figure 2, were a better indicator of the normal in-field fluctuation of a population since there was a natural decline of the population taking place at this time based on information from this and other study sites.

As noted before, WCR beetles are only visually attracted to the yellow sticky traps, such as Pherocon AM and Multigard traps. Thus, when these are placed in a field, only beetles within sight of a trap have the likelihood of being caught. The range of the HP trap as presently designed goes beyond a single field, thus making reliable estimates of WCR beetle abundance within a field nearly impossible. When making a pest control decision for a field, it is important to make that decision based on the specific field population. The HP trap is by far the best trap for detecting the spread of a WCR population, and its early buildup within an area. However, once economic populations are present, visual traps such as the Pherocon AM and Multigard traps are more efficient in predicting the potential for economic losses to occur the following season from larval feeding on maize roots.

Acknowledgments

We are indebted to Jim Wilkinson for allowing us to use his farm for these studies. We are grateful to the Food and Agriculture Organization of the United Nations for supplying the Hungarian pheromone traps. This is Purdue Agricultural Research Programs Paper No. 15695.

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(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Pflanzenschutzberichte
Band 57, Heft 2, 1998

Vorläufige Ergebnisse der Versuche zur chemischen Bekämpfung der Larven des Western Corn Rootworm *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae)

Preliminary results of chemical control against Larvae of Western Corn Rootworm *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae)

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Zusammenfassung

Nach dem ersten Auftreten von Adulten des Western Corn Rootworm (WCR) *Diabrotica virgifera virgifera* LeConte (Coleoptera: Chrysomelidae) im Hochsommer 1995 in Ungarn wurde in den darauffolgenden Jahren eine beträchtliche Verbreitung dieses Schädlings festgestellt. Beobachtungen mit Pheromonfallen haben gezeigt, daß sich die WCR-Population auf den angrenzenden Maisfeldern in den südlichen Provinzen um ein Vielfaches vermehrt hat. Die ersten Bekämpfungsversuche gegen WCR Larven mit Insektiziden wurden 1997 in zwei Standorten der Provinz Csongrad durchgeführt. Die Insektizide wurden in Form von Saatgutbehandlung und als Saatfurchenbehandlung während der Aussaat Ende April und in der ersten Woche des Monats Mai eingesetzt. Die Bewertung dieser Maßnahme fand Mitte Juli durch Benotung der Wurzelschäden nach der „Iowa-Skala“ von 1 bis 6 statt.

Im Vergleich zu den unbehandelten Parzellen wurden keine signifikanten Unterschiede festgestellt. Dies kann auf das späte Schlüpfen der Larven und gute Regenerierung des Wurzelsystems durch ausreichenden Niederschlag in den Monaten Juni und Juli zurückzuführen sein. Geringe Wurzelschäden wurde ebenfalls auf unbehandelten Parzellen festgestellt.

Stichwörter: *Diabrotica virgifera virgifera* LeConte, Chemische Bekämpfung, Saatgutbehandlung, Saatfurchenbehandlung.

Summary

After the first appearance of Western Corn Rootworm adults (WCR), *Diabrotica virgifera virgifera* LeConte (*Coleoptera: Chrysomelidae*) in Hungary in the middle of summer 1995, a considerable spread of the pest was registered in the following years. Pheromone traps observations showed that the WCR population had increased manifold in the southern counties on bordering corn fields.

The first experiments using insecticides to control WCR larvae were carried out in 1997 in two locations of Csongrád County. Insecticides were applied as seed-dressings and as furrow treatments at time of sowing at the end of April and in the first week of May. Assessments took place in the middle of July by determination of root damage according to the “Iowa-scale” of 1–6.

Treatments showed no significant difference compared to untreated plots. This can be explained by late larvae hatching, and good regeneration of root systems because of a suitable amount of precipitation during June and July. Negligible root damage level was observed on untreated plots as well.

Key words: *Diabrotica virgifera virgifera* LeConte; WCR; chemical control; seed-dressing; furrow treatment.

Introduction

Western Corn Rootworm (WCR), *Diabrotica virgifera virgifera* LeConte (*Coleoptera: Chrysomelidae*) originates from North America, where it is among the most economically important pest in the corn belt. Cumulative losses due to yield reduction and control costs amount to almost 1 billion dollars per year. Annually, 20 to 25 million acres (8–10 million hectares) of corn are treated with soil insecticides to protect the crop from larval feeding damage (WOODSON and CHANDLER, 1997).

Since WCR was found in Yugoslavia in 1993 distinctive interest has been shown in this pest all over Europe. According to comparative studies on weather conditions of BACA ET AL. (1995) WCR is able to find suitable ecological circumstances for establishment and reproduction and therefore represents a potential economic risk for European corn production, particularly in the central European countries.

First WCR were detected in Hungary in the middle of summer, 1995. In 1996 and 1997 a monitoring system was established all over the country using pheromone traps. Based on results of captures, a considerable spread of the pest was registered. Observations indicated the establishment of WCR in bordering corn fields of southern regions with a manifold increase in the pest population.

No economic damage caused by either larvae and or beetles of WCR was observed in Hungary till now. However, in 1997 some feeding scars caused by larvae on roots and feeding traces of beetles on leaves and silk were observed in the most infected areas.

In 1996 a nationwide WCR program (coordinated by the Ministry of Agriculture and implemented by specialists in the plant protection network) was started to slow down the spreading process and to delay the increase of economic damages. As a part of this program, in 1997 two experiments were conducted in the most infected areas of Csongrád county to get preliminary information on the possibilities of chemical control against WCR larvae. Monitoring data from 1996 predicted the possibilities of root damage in these fields the following year.

Material and Methods

Experimental plots were situated in the district of Szeged near the Yugoslavian border and in Csanádpalota neighbouring Romania. The most important data concerning the fields and the set-up of trials are summarised in Table 1.

Sowing took place in Csanádpalota one week later than in Szeged. Variety, plot size and the number of replicates were the same on both experimental sites. Plots were placed randomly.

Table 1: Data of experiments for control of WCR larvae

Sites	Szeged	Csanádpalota
Date of sowing / treatment	April 29	May 05–06
Variety	Szegedi TC 465	
Preceding crop	corn for 18 years	corn for 3 years
Plot size	50 m²	
Replicates	4	
Type of soil	meadow clay soil	meadow chernozem soil
Assessments:		
– root rating	July 14	July 15

Applied pesticides were selected on the basis of soil insecticides registered in corn crop in Hungary and some new not yet registered products have been taken into account as well. Treatments were carried out according to the instructions of manufacturers (Table 2).

Seed-dressing was done in the laboratory with ROTADEST equipment. Soil insecticides were applied at the time of sowing, but not directly on seeds. Before granulate formulations were dispersed by hand and the liquid formulations spread by knapsack sprayer (F2000 type) seeds were covered with 2–3 cm soil blanket, and after the treatments a 4 cm soil layer was put on the rows.

Assessments of trials were completed in the middle of July to determine root damage caused by larvae. On each plot 5 x 2 roots were dug and washed out randomly. Root damage was rated according to the "Iow-scale" of 1–6 values (EDWARDS ET AL., 1992).

Table 2: Treatments applied for control of WCR larvae

Products	Active ingredient	Rate	Application
Aztec 2.1 G	tebupirimfos+cyflutrin	75 g/metre of the row	furrow treatment
Chinufur 40 FW	carbofuran	2.0 l/ha	furrow treatment
Cosmos	fipronil	700 ml/100 kg seed	seed-dressing
Counter 5 G	terbufos	20 kg/ha	furrow treatment
Force 10 CS	tefluthrin	0.5 l/ha	furrow treatment
Force 10 CS	tefluthrin	4.0 l/100 kg seed	seed-dressing
Gaucho 350 FS	imidacloprid	3 µl/seed	seed-dressing
Marshal 25 EC	carbosufan	2.0 l/ha	furrow treatment
Mospilan 20 SP	acetamiprid	700 g/100 kg seed	seed-dressing
Regent 15 G	fipronil	10 kg/ha	furrow treatment

Results

Temperature threshold (t) and thermal constant (K) for egg hatching were determined by LEVINE ET AL. (1992) $t = 12.7$ °C and $K = 209.7$ day-degrees respectively. According to these data egg hatching generally can be expected from the middle of May. In 1996 egg hatching was observed on 13 May in Serbia (BACA ET AL., 1995).

A considerable fall in temperature was observed in the second half of May in both experimental fields with daily average temperatures of 15,3 °C in Szeged and 11,2 °C in Csanádpalota respectively.

The first newly hatched larvae were found in Szeged on 16 June. The larvae hatching period started also in the middle of June in Serbia (SIVCEV, personal communication) that year.

Favorable weather conditions accelerated the development of larvae later in the season (rising temperature, good amount of precipitation). Precipitation during June influences on yield reduction due to root damage (SIVCEV, 1997). Climatic conditions in June and July had a positive effect on root system regeneration and resulted in good development for corn plants.

On both experimental fields we found very low damage from larvae on roots. The average values of root damage did not exceed the 2,5 level of scale on untreated control plots either in Csanádpalota, or in Szeged. (Economical losses can be expected over a value of 3 – EDWARDS, personal communication.) Average root damage levels were generally slightly higher in Csanádpalota than in Szeged.

Results summarized for seed-dressing in Table 3 and for soil treatments in Table 4 show no clear differences between the efficiency of applied insecticides.

Table 3: Effect of seed-dressing on WCR larvae according to evaluation of root damage

Treatments	Replicates	Average root damage rate (Iowa-scale)	
		Szeged	Csanádpalota
Untreated control	1	2,0	2,1
	2	2,0	2,3
	3	2,1	2,8
	4	2,0	2,0
	average	**2,03**	**2,30**
Cosmos 700 ml/100 kg seed	1	1,6	1,7
	2	2,0	2,1
	3	1,8	2,0
	4	1,4	2,0
	average	**1,70**	**1,95**
Force 10 CS 4.0 l/100 kg seed	1	1,8	1,6
	2	2,0	2,2
	3	1,7	2,7
	4	1,7	1,6
	average	**1,80**	**2,03**
Gaucho 350 FS 3 µl/seed	1	2,0	2,0
	2	1,7	1,6
	3	1,8	3,4
	4	1,9	1,6
	average	**1,85**	**2,15**
Mospilan 20 SP 700 g/100 kg seed	1	1,9	1,7
	2	1,7	2,2
	3	2,0	2,6
	4	1,8	2,0
	average	**1,85**	**2,13**

Table 4: Effect of soil treatments on WCR larvae according to evaluation of root damage

Treatments	Replicates	Average root damage rate (Iowa-scale)	
		Szeged	Csanádpalota
Untreated control	1	2,0	2,1
	2	2,0	2,3
	3	2,1	2,8
	4	2,0	2,0
	average	**2,03**	**2,30**
Aztec 2.1 G* 75 g/metre oft the row	1	—	1,7
	2	—	1,9
	3	—	1,9
	4	—	1,8
	average	**—**	**1,8**
Chinufur 40 FW 2.0 l/ha	1	1,9	1,8
	2	1,8	2,0
	3	1,8	2,2
	4	1,9	2,1
	average	**2,08**	**2,03**
Counter 5 G 20 kg/ha	1	2,1	1,6
	2	2,1	2,1
	3	2,0	2,0
	4	2,1	1,6
	average	**2,08**	**1,8**
Force 10 CS 0.5 l/ha	1	1,9	2,0
	2	1,8	2,0
	3	2,0	1,7
	4	2,0	2,0
	average	**1,93**	**1,93**
Marshal 25 EC 2.0 l/ha	1	1,9	1,6
	2	1,7	2,6
	3	2,0	2,0
	4	1,7	2,0
	average	**1,83**	**2,05**
Regent 15 G 10 kg/ha	1	1,6	1,6
	2	1,6	2,0
	3	1,7	3,5
	4	1,9	1,9
	average	**1,70**	**2,25**

* Treatment with Aztec 2.1 G was not carried out in Szeged.

Discussion

However, the most efficient and cheapest way to interrupt the reproduction of WCR is crop rotation, which could not be practised in all cases in the corn producing areas. Tillage did not significantly affect the survival of *Diabrotica* (GRAY and TOLLEFSON, 1988). Prophylactic insecticide applications seem to be necessary in the future to control western corn rootworm. Refer to Table 5 for insecticides that are recommended for rootworm control by EDWARDS ET AL. (1995).

Table 5: Insecticides for rootworm control in USA

against adults	against larvae
carbaryl (Sevin)	chlorpyrifos (Lorsban 15 G)
carbaryl+cucurbit bitters (Slam)	ethoprop + fonofos (Holdem 20 G)
chlorpyrifos (Lorsban)	fonofos (Dyfonate II 15 G)
diazinon (Diazinon)	phorate (Thimet 20 G)
esfenvalerate (Asana XL)	terbufos (Counter 15 G)
malathion (Malathion)	tefluthrin (Force 1.5 G)
methyl paration (Penncap-M)	
permethrin (Ambush, Pounce)	
phosmet (Imidan)	

Based on preliminary results of these two experiments it is impossible to make final conclusions about preferable active ingredients or methods of application against *Diabrotica* larvae. Since the damage level was low on roots, it was difficult to judge the efficiency of tested preparations. The question is whether there are any insecticides able to keep their effect long enough to provide acceptable control of WCR larvae during such a prolonged larvae hatching period, as in 1997.

Control strategies have to be expanded to protect corn fields from the mass egg laying of females. For adult control a semiochemical insecticide-bait (SLAM) was also used with aerial application in the same experimental fields later in the season.

Some promising laboratory test results are mentioned in the literature on beneficials, particularly entomoparasitic nematodes (BURGT ET AL., 1997; JACKSON and BROOKS, 1995; NICKLE ET AL., 1994), which can attack different developmental stages of the pest. There are no real efficient biological agents available to put into practice yet. Further investigations are also necessary in this field.

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(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Pflanzenschutzberichte
Band 57, Heft 2, 1998

Umsetzung eines großflächigen USDA-ARS Pflanzenschutzprogramms gegen den Corn Rootworm in den USA

Implementation of the USDA-ARS Corn Rootworm areawide managment program across the United States

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Zusammenfassung:

Das großflächige Pflanzenschutzprogramm des USDA-ARS wurde als koordiniertes IPM Programm für die Behandlung von Schädlingspopulationen bzw. ihre Einschränkung auf vorgegebene Befallsgrade durch die einheitliche Anwendung von Pflanzenschutzmaßnahmen über weite abgrenzbare geographische Gebiete konzipiert. Im Jahr 1995 wurden Mittel für eine Machbarkeitsstudie über die Durchführung eines großflächigen IPM Programms gegen den Western Corn Rootworm *Diabrotica virgifera virgifera* LeConte und den Northern Corn Rootworm *Diabrotica barberi* (Smith und Lawrence) zur Verfügung gestellt. Im Jahr 1996 wurden, im Rahmen der ersten Phase des Programms, Standorte ausgewählt, um dort Hintergrundinformationen über die Entwicklung der Corn Rootworm-Population und entsprechende Pflanzenschutzmaßnahmen zu sammeln. Für die folgenden Staaten wurde jeweils ein Standort ausgewählt: Illinois/Indiana, Iowa, Kansas, South Dakota und Texas. Jeder Standort umfaßt eine Fläche von 41,4 km², nur das texanische Testgebiet ist mit 20,7 km² kleiner.

Im Jahr 1997 begann die Umsetzung des Programms auf nationaler Ebene (Phase 2). Die Zahl der Adulten des Corn Rootworm wurde genau überwacht, und bei Erreichung eines vorgegebenen Grenzwertes wurde der semichemische Insektizidköder SLAM® eingesetzt. Neben der Sammlung von Erfahrungswerten über die Bekämpfung von Corn Rootworm-Populationen wurden Umfragen durchgeführt um festzustellen, welche wirtschaftlichen und soziologischen Vorteile dieser großflächige Ansatz für Landwirte, Agrarbetriebe und andere Kunden bringt. Auch der relative Empfindlichkeitsgrad einzelner Rootworm-Populationen gegenüber Insektiziden wurde festgestellt. Das Programm wird noch bis ins Jahr 2000 weitergeführt in der Hoffnung, daß dann ein Technologietransfer zum Privatsektor stattfinden wird.

Stichwörter: Corn Rootworm, *Diabrotica virgifera virgifera, Diabrotica barberi,* großflächiger Pflanzenschutz, Insektizidköder, IPM.

Summary

The USDA Agricultural Research Service administered areawide pest management initiative is designed to be a coordinated IPM program targeted at suppressing or maintaining a pest population at predetermined levels using uniformly applied control measures over large definable geographic areas. In 1995 funds were provided to study the feasibility of conducting an areawide IPM program against the western, *Diabrotica virgifera virgifera* LeConte, and northern, *D. barberi* Smith and Lawrence, corn rootworms. Phase 1 of the program was conducted in 1996 to identify study sites and gather site background data related to corn rootworm population dynamics and management practices. A single site was selected for each of the following states: Illinois/Indiana, Iowa, Kansas, South Dakota, and Texas. Each site was 41.4 km² in size, except for Texas which was approximately 20.7 km²

Full scale implementation of the program (Phase 2) was initiated in 1997 Corn rootworm adults were monitored and a semiochemical insecticide-bait, SLAM, was applied when beetle numbers reached predetermined thresholds. In addition to the information on corn rootworm population suppression, surveys were conducted to determine economic and sociological benefits of the areawide approach to growers, agricultural businesses, and other customers. Relative levels of insecticide susceptibility between rootworm populations were also determined. The program will continue through the year 2000, with hopes that transfer of the technology to the private sector will occur at that time.

Key words: corn rootworm, *Diabrotica virgifera virgifera, Diabrotica barberi,* areawide pest management, insecticide-baits, IPM

Introduction

The western (WCR), *Diabrotica virgifera virgifera* LeConte (including the Mexican corn rootworm subspecies *zeae*), and northern (NCR), *D. barberi* Smith and Lawrence, corn rootworms are primary insect pests of maize (*Zea mays* L.) throughout the United States corn belt (METCALF, 1986). Annually, crop losses and control costs attributed to both species approach $ 1 billion (U. S. dollar). Soil insecticides targeted at larvae, foliar insecticides for adults, and crop rotation remain the three primary tools for management of these insects. These strategies have all been successful, but some problems now exist with each method. Soil insecticides do not provide population management and thus, despite protecting maize root systems, do not always reduce the need for yearly applications of toxicants (GRAY ET AL., 1992 and SUTTER ET AL., 1991). Two distinct WCR populations in Nebraska are known to be resistant to two common foliar applied insecticides, carbaryl and methyl parathion (MEINKE ET AL., 1998). Additionally, WCR is known to lay eggs in soybean in portions of Illinois and Indiana, thus reducing the effectiveness of corn/soybean rotations as management tools in that region (EDWARDS ET AL., 1996). Another problem with crop rotations is related to a portion of NCR eggs which hatch only after remaining in the soil for more than a single winter (extended diapause). Damage to maize planted after soybean occurs when these insects hatch after the second winter. Because of the above concerns management of rootworms must now be based on alternative control methods depending on the region of the United States maize is grown in.

In the late 1980's scientists with the USDA Agricultural Research Service (ARS) and cooperating universities developed a new management tool based on suppression of adult rootworms using an environmentally friendly insecticide-bait (SUTTER and HESLER, 1993). The bait, composed of cucurbitacins, carriers, and carbaryl, is applied to maize foliage before beetles have an opportunity to lay the majority of their eggs, thus preventing economic larval infestations from occurring the following year. Cucurbitacins are found in most plants of the family Cucurbitaceae and are known to stimulate rootworm beetle feeding while repelling other insects. The increased feeding activity exposes beetles to the toxicant and eventually kills the insect. The insecticide-bait that is currently used, SLAM (MicroFlo Co.), can be applied with air or ground sprayers and uses 95 to 98% less active ingredient than traditional foliar insecticides (CHANDLER and SUTTER, 1997 and CHANDLER, 1998). These baits, if used over a large geographic area (areawide management), have been shown to successfully manage rootworm populations (SUTTER ET AL., 1998).

Areawide management of agricultural pests has been defined as a systematic reduction of a target pest(s) to predetermined levels through the use of uniformly applied pest mitigation measures over large geographical areas, as opposed to a farm-to-farm basis, that are clearly defined by biologically based criteria. The areawide pest management program administered by ARS is charged with establishing and implementing action programs for key pests and crop systems that have been identified as high priority (CALKINS ET AL., 1997). Programs are to 1) result from a stakeholder partnership and collaboration dedicated to the development and adoption of improved crop-management technologies; 2) demonstrate the positive impacts and advantages of such a program over a large area through enhanced grower profits, reduced worker risks, an enhanced environment, and the proven superiority of an areawide IPM strategy as compared to past and current control approaches; and 3) achieve a mature areawide pest management system so farmers, consultants, and local organizations will be left with an operational program that will meet the overall goals through its adoption (CALKINS ET AL., 1997). These voluntary programs require a partnership between Federal, State, and local governments and private interests.

The information presented in this report summarizes the current efforts involved in implementing an areawide management program for WCR and NCR across the United States. Data presented will be limited to development of the program and initial summaries of the 1997 results.

Materials and Methods

In 1995 the Corn Rootworm Areawide Management Ad-Hoc Committee was formed to guide the development and implementation of the program. The Committee is composed of individuals from several Federal government agencies and cooperating universities. A conceptual plan was developed and the program divided into three distinct phases: 1) site development and background information gathering – 1996; 2) program implementation – 1997 to 1999; and 3) final assessment and technology transfer – 2000. Three university and two ARS areawide management sites were selected for the study: a) Illinois/Indiana – partners are Purdue University and the University of Illinois; b) Iowa – partners are Iowa State University, South Dakota State University, and the University of Minnesota; c) Kansas – partner is Kansas State University; d) South Dakota – conducted by ARS with South Dakota State University; and e) Texas – conducted by ARS with Texas A&M University (Figure 1). Each site is 41.4 km^2 in size, with the exception of Texas which is approximately 20.7 km^2 Various size commercial production control areas outside of each areawide management site were selected for comparison of the effectiveness of the program. Three augmentative programs were established to provide needed assessment of the utility and viability of the areawide concept. These programs were: a) economic assessment – conducted by Purdue University; b) sociological assessment – conducted by Iowa State University; and c) insecticide resistance management – conducted by the University of Nebraska.

Phase 2 (implementation) of the program was initiated during the 1997 growing season. Each study site selected a manager who was charged with developing protocols to conduct the areawide program. Growers within each site met with the study investigators and partnerships were developed. Each maize field within the management sites and the control areas were mapped (GIS/GPS) and then scouted weekly for corn rootworm beetles. Soybeans were also mapped and scouted in Illinois/Indiana. Emergence cages were placed in selected fields to track adult development. Yellow sticky traps (Pherocon AM), whole plant counts, or a combination of both methods were used to determine the number of insects present within a field and to decide upon timing of the bait applications. Bait applications were made by aircraft. At the end of the growing season yield information was gathered from participating growers.

Results and Discussion

WCR were numerous in the Illinois/Indiana, Iowa, and Kansas sites during the 1997 growing season. WCR and NCR occurred in substantial numbers (> 1 beetle/plant) in many fields in the South Dakota site. Mexican corn rootworm numbers in the Texas site were low. Applications of insecticide-bait were made at all sites. The Illinois/Indiana site, which is in the center of the region where WCR has experienced a behavioral change leading to oviposition in soybeans, required numerous bait applications to maize and soybeans to lower beetle populations. A total of 94 maize fields (2066 ha) and 73 soybean fields (1823 ha) were monitored. Out of that total 39, 50, and 5 maize fields and 40, 21, and 6 soybean fields were treated with SLAM once, twice and three times, respectively. In the Iowa site, 2440 ha of maize were scouted and 93% treated one time and 54% treated twice. The Kansas site treated 69% of their maize (1720 ha) one time and retreated 27% of their fields. In South Dakota, 535 ha (39% of the total) of maize were treated with no retreatments required. Fourteen maize fields (421 ha) were treated with SLAM in Texas and no retreatments were made. All applications substantially reduced (up to 95%) corn rootworm adult numbers. No indication of insecticide resistance to carbaryl was observed in beetles from any of the sites. Most applications of SLAM provided up to 10–14 day residual. Site managers were generally satisfied with the mortality provided by the bait even though some fields had to be sprayed multiple times. Single applications of insecticide-bait appear economically comparable to conventional rootworm control methods using either soil or foliar applied insecticides.

Further evaluation of 1997 results will be made during the 1998 growing season. Root ratings will be made from plants in each field per site to determine the effectiveness of the bait applications in limiting oviposition. If soil insecticides are applied to any fields, growers will be requested to leave untreated strips to evaluate rootworm populations with and without the effects of soil toxicants. Further economic and sociological surveys with growers will be made to assess the impact the areawide program is having with the local economy and quality of life.

Although the implementation phase of the program has been in place for only a single year positive results have occurred. Cooperation among universities, government agencies, and the private sector has been outstanding. The management structure of each site has evolved and is now positioned to foster the transfer of the areawide technology to users if further assessment of the results indicate that management of corn rootworm is feasible using this approach. We recognize that areawide management of corn rootworms may not work well for every maize growing area in the United States. However, the data we have gathered and continue to compile will provide us with needed information to more correctly structure these large scale programs to the needs of local clientele.

Acknowledgments

All of the participants at each corn rootworm areawide management site and within the augmentative research programs are gratefully acknowledged for their valuable help and willingness to be involved in this large undertaking. Additionally, ARS thanks the growers and local business people who entered into agreements with each site to conduct the studies and allow their farms and crops to be an integral part of the program.

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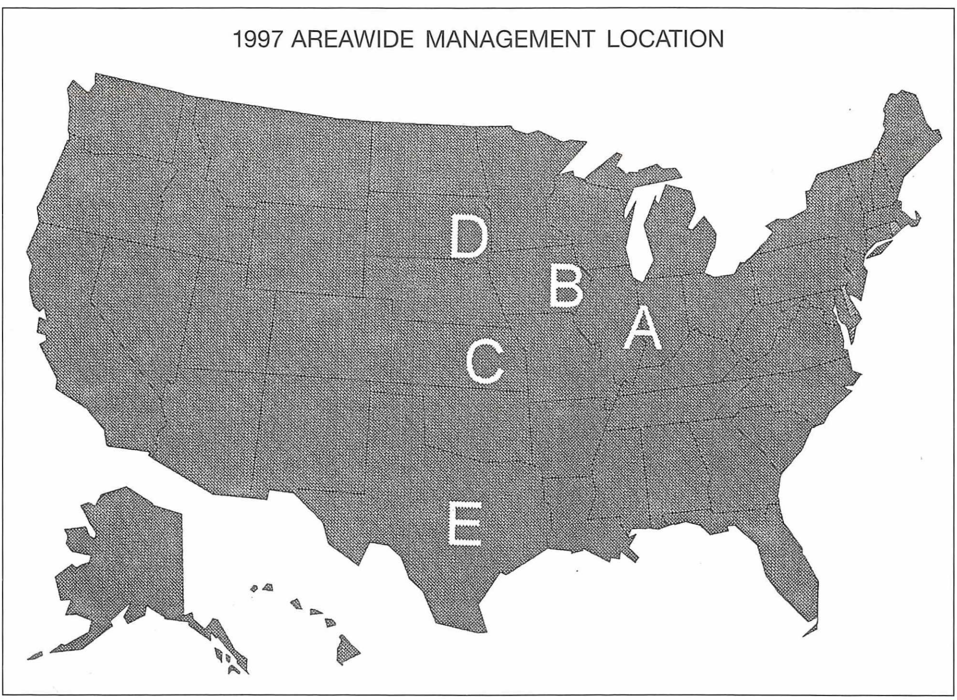
(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Figure 1: Locations of the corn rootworm areawide pest mangement study sites in the United States: A) Illinois/Indiana; B) Iowa; C) Kansas; D) South Dakota; and E) Texas.



Pflanzenschutzberichte
Band 57, Heft 2, 1998

Großflächiges Pest Management beim Western Corn Rootworm in Indiana und Illinois – die erste Runde

Areawide Pest Managment of Western Corn Rootworm in Indiana and Illinois – turning the first corner

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Zusammenfassung

Dieses großflächige Pflanzenschutzprogramm stammt aus Indiana bzw. Illinois und dient der Bekämpfung des Western Corn Rootworm (WCR) (*Diabrotica virgifera virgifera* LeConte) mit dem semichemischen Insektizidköder SLAM® in weitläufigen geographischen Gebieten.

Das Programm umfaßt 45 Betriebe mit ungefähr 4900 ha Mais- und Sojabohnenfeldern an der Grenze zwischen Indiana und Illinois. Es wurde festgestellt, daß der WCR sein Verhaltensmuster dort stark verändert hat und verhältnismäßig viele Eier in Sojabohnenfelder legt. Dieses neue Verhaltensmuster hat alle Vorteile der Fruchtfolge so gut wie zunichte gemacht und die Landwirte zum Einsatz von Bodeninsektiziden auf dem Großteil ihrer Maisfelder genötigt. Die Dichte der adulten WCR-Population in den Maisfeldern wurde durch Stichproben erhoben, wobei die Anzahl von Schädlingen auf zwei Pflanzen pro Testparzelle in einem Feld gezählt wurde. In Sojabohnenfeldern wurde die Schädlingspopulation mit Hilfe gelber klebriger Pherocon AM®-Fallen und einem Insektenfangnetz erfaßt. SLAM wurde auf nahezu 4.050 ha Testgebiet eingesetzt. Vierzehn Mais- und elf Sojabohnenfelder, d. h. 850 ha aneinandergrenzende Felder innerhalb des großflächigen Standortes, wurden als unbehandelte Kontrollgruppe ausgespart. Durch die permanente Anwesenheit dieses Schädlings wird die Behandlung der adulten Population auf diesem großflächigen Standort äußerst kostspielig. Die abschließenden Statistiken für 1997 haben gezeigt, daß auf 166 der 169 Felder des behandelten Testgebiets mindestens einmal eine chemische Behandlung durchgeführt wurde. Insgesamt wurden auf diesen 166 Feldern 279 Behandlungen verzeichnet; 70 Felder wurden einmal behandelt, 80 zweimal, 15 dreimal und 1 viermal. Drei Sojabohnenfelder wurden wegen unrentabler Dichte an adulten WCR nicht behandelt. Insgesamt wurden mehr als 6.075 ha mit einem Flugzeug zur Beobachtung und Kontrolle überflogen.

Key Words: Großflächiges Pest Management, Western Corn Rootworm, *Diabrotica virgifera virgifera* LeConte, Pheromonfalle, Cucurbitacin, Slam®, Pherocon AM® Falle, Soyabohne, *Glycine max,* Mais, Zea mays

Summary

The Indiana and Illinois areawide pest management program was designed to manage the western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, over a wide geographic area using the semiochemical insecticide-bait, Slam®. The program included 45 farmers with approximately 4900 ha of maize and soybean on the Indiana and Illinois border. WCR beetles in this area have exhibited a dramatic change in behavior by laying high numbers of eggs in soybean fields. This behavioral change has virtually eliminated the benefits of crop rotation as a rootworm management tactic, and caused growers to apply soil insecticides to most of their maize fields. WCR adult populations in maize fields were sampled by counting the number of beetles infesting two plants in each of 10 locations within a field. Populations were estimated in soybean fields using Pherocon AM® yellow sticky traps and an insect sweep net. Nearly 4050 ha comprised the management zone in which Slam was applied (3887 ha maize and soybean, and 163 ha other). Fourteen maize and 11 soybean fields adjoining or within 850 ha km of the areawide site served as the untreated check. The continuous presence of beetles within the areawide site made adult control a costly proposition. Final statistics for 1997 showed that of the 169 fields in the treated zone, 166 received at least one chemical application. In these 166 fields, 279 applications were made. Of the fields receiving treatments, 70 were treated once, 80 twice, 15 three times, and 1 four times. Three soybean fields were not treated due to sub-economic levels of WCR adults. Over 6.075 ha of beetle-control flights were logged by the two aerial applicators.

Key Words: Areawide Pest Management, Western Corn Rootworm, *Diabrotica virgifera virgifera* LeConte, pheromone trap, cucurbitacin, Slam®, Pherocon AM® trap, soybean, *Glycine max,* maize, Zea mays

Introduction

In areas of Indiana and Illinois, the adult of the western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, has exhibited a dramatic change in behavior by laying high numbers of eggs in soybean, *Glycine max* (L.), fields (LEVINE and OLOUMI-SADEGHI, 1996; SAMMONS ET AL., 1997). Previously, most eggs were laid in maize, *Zea mays* L., fields where the adults emerged or immigrated. This behavioral change has virtually eliminated the benefit of crop rotation as a rootworm management tactic in the affected region, and caused growers to apply soil insecticides to most of their maize fields. The areawide pest management (AWPM) program has been established to manage the WCR over a large, well-defined area in Indiana and Illinois so as to provide an alternative to traditional methods of control and to test the feasibility of areawide pest management.

The AWPM program is a coordinated effort that links a group of farmers together with crop consultants, applicators, an agricultural chemical dealer, and university and government researchers. The summer of 1997 marked the start of this 4-year study. Similar projects, sponsored by the United States Department of Agriculture (USDA), are being conducted in Iowa, Kansas, South Dakota, and Texas. A primary component of these AWPM projects is the use of a liquid semiochemical insecticide-bait, Slam® (Micro Flo, Lakeland, Florida), to manage WCR adult populations over a large contiguous area. Targeting adults with insecticides or an insecticide bait has been shown to be an effective means for reducing rootworm adult populations (PRUESS ET AL., 1974; MAYO, 1976; LANCE and SUTTER, 1992).

Materials and Methods

A 41.4 km^2 area that includes parts of Benton and Newton Counties in Indiana and Iroquois County in Illinois was selected as the AWPM study site. This location was chosen because it is located in one of the areas where WCR beetles have exhibited the behavioral change of laying high numbers of eggs in soybean fields, and because it is in close proximity to the institutions coordinating the study, Purdue University and University of Illinois. The AWPM study enlists the partnership of 45 farmers with approximately 4601 ha of maize and soybean in the study area. In general, these farmers rotate maize/soybean and practice conservation tillage. Approximately 3,887 ha of maize and soybean fields (94 maize fields, 2065 ha; 75 soybean fields, 1822 ha) and 163 ha of other fields are within the management site. About 714 ha of untreated maize and soybean fields (14 maize fields, 417 ha; 11 soybean fields, 297 ha) are adjoining or within about 0.85 km of the management site.

The central component to the AWPM program is the product Slam. Slam consists of cucurbitacins, which are feeding stimulants (FERGUSON ET AL., 1983; METCALF et al., 1987); a low-rate of carbaryl insecticide, which acts as the toxicant; and inert carriers. Cucurbitacins are derived from the dried roots of the buffalo gourd, *Cucurbita foetidissima* H. B. K. They cause compulsive feeding by the rootworm beetles when the beetles come into contact with them. Because of the beetle's voracious appetite for cucurbitacins, only a small dose of carbaryl in the bait is required to kill it. Also, the carbaryl dose in the bait has been shown to be less toxic to the predatory ladybird beetle, *Coleomegilla maculata* (DeGeer), than the standard rate of carbaryl applied by most farmers (WEISSLING and MEINKE, 1991). Therefore, when compared with other rootworm adulticides, the points noted above make Slam an ideal product for use in an areawide pest management program.

Slam was applied whenever populations of rootworm beetles exceeded the economic thresholds in maize and soybean fields. The treatments were made to individual fields by airplane. In order to determine the need and proper timing of chemical treatment, agronomists from Midwest Consulting Service (MCS), Maple Park, IL, monitored the maize and soybean fields within the management site for WCR beetles. The untreated check fields which were outside the management site were monitored by MCS as well, but were not treated for WCR adult management.

Sampling for adult WCR in maize and soybean fields was conducted for 7 weeks; beginning 21 July and ending 3 September. Adult WCR populations in maize were sampled by counting the number of beetles infesting 2 plants 0.9–1.5 m apart in each of 10 locations within a field. WCR adult populations were estimated in soybean fields using Pherocon® AM yellow sticky traps (Tre'ce' Inc., Salinas, California) and a 38.1 cm diameter sweep net. Pherocon traps, distributed through the field in 2 rows of 4 traps each, were positioned so that 1/2 the trap was above the soybean canopy. Old traps were replaced with new traps after 1 week. Four sets of 25 sweep net samples were collected in the soybean fields when the Pherocon traps were changed each week. Numbers of male and female WCR; northern corn rootworm, *D. barberi* Smith & Lawrence; ladybird beetles, and lacewings were recorded each week for both sampling methods in soybean.

The decision to treat for WCR beetles was based on economic thresholds for maize of 0.5 beetle/plant in first-year maize and 0.7 beetle/plant in continuous maize (EDWARDS ET AL., 1998), and at least 10% of the female beetles being gravid. The economic threshold in soybean was arbitrarily determined to be 2 beetles/Pherocon trap/day. The actual adult threshold in soybean, as it relates to the threat of economic injury by larvae in maize the following year, is not yet known. However, the threshold used in soybean should be low enough to prevent significant egg-laying from occurring in these fields. Empirical observations of the population levels of WCR adults in soybean during the past several years suggest that it is economically impractical to manage WCR using a threshold lower than 2 beetles/Pherocon trap/day. By using the maize thresholds described above, the goal was to kill a majority of WCR beetles in maize fields with Slam before they migrated to soybean to lay their eggs. With this strategy in mind, it was expected that less than 1/2 of the soybean fields in the study site would need to be treated with Slam.

Although Slam formed the basis of the AWPM program and was the primary chemical used to control WCR adults, Slam expenditures reached a level in late summer that necessitated the use of more economical chemical products to finish the beetle-control season. Sevin® XLR

Plus (Rhone-Poulenc, Research Triangle Park, North Carolina) and Penncap-M® (Elf Atochem North America, Philadelphia, Pennsylvania) were selected and used at rates of 1.17 l/ha and 1.75 l/ha, respectively, in 33 fields.

In addition to WCR beetle scouting, MCS provided full season scouting for weeds, plant diseases, and other insects to all growers participating in the AWPM program. Full season scouting was conducted on all program maize and soybean fields inside and outside of the management site. This service was made available to growers at a discounted cost of U. S. $ 0.81/ha. The remainder of scouting costs were paid through the USDA grant. Additional features of the scouting program included maize yield estimates and global positioning boundary mapping of all fields in the study. An optional fertility testing program was made available to each farmer through MCS. The costs associated with the purchase and application of chemicals used to control WCR beetles in the management site were provided at no cost to the growers through the USDA grant.

Results and Discussion

Growers experienced unusual weather in 1997 Favorable conditions in the spring allowed for early planting of maize and soybean. However, cool temperatures followed planting which delayed plant germination and growth. A period of little to no precipitation during crop establishment was followed by heavy rain that resulted in loss of crops in some areas, some of which were replanted. Although hot and dry conditions prevailed during most of the maize pollination period, several timely rains reduced stress to the crops in the study site area.

WCR beetle populations were extremely high in both maize and soybean in 1997 This abundance of WCR adults could have been predicted from the extensive larval damage observed in many first-year maize fields, most of which were treated at planting with reduced or labeled rates of granular soil insecticides. The prevalence of rootworm larval damage in insecticide-treated maize may have resulted from several factors including early planting dates in conjunction with delayed egg-hatch, and/or early-season rain which may have caused the insecticide to leach from the root zone or hastened its degradation.

WCR beetles were first observed in maize fields in the AWPM program site on 14 July. Populations increased quickly, and by 28 July, 2 maize fields were treated with Slam. In the 3 days following, 63 maize fields and 5 soybean fields were treated. Whole-plant beetle counts in some of these maize fields ranged from 7-10 beetles per plant. The initial treatment rate for Slam was 0.07 kg in 2.84 l H_2O/ha. Windbrake® (Terra International, Inc., Sioux City, Iowa) drift retardent was added to Slam at a rate of 0.34 kg/379 l spray solution. Slam treatments during this time appeared to be efficacious in maize. Within 15 hours post-treatment, virtually all WCR beetles were dead. However, due to a concern about the lack of residual toxicity in several maize and soybean fields, and the rapid increase in the number of soybean fields reaching threshold levels within the first 8-9 days of treatments, a decision to increase the rate of Slam to 0.09 kg/ha was made on 6 August.

The first rain after the initiation of the Slam treatments came on 11 August. Wet and windy conditions lingered through the week and culminated in a 5.59 cm rain on 16 August. With no improvement in reducing the number of fields requiring treatment, the rate of Slam was reduced to 0.07 kg on 19 August. From 4–22 August, an equal number of maize and soybean fields were treated. By that time, 39, 50, and 5 maize fields, and 40, 21, and 6 soybean fields had been treated once, twice, and three times, respectively, using 2,676 total kg of Slam. The large beetle population coupled with an extended period of beetle emergence from the soil hampered our ability to control this pest with available funding. From 28 August to 6 September, only soybean fields located 0.85 km or more from the edges of the areawide management site were treated. Sevin XLR Plus and Penncap-M were substituted for Slam. This option was pursued primarily for economic reasons, but the lateness of the season also reduced need for residual beetle control. The two aerial applicators who were contracted for in this project, Joe Zumwalt, Zumwalt Aviation, Sheldon, Illinois; and Scott Schertz, Schertz Aerial Service, Inc., Hudson, Illinois, collectively treated approximately 6,359 ha. They treated fields within 12 to 24 hours of notification.

In conclusion, a continuous wave of WCR beetles that inundated the AWPM program site made adult control with Slam a formidable, and costly, proposition. Final statistics show that 75 fields were treated once with Slam, 65 twice, and 11 three times. Twenty-eight fields were treated with Sevin XLR Plus and 5 were treated with Penncap M (Tables 1 and 2). Three soybean fields did not reach threshold levels and were therefore not treated. Most of the fields in the untreated areawide zone (bordering or within 0.85 km of the outer most fields of the WCR management site) reached beetle threshold levels, but were not treated.

Table 1: Frequency of Slam®, Sevin® XLR Plus and Penncap-M® treatments applied to maize and soybean fields located in the areawide study site during 1997

	MAIZE			SOYBEAN			TOTAL
	1*	**2***	**3***	**1***	**2***	**3***	
Slam	41	48	5	39	17	6	243
Sevin XLR+	0	0	0	27	1	0	29
Penncap-M	2	0	0	1	2	0	7
Total	43	48	5	67	20	6	279

* Frequency of insecticide application

Table 2: Frequency of Slam® applications followed by Sevin® XLR Plus or Penncap-M® to maize and soybean fields located in the areawide study site during 1997. Number of fields receiving these tretment combinations are in parantheses.

	MAIZE	SOYBEAN
Slam / SevinXLR+	0* 0* 0* 0*	1* + 1* (14) 2* + 1* (4) 1* + 2* (1) 3* + 1* (1)
Slam / Penncap-M	1* + 1* (1)	1* + 1* (1)

* Frequency of insecticide application

The degree of success of this year's AWPM study will not be fully apparent until the mid growing season of 1998 when the effect of beetle control on the 1998 WCR larval population becomes apparent. However, undoubtedly, the successes of the first year of this study have to be judged by the farmers' willingness to participate in the study and the establishment of a strong infrastructure – composed of crop consultants, aerial applicators, agriculture chemical dealer, and university and government researchers – that is poised to carry this program into the future.

Acknowledgments

We are grateful to the farmers, crop consultants, aerial applicators, agriculture chemical dealer, and others who helped design and execute this program. Also, we would like to thank USDA/ARS for providing the funds that made this study possible. This is Purdue Agricultural Research Programs Paper No. 15693.

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(Manuskript eingelangt am 15. April 1998, angenommen am 20. Oktober 1998)

Buchbesprechung / Book review

W. BÖHM

Bibliographisches Handbuch zur Geschichte des Pflanzenbaus.
398 Seiten
DM 198,–, S 1445,–, sfr 176,–
K. G. Saur Verlag, München, 1997

Im bezogenen bibliographischen Werk wurden 669 Persönlichkeiten, in erster Linie aus der akademischen Pflanzenbauwissenschaft, aber auch Fachpersönlichkeiten der pflanzenbaulichen Tochterdisziplinen wie z. B. Phytopathologie, Bodenkunde, Gemüse- und Obstbau, Grünlandlehre, Agrarmeteorologie u. a. aufgenommen. Die Auswahl betrifft die Persönlichkeiten aus dem 19. und 20. Jahrhundert. Auf ein Werk, das die vorherige Zeitperiode zum Inhalt hat, wird hingewiesen: Guntz, M., Handbuch der Landwirtschaftlichen Literatur, 1897

Die Darstellung der Persönlichkeiten in Form von Kurzbiographien folgt einheitlich dem Konzept der diesbezüglichen Richtlinien der Bayerischen Akademie der Wissenschaften. Neben den biographischen Grunddaten, den Stationen des wissenschaftlichen Lebensweges und der Würdigung herausragender Leistungen sind jeweils die wichtigsten Buchveröffentlichungen und wichtige Veröffentlichungen in Zeitschriften angeführt.

Der Autor stellt im Vorwort ohne weitere Alternative den landwirtschaftlichen Pflanzenbau als Mutterdisziplin der Agrarwissenschaften heraus. Dem Rezensenten, der beruflich selbst dem photopathologischen Pflanzenbaubereich angehört, ruft diese Bestimmtheit ein Schmunzeln heraus, zumal ihm erinnerlich ist, daß diesen Anspruch auch Agrarökonomen erheben; unter den Ausführungen zu Thaer, A. C., ein Agrarökonom, wird diese Feststellung auch etwa in diesem Sinne bestätigt.

Der Rezensent fühlt sich Charles Darwin, britischer Naturforscher 1809–1882, und seiner Evolutionstheorie (Deszendenztheorie, Selektionstheorie) besonders verbunden („The Origin of Species", 1859). Es war daher interessant, im vorliegenden bibliographischen Werk zwar den Hinweis zu finden, daß Charles Darwin als berühmtester und einflußreichster Naturwissenschafter des 19. Jahrhunderts gilt und als Begründer der neuzeitlichen Evolutionstheorie in die Geschichte Eingang fand, daß aber Charles Darwin, den interessanten Ausführungen folgend, auch unmittelbar dazu beigetragen hat, die entsprechend der damaligen Lehrmeinung als pflanzenschädigend geltenden Regenwürmer als Nützlinge für die Bodendurchmischung und für die Erhaltung und Mehrung der Bodenfruchtbarkeit zu dokumentieren. Diese Feststellung hatte in der Folge eine rege Forschungstätigkeit in dieser Frage zur Folge. Heute wird die Rolle der Regenwürmer wohl von niemandem angezweifelt.

Bei der Darstellung verschiedener Fachpersönlichkeiten werden interessante Abschnitte zur „Geschichte der Photopathologie" vermittelt, und aus heutiger Sicht interessante Neuerkenntnisse, aber auch Irrungen und Extremerkenntnisse aufgezeigt. Unter letzteren wären z. B. Aussagen von Thormann, F. C. (1896–1977) aufzuzeigen, dessen „Erfolg in Förste" offensichtlich keine ausreichende Nachhaltigkeit in der Bewirtschaftung ermöglichte.

Noch ein weiterer Eindruck wird bei der Lektüre über die Fachpersönlichkeiten erweckt; z. B. bei Rudolf Steiner: Heute besteht oft der Eindruck, als wäre die biologische Landwirtschaft in den verschiedenen Ausprägungsformen eine jüngste Entwicklung gegen die derzeitige wissenschaftlich-technische Landwirtschaft. An Hand der Biographie über Rudolf Steiner (1861–1925) wird gewahr, daß dessen Aktivitäten in eine Zeit fallen (1924), in der in der Landwirtschaft von einem wissenschaftlich-technischen Stadium im Sinne der pflanzlichen Ertragssicherung durch Hochzuchtsorten, durch verschiedene Formen der Bodenbearbeitung, aber auch durch Nutzung von Agrarchemikalien wie Mineraldüngern und synthetischen Pflanzenschutzmitteln noch keine Rede sein konnte. Aus dem Versuchsring anthroposophischer Landwirte (gegründet 1924!) entwickelte sich der biologisch-dynamische Landbau. Auf den Komponenten Umweltschutz, Ressourcenschutz und Nachhaltigkeit in der praktischen Landbewirtschaftung hat sich schon zu einer Zeit ein Zielfkonflikt entwickelt, zu der nach heutiger Sicht die heutigen Kontroversen fehlten.

Es liegt für den Rezensenten wohl nahe, das Buch auch auf österreichische Pflanzenbaupersönlichkeiten hin durchzustöbern. Und es ist ein befriedigendes Erlebnis, auch zahlreiche österreichische Wissenschafter, sogar aus jüngster Zeit, zu finden und deren Personendaten und deren Werdegang und Wirken dokumentarisch zu erfahren.

Ferner ist bemerkenswert, daß in die Wirkungszeit der Persönlichkeiten des vorgegebenen Zeitabschnittes sehr häufig die Gründung neuer wissenschaftlicher Einrichtungen, neuer Institute, neuer landwirtschaftlicher Akademien, neuer Landwirtschaftsgesellschaften und neuer landwirtschaftlicher Forschungs- und Prüfungsanstalten fällt.

Das Buch ist ein inhaltsreiches Informations- und Nachschlagwerk, bei dessen Lektüre eine überspringende Spannung über Werdegang und Leistungen historischer Fachpersönlichkeiten vermittelt wird. Sie waren nach heutigem Jargon allesamt „innovationsbereit und belastbar“ Es sei angemerkt, mit einem gewissen Bedauern, daß die Fachpersönlichkeiten konsequent ohne Porträt-Abbildung vorgestellt werden. Dieses interessante und beim Lesen interesseweckende Werk könnte in Fachkreisen durchaus auch als begehrtes und repräsentatives Geschenk bei besonderen runden Anlässen Eingang finden.

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