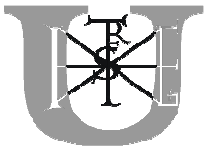

SZENT ISTVÁN UNIVERSITY

EVALUATION OF THE WESTERN CORN ROOTWORM (*DIABROTICA VIRGIFERA VIRGIFERA* LeCONTE) ADULT POPULATION THROUGH TRAPPING AND INFORMATION ON THE ADAPTATION OF THIS INSECT TO THE SOYBEAN-CORN CROP ROTATION SYSTEM

Thesis of Ph. D.

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GÖDÖLLŐ

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1. INTRODUCTION

1. 1. Actuality and importance of the project

The Western Corn Rootworm (*Diabrotica virgifera virgifera* LeConte) (WCR) is the most serious insect pest of maize (Zea mays) in The USA since 1900 (Krysan and Miller, 1986). WCR was first observed in Europe in maize in 1992 at Surcin, Yugoslavia (i.e., in Serbia), near the Belgrade International Airport (Bača, 1993). Since its first discovery in Yugoslavia its spread is continuous. WCR spread covered 182 000 km^2 by the end of 2000 while the pest reached the economic threshold on 26 500 km^2 (Kiss and Edwards, 2001). Crop losses can reach 4t/ha annually in the US (Edwards, 2000).

This new corn pest, which was unknown in Europe till 1992, can greatly impact the Integrated Pest Management in corn, and needs new management practices. Population sampling and forecast data form the basis of its management and decision strategy. Beside the quick spread intensity of WCR, the population WCR is still at low level in Hungary, but there are some locations where it reaches economic threshold. Due to the increase of WRC population the adaptation of sampling methods and threshold values are to Hungarian conditions are of great importance.

Data are available for decision-making and sampling methods from the mid-western states of the USA, where the population density is high. These data may contribute to create IPM strategies and decision making for WCR in Europe.

1. 2. Research objectives

Expecting spread and population increase of Western Corn Rootworm in Europe request to create the management practices against this corn pest. Sampling methods and data from maize/soybean fields in northwestern Indiana counties served the basis of this research.

Research objectives:

1. Examination of the suitability of different types of insect traps for gauging WCR adult population levels.

2. Optimizing trap placement in cornfields.

3. Analyze the factors that lead to the adaptation of the WCR to the soybean-corn crop rotation system.

4. Pest forecast possibilities for WCR larval problems in corn grown in the soybean-corn crop rotation system:
   - in soybean cultures, based on western corn rootworm adult surveys
   - soybean-corn rotation, based on trapped male/female adult results

5. Examination of the relationship between trap catch numbers and the following year's damage, as caused by WCR larvae, as a measure for root protection.

2. MATERIALS AND METHODS

In order to study the population dynamics of and control methods for the western corn rootworm (WCR), *Diabrotica virgifera virgifera* LeConte, I carried out, in collaboration with personnel from the Department of Entomology, Purdue University, W. Lafayette, Indiana, USA, a trapping study with several types of insect traps in 6 Indiana counties in 1996, 1997 and 1998. (**figure 1.**).

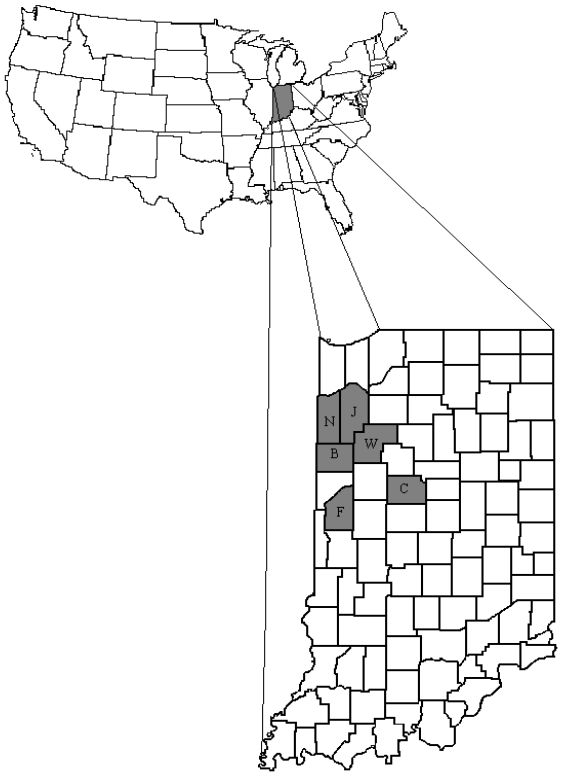

Figure 1. Location of Indiana counties where sampling was conducted (W=White, C=Clinton, N=Newton, J=Jasper, F=Fountain, B=Benton)

Seventeen pairs of maize/soybean fields in 6 northwestern Indiana counties were used in my study. Field size varied from 12-45 hectares. Tillage, planting date and crop inputs were managed as generally accepted. The above mentioned counties farmers' produce only corn and soybean in yearly crop rotation.

My basic hypothesis was that decision on treatment for rootworm larvae in corn should be predicted through monitoring of WCR adults in previous soybean. For this reason I carried out the study on yearly rotated corn-soybean fields.

2. 1. Examination of the suitability of different types of insect traps for gauging WCR adult population levels.

The suitability of different types of traps for capturing WCR adults was examined in 6 paired corn and soybean fields in 1996, 1997 and 1998. The experiment was conducted in Benton County in northwest Indiana. In each field the following traps were placed:

- Pherocon AM unbaited yellow sticky trap,
- Cucurbitacin baited vial trap,
- Olson unbaited sticky trap, and
- yellow Cone [Survey Trap]).

In 1996 traps were randomly placed in corn rows 12., 24., 36., 48., 60., 72. with row 12 being closest to the soybean field. This arrangement was used to determine the efficiency of each trap for trapping WCR adults, and to look at variability among traps within a field and variability of WCR across a field. As a result of the analysis of data generated in 1996, it was decided that only one type of trap was needed in corn to provide WCR population data sufficient for relating to populations in soybean. The trap of choice was the Pherocon AM trap.

In the soybean fields, 6 trap of each trap type, as noted above for corn in 1996 were placed randomly in one of 4 trapping lanes in 1996. In 1997, the same types of traps were used in soybean, excepting the cone trap, that was replaced by the new Pherocon CRW trap, which contained cucurbitacins as the feeding stimulant, carbaryl as the toxicant and paraffin as the carrier. Since the results from 1996 were basically the same in each row in the corn, it was not necessary to place traps in multiple rows in 1997 and 1998. The first row of corn next to each soybean test field was selected for WCR trapping in 1997 and 1998. Also, since

the primary trapping was to be concentrated in soybean, it was not necessary to use all trap types in corn. Therefore, the Pherocon AM trap was selected for use in the corn.

To have more precise analysis for the trial, the trap numbers were increased to 8 in the last two trapping seasons. Due to the results and bed experience of Olson unbaited sticky trap I did not use this trap type in 1998.

I also managed the comparison of Pherocon AM and Csalomon sex-pheromone baited traps in separated fields. There are two frequently used trap types in Europe, the Csalomon sex-pheromone baited trap and the visual Multiguard or Pherocon AM unbaited trap.
To evaluate results from Europe (sampling of population density at low level) I have made an evaluation at a high-level population density (USA) as the base of comparison.
Trap catch comparison study was divided into two parts:

- a comparison of trap catches for Csalomon sex-pheromone and Pherocon AM traps over time in corn and soybean, and
- a comparison of the two trap types in corn. The latter study was added because of the results obtained in the initial stages of the first part, and to better simulate the WCR situation in corn in Central Europe.

In the first part of the study Csalomon traps were placed in soybean fields between the Pherocon AM trap locations in soybean and corn. Therefore, the 3 treatments in the first part were:

1) Csalomon sex-pheromone traps placed in soybean
2) Pherocon AM traps in soybean, and
3) Pherocon AM traps in corn.

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 were sampled over a four-week period from 11 August through 9 September 1997. Traps were collected weekly and replaced with new traps.

In the second part of the study a similar arrangement was used as in the first part. The treatments were placed in maize in a trapping row for each trap type. The two treatments were:

1) Csalomon sex-pheromone traps and
2) Pherocon AM traps.

This study was conducted in two 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 part 1, the traps were collected weekly and replaced with new traps at each trapping site.

In 1998, trap types comparisons were conducted in 4 individual corn-soybean fields. Trap placement in the fields were the following:

- 8 Pherocon AM traps were in the middle row of corn field,
- 8 Pherocon AM traps also in the middle row in the neighboring soybean field.

From the 6 Csalomon sex pheromone traps there were 4 in the corner of corn-soybean neighboring fields and 2 traps in the border of corn and soybean crops. This study was conducted over a 10-week period.

2. 2 Optimizing trap placement in cornfields

Sampling procedure was conducted over three year period in 11 corn-soybean fields in 1996, 1997, and 1998:

Six Pherocon AM traps were placed in each of 11 paired corn and soybean fields. In 1996, three traps were placed in each of corn rows 12 and 24, with corn row 1 being next to the soybean field. Soybean fields were divided into thirds lengthwise, creating two transects running the length of the field between the three sections. Three Pherocon AM traps were placed in each transect and were separated by equal distance to cover the length of the field. In 1997 and 1998, the arrangement of traps in both corn and soybean was changed based on observations of trapping results from 1996. The data from the 1996 trapping activity showed that there was no difference between the two trapping rows in soybean and in corn. Therefore, trapping was simplified in 1997 and in 1998. The same numbers of traps, that being 6 per crop were utilized for three years. In corn in 1997 and in 1998, all 6 traps were placed at an equal distance from each other in the corn row nearest the soybean test field. In soybean, 6 traps were placed at equal distance in the middle of the field.

2. 3. Analysis of the factors leading to the adaptation of WCR to soybean-corn crop rotation system

By using emergence cages, the emergence of WCR adults in corn fields from eggs laid the previous year in soybean can be observed and the numbers of emerging adults recorded. Two pairs of untreated (no insecticide) rows were designated as the sampling unit in each corn field. Six traps were placed in each of 2 untreated rows for a total of 12 emergence traps per field. These samplings were conducted during three years (1996, 1997, 1998) on 8 corn fields with 96 emergence cages per year.

2. 4. Pest forecast possibilities for WCR larval problems in corn grown in the soybean-corn crop rotation system

As a part of the above studies, sweep net samples were taken each week in each soybean field so as to collect 30 beetles for sex ratio and stage of female ovarial development determinations. In corn fields, 30 beetles were also collected for the same purpose. The beetles in corn were collected by knocking them into a vial containing ethyl acetate.

2. 5. Examination of the relationship between trap catch numbers and the following year's damage, as caused by WCR larvae, as a measure for root protection

Relationship between damaged corn roots and next years' WCR population density in soybean fields were tested by conducting root-sampling procedure. The experiment was conducted as a part of the above studies. During three years of sampling period I dug 25 roots with 4 replications from each field in each year. Roots were dug, signed and cleaned with high pressure spraying machine. Evaluation was made by using Iowa 1-6 scale to examine larval feeding damage. Using data of captured WCR beetles in 1996 and larval damage values from 1997, I carried out statistical analysis to see relation between traps captures and larval feeding damage. The same analysis was made by using data of captured insects in 1997 and larval damage values from 1998.

3. RESULTS

3. 1. Suitability of different types of insect traps for gauging WCR adult population levels

The most efficient traps used in **corn** in 1996 were the Pherocon AM trap and the Olson unbaited sticky trap. Efficiency of Cucurbitacin baited vial trap and Cone WCR trap were on lower level. The most efficient traps used in **soybean** in 1996 were the Cucurbitacin baited vial trap and Cone WCR trap. Efficiency of Pherocon AM and Olson unbaited sticky traps were on lower level.
Due to the results and bed experience of Olson unbaited sticky trap in 1997 (dislodging of the Olson unbaited traps from the stakes in soybean by numerous periods of heavy rainfall and strong winds) I did not manage use of this trap type in 1998. (**figure 2.**).

Cone WCR trap was replaced by the new Pherocon CRW attracticide trap in 1997 (lower price). This type of trap showed high capture data, but its efficiency did not reach the Cucurbitacin baited vial trap. Capture data was the highest in week 12. August 1997 in the Cucurbitacin baited vial trap (925beetles/trap/week).

Efficiency of Pherocon AM trap capture was examined by many researchers (Steffey et al., 1982; Hein and Tollefson, 1984, 1985b; Karr, 1984; Shaw et al., 1984; Karr and Tollefson, 1987; Youngman et al., 1996) According to their results and simplicity of use this type of trap is the most common tool in sampling of WCR.

Using data from three years of trapping period I conclude that the Pherocon AM trap captures properly represent the WCR population density. This type of trap reflected the population fluctuation in corn and soybean fields (**figure 3.**).

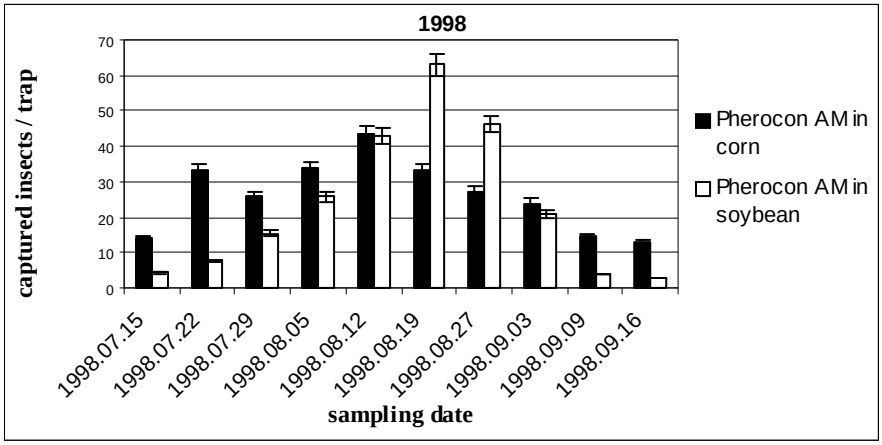

Figure 3. Western Corn Rootworm beetle captures on Pherocon AM traps in corn and soybean (USA, Indiana, 1998)

Data of captured WCR beetles in corn and soybean in 1996, 1997 and 1998 diagram shows that the population density was the lowest in 1998 caused by unfavorable weather conditions. Comparing data from 1996 and 1997 the population level was lower in 1996.

The WCR population density changed in each year in soybean and corn crops. Different population densities in corn and soybean were demonstrated by Pherocon AM traps. We concluded that this type of trap can be used suitably in corn and soybean crops even at different population level (**figure 4.**).

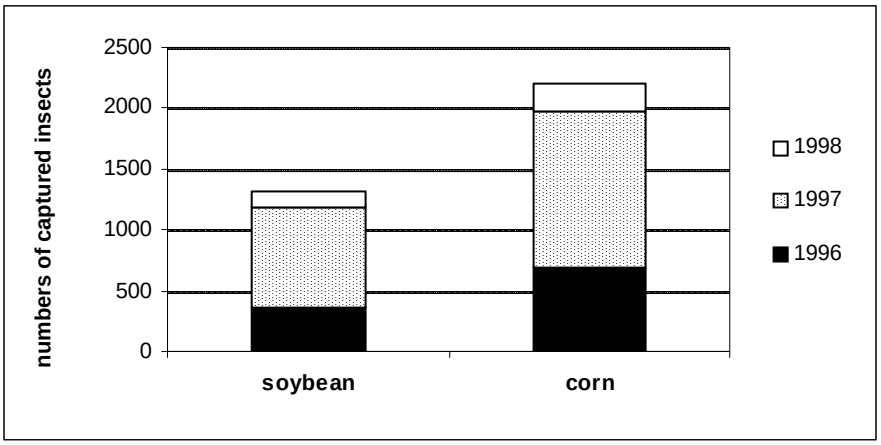

Figure 4. Pherocon AM trap yearly captures in 1 trap in soybean and corn crops (USA, Indiana, 1996, 1997, 1998)

Comparing capture data ba Pherocon AM and Csalomon sex-pheromone traps there were significantly higher catches in Csalomon sex-pheromone trap in 1997.

Pherocon AM trap catches were significantly lower in soybean than in corn in the first week of the trapping period. There was no difference in catches between different crops in the second week, contrary in the 3rd and 4th week when catches in soybean were lower again.

Csalomon sex-pheromone traps in soybean had an average of 235 beetles/trap/week in the 4th week what represents the highest catches. The Pherocon AM traps in corn catched the next highest (182 beetles/traps/week), and the Pherocon AM traps in soybean represented the lowest catches (94 beetles/traps/week). In the second part of the study in 1997 Csalomon sex-pheromone traps caught significantly more beetles than Pherocon AM traps over the 3-week trapping period.

In 1998 there was no significant difference between Pherocon AM trap catches in soybean and corn crops. In case of Csalomon sex-pheromone traps there was

strong relationship between catches from corn, soybean and the from interface of two crops. Csalomon sex-pheromone traps in soybean had the highest average catch. Significant difference can be seen between capture of two types of traps in soybean and corn crops. The fluctuation of WCR population density can be followed up by Pherocon AM traps in corn and soybean crops during sampling period.

The Csalomon sex-pheromone trap also shows the WCR population dynamic in the two crops and in the corn soybean interface. The Csalomon sex-pheromone trap efficiency was significantly higher in soybean in week 4, 6, and 7 than in corn and in the crop interface.

The Csalomon sex-pheromone trap did not follow the WCR population fluctuation as good as the Pherocon AM trap. There were permanent high WCR captures in the last three weeks of the trapping period in Csalomon traps, while the Pherocon AM traps indicated the collapse WCR population (**figure 5.**).

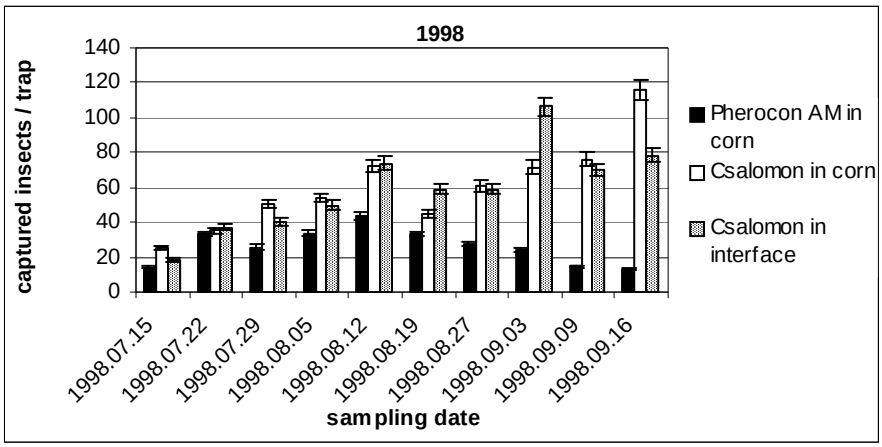

Figure 5. Pherocon AM and Csalomon sex-pheromone trap capture in corn and in corn-soybean interface (USA, Indiana, 1998)

Examining trap capture efficiency there were significantly higher capture in Csalomon sex-pheromone placed in soybean and in the two crop interface, than in Pherocon AM traps in soybean.

There is no significant difference between Csalomon sex-pheromone trap capture in soybean and in the two corps interface, except for weeks 4, 7, and 9. In case of these three weeks the most captured beetles were in sex-pheromone traps in soybean. There is no significant difference between Pherocon AM and Csalomon sex-pheromone traps placed in weeks 1, 2, 3, 4, 6 in corn and in the two crop's interface.

There is no significant difference between trap catches in corn and in the two crop's interface. The highest capture was in the Csalomon sex-pheromone traps placed in soybean. Captures in corn differ only with 11%in corn and with 12% in the interface of corn soybean crops.

Based on data from Pherocon AM traps, their efficiencies were almost the same in soybean and corn crops.

3. 2. Optimizing trap placement in cornfields

Using data from Pherocon AM traps I have conducted statistical analysis what proved that there is no significant difference between captures in row 12 and 24 in corn. In 1997 and 1998, the arrangement of traps in both corn and soybean was changed based on observations of trapping results from 1996. Therefore, trapping was simplified in 1997 and in 1998. As a result of the analysis of data generated in 1996, it was decided that only one row placement of traps was needed in corn to provide WCR population data sufficient for relating to populations in soybean. There is no need to place traps into rows in corn what decreases time of labor work.

3. 3. Analysis of factors that lead to the adaptation of the WCR to the soybean-corn crop rotation system

Figure 6. summarizes the results of WCR adult captures in emergence cages in corn following soybean for three years of the study. Although peak emergence occurred later in 1996 than in 1997 and in 1998, the dates of the beginning of emergence and completion of emergence for the three years were similar. The highest number of beetles captured in 1996 was 23 beetles/m^2 while 15 beetles/m^2 were captured in 1997.

Due to the heavy rainfall in springtime the population density was the lowest in 1998. The highest number of beetles captured in this year was only 5 beetles/m^2 (**figure 6.**).

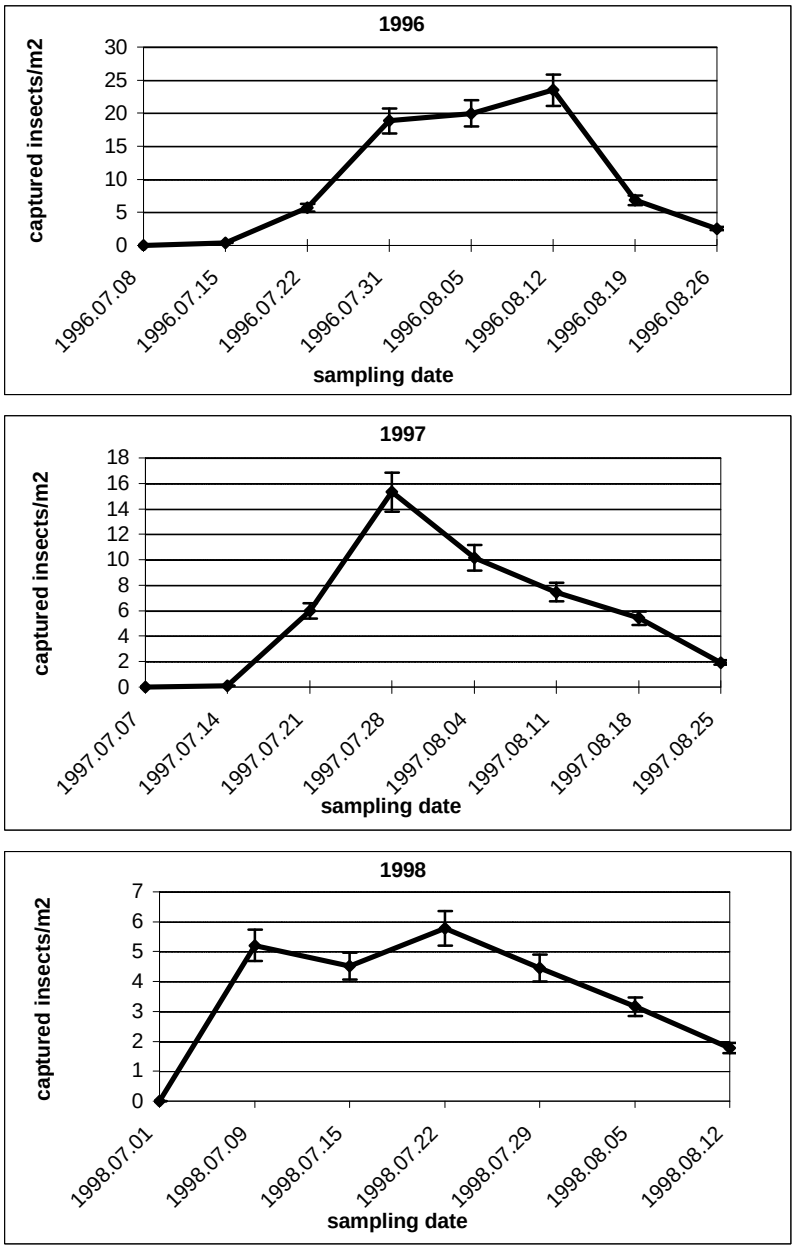

Figure 6. Western Corn Rootworm beetle captures in emergence cages (USA, Indiana, 1996, 1997, 1998)

3. 4. Pest forecast possibilities for WCR larval problems in corn grown in the soybean-corn crop rotation system

Western Corn Rootworm population estimates were made by determining beetle number on Pherocon AM traps in 1996, 1997 and 1998. During the sampling periods, when WCR beetles were present in corn they were also present in soybean. Statistical analysis were conducted and proved that the population density is significantly higher in corn than in soybean. However the population dynamic is similar in corn and soybean crops.

During the three years sampling period, at the time of WCR adult peak, an approximately 85-90% of beetles were female. From the start of sampling period, the number of male beetles was decreased both in corn and soybean. Number of female beetles was higher in soybean in 1996, 1997 and 1998 while number of male beetles was higher in corn.

Statistical analysis proves significant high numbers in soybean in three years than in corn. Numbers of female beetles were increased in both corn and soybean at the end of trapping period.

3. 5. Examination of the relationship between trap catch numbers and the following year's damage, as caused by WCR larvae, as a measure for root protection

Evaluation was made by using Iowa 1-6 scale to examine larval feeding damage. In 17 experimental fields there were only 5 fields (29%) where the larval feeding damage reached the economic threshold (grade 3 on Iowa 1-6 scale). Larval damage was different, but not significant between rows treated with insecticides and untreated corn rows.

Using data of captured WCR beetles in 1996 and larval damage values from 1997, I carried out statistical analysis to see relation between traps captures and

larval feeding damage. By using regression analysis I examined relationship of two variables. I was searching for tightness of linear relation between variables by using correlation analysis. The same analyses were made by using data of captured insects in 1997 and larval damage values from 1998.

For the analysis I have used data from 3-week period (12 August-3 September) in each year. By the regression analysis in 1996-1997 and in 1997-1998 trapping period there was weak relationship between WCR population and next years' larval feeding damage.

4. DISCUSSIONS

To establish control decision-making of Western Corn Rootworm the use Pherocon AM trap is suitable.

Data show that overall the Pherocon AM trap is the most efficient trap among the trap types evaluated to use in soybean and corn. The Pherocon AM trap provides more accurate data on the population dynamic of the WCR than did the Csalomon sex-pheromone trap. However sex-pheromone traps provide higher captures from greater distance.

Based on results from three years of trapping period it is obvious that a portion of the WCR population prefers soybean over corn during this time period.

Laying eggs in soybean fields increases the likelihood of larval survival the following growing season since a high percentage of soybean fields will be rotated to corn. During this period WCR adults are also represent in alfalfa, millet, ragweed. I also observed them on *Setaria*, *Ambrosia*, and on *Abutilon theophrasti* Medic. These observations prove that WCR feeding habit had changed partly; they lost exclusive attraction to feed corn. Sampling of WCR adults in previous soybean provides suitable basis for insecticide control decision-for next year corn.

5. SUMMARY

Results:

1. Based on the trapping results for 1996, 1997 and 1998, I concluded that for WCR population information and establishing control decisions based on 4 trap types, the most reliable insect trapping value is generated from the Pherocon AM unbaited yellow sticky trap. The identification of captured WCR adults on this trap is easy. This trap shows the dynamics of the pest population (adult/trap, sex ratio) in accordance with that of the natural population.

2. In the comparison made between the Hungarian pheromone baited trap and the Pherocon AM unbaited yellow sticky trap, I concluded that the Pherocon AM trap better mimics the natural field population. Data from the pheromone baited trap, which attracted only males, showed that it did not give a true picture of field level population.

3. Based on the results from the Pherocon AM portion of the trapping study, I concluded that placing the traps in the outside row of the cornfield is good enough to determine the possibility for larval damage to occur the following year in the field next to the corn.

4. Based on the results from the Pherocon AM unbaited sticky traps, I established that the adults of WCR immigrate in large numbers into soybean fields from surrounding cornfields. Based on the results from emergence cages in the following year's corn (in soybean the previous year), I verified that damage can also occur in corn in the soybean-corn crop rotation system.

Females lay eggs in soybean fields and root damage shows up on the roots in the next year's corn crop. This fact proves that the WCR has adapted to the soybean-corn crop rotation system.

5. I established that surveys for WCR adults in soybean fields can serve as an indicator for possible rootworm larval problems in that field if it goes to corn the next year.

6. I verified what this year's WCR adult trap numbers mean in next year's corn as far as larval activity is concerned. These values provide information for decision making regarding WCR larval control in next year's corn crop

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Ferenc Tóth, **Gy Barna** (1999): A new aspirator device for sampling spiders or insects. (Poster display presentation, 18th Eropean Colloquium of Arachnology, 12-17. July 1999).

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