A Preliminary Threshold for Western Corn Rootworms Monitored in Soybeans: A New Management Tool in the Protection of First-Year Corn

Matt O'Neal, Mike Gray, Kevin Steffey, and John Shaw

As early as the mid-1980s, economic levels of rootworm damage in rotated corn (first-year corn) had occurred in east central Illinois. Most larval injury in the 1980s and early 1990s was attributed to the extended diapause of northern corn rootworms. However, in 1995 the severity and frequency of rootworm larval damage to corn planted after soybeans reached a new, devastating peak (Levine & Gray, 1996). Apparently the widespread use of crop rotation in east central Illinois had selected for a strain of western corn rootworms that could circumvent crop rotation by laying eggs in soybeans.

Rootworm adults lay eggs in the soil from late July through early September, and the eggs overwinter until the following spring. The eggs hatch and larvae feed on the roots of corn during June and July. Because rootworm larvae cannot survive on soybean roots, and because adults laid eggs only in corn (or so we thought), the rotation of corn and soybeans has been very effective for managing rootworm populations.

In response to grower requests for management information about this new strain of western corn rootworm, we began a two-year study to develop an economic threshold for western corn rootworm adults captured with Pherocon AM yellow sticky traps in soybeans. The trap was chosen as the sampling tool because it is available commercially and an economic threshold had been developed for western corn rootworms in continuous corn (Hein & Tollefson, 1985).

Since 1995, extension entomologists in Illinois have recommended the use of a soil insecticide as a practical approach to the uncertainty of rootworm larval injury to corn planted after soybeans for growers in the problem area of east central Illinois (Gray et al., 1997). Such a recommendation, without the use of an economic threshold, increases the probability of unnecessary use of soil insecticides. We present for the first time a preliminary economic threshold that should allow growers to make a more informed decision about the use of a soil insecticide for first-year corn production. Pherocon AM traps also can be used by extension educators to follow the movement and establishment of this new strain of western corn rootworm in their area. If this sampling approach and use of the associated threshold are adopted, the unnecessary use of soil insecticides should decrease.

Materials and Methods

One of our goals in constructing an economic threshold was to conduct on-farm research with the cooperation of growers. On-farm research has two inherent benefits for pest management research. Measurements taken on-farm more accurately reflect the environment in which an economic threshold might be used. Also, working directly with growers in their fields should encourage the use of our scouting protocol after the threshold is established.

In the spring of 1996, 20 east central Illinois farmers were invited to participate in our on-farm research project. Growers were asked to monitor adult western corn rootworms with Pherocon AM traps according to our standardized protocol. Producers also were asked to leave four untreated check strips throughout the length of a rotated cornfield. At the start of each growing season, we met with participants to discuss the mechanics of the experimental protocol. By meeting with farmers, we could fine-tune certain procedures to reflect a real-world approach to our study. In addition to the growers in east central Illinois, we recruited growers from western Illinois (McDonough County). At the start of 1996, their location was considered to be in no danger of western corn rootworm larval damage to

first-year corn, so the fields in western Illinois served as control fields. Through 1997 (O'Neal et al., 1997) few if any western corn rootworms had been collected in soybeans for these fields.

Root Ratings

In 1995, Eli Levine (Levine & Gray, 1996) surveyed for root damage in severely lodged first-year cornfields throughout east central Illinois. These first measurements were a response to the numerous reports from surprised growers who had experienced what was later determined to be western corn rootworm larval injury to first-year corn. Roots of untreated corn were evaluated for rootworm injury because few growers had considered treating rotated corn with a soil insecticide. Root ratings were alarmingly high. Mean root ratings in 4 of the 16 fields examined were above 4.0 on the Iowa State scale (1 to 6, Hills & Peters, 1971). The mean root rating for all 16 fields was 3.72. A root rating of 3.0 or greater is considered by many entomologists as a reasonable indicator of potential economic damage.

At the start of our threshold study, we developed a protocol for our volunteers that allowed for a fair comparison between treated and untreated first-year corn. Producers were asked to leave four untreated check strips (no soil insecticide used) in their rotated corn. Fifteen roots were dug throughout the length of each of the four alternating treated and untreated strips (n = 120 roots per field).

In 1996, because of the extremely wet and cool conditions and delays in planting, only 14 producers were able to plant corn in a timely fashion and establish check strips. However, these data could not be compared with beetle counts from soybean fields from the previous year. Nevertheless, the 1996 root ratings were useful both as an index for larval pressure during 1996 and as a comparison with root ratings from 1995. Overall, root ratings in 1996 were lower than those in 1995. In fact, only three fields had average root ratings of 3.0 or greater (Table 1).

In 1997, the larval pressure in rotated corn was heavy, noticeable in the overall increase in root ratings in all of our cooperators' fields (Table 1). Only one field (Livingston County, field 2) sampled had a lower rating in 1997 than in 1996, and that occurred only in the treated strip.

Table 1. *Mean root ratings[a] from first-year cornfields in six counties in east central Illinois. Ratings are for corn roots dug from treated (soil insecticide used) and untreated strips.*

	1996		*1997*	
County	*Treated*	*Untreated*	*Treated*	*Untreated*
Kankakee	NA	NA	2.17	2.86
Livingston				
Field 1	2.08	2.03	2.27	3.17
Field 2	2.10	2.67	1.93	2.62
Field 3	NA	NA	2.47	3.02
Grundy				
Field 1	1.33	1.26	1.98	2.27
Field 2	1.50	1.56	2.20	2.40
Ford				
Field 1	NA	NA	1.98	2.63
Field 2	NA	NA	3.75	4.91
Field 3	1.85	2.27	2.33	3.28
Iroquois				
Field 1	1.73	1.97	2.18	3.09
Field 2	2.07	2.33	2.45	3.70
Field 3	2.13	3.22	2.38	4.50
Field 4	2.15	3.03	2.74	4.02
Vermilion				
Field 1	2.08	3.30	2.85	4.13
Field 2	1.41	1.48	2.29	3.71
Field 3	2.05	2.07	3.89	4.28
Champaign	NA	NA	2.36	3.14
Average	1.89	2.27	2.48	3.40

[a] The root rating system used was the Iowa State University root-rating scale (Hills & Peters, 1971):

1. No visible damage or only a few minor feeding scars.
2. Some roots with feeding scars but none eaten off to within 1.5 inches of the plant.
3. Several roots eaten off to within 1.5 inches of the plant, but never the equivalent of an entire node of roots destroyed.
4. One node of roots destroyed or the equivalent.
5. Two nodes of roots destroyed or the equivalent.
6. Three or more nodes of roots destroyed.

Pherocon AM Traps

The following protocol was followed by all our cooperators who monitored their soybean fields with the Pherocon AM trap. Sixteen yellow sticky traps were placed just above the soybean plant canopy on metal fence posts. Traps were replaced every 7 days during a 3- to 4-week period. In 1996, we asked our cooperators to begin trapping during the third week of July. In 1995, densities of western corn rootworm adults peaked during this period.

Twelve of the sixteen traps were placed inside the field in three evenly spaced rows of four traps each (Figure 1). The remaining four traps were placed around the perimeter of the field, one trap

Table 2. *Eight-county summary of western corn rootworm beetles captured with Pherocon AM yellow sticky traps in soybean fields in 1996. Populations are estimated by mean number of beetles/trap/day; mean percentage of females are provided in parentheses.*

County	*Sampling Period*							
	July 22-29		*July 29-Aug 5*		*Aug 5-12*		*Aug 12-20*	
	In[a]	*Out*[b]	*In*[a]	*Out*[b]	*In*[a]	*Out*[b]	*In*[a]	*Out*[b]
Kankakee[c]	2.2	2.8	2.6	3.9	3.2	7.9	NA	NA
	(74)	(61)	(78)	(75)	(70)	(67)		
Livingston[d]	0.4	0.6	1.54	0.9	2.5	2.2	12.3	12.6
	(53)	(31)	(48)	(38)	(70)	(74)	(76)	(67)
Grundy[e]	0.3	0.6	0.8	1.4	1.9	3.0	5.4	4.7
	(63)	(64)	(81)	(19)	(84)	(64)	(50)	(49)
Ford[e]	NA	NA	1.6	2.0	3.2	2.6	3.3	3.9
			(77)	(81)	(79)	(74)	(62)	(63)
Iroquois[f]	2.2	2.8	5.3	5.9	8.3	10.8	15.1	22.7
	(33)	(32)	(69)	(71)	(74)	(70)	(68)	(70)
Vermilion[d]	2.5	4.9	5.4	9.6	8.3	12.9	17.3	7.9
	(39)	(39)	(59)	(63)	(69)	(61)	(72)	(61)
Champaign[3]	4.5	6.6	4.0	6.8	7.5	9.1	NA	NA
	(45)	(11)	(54)	(25)	(63)	(50)		
McDonough[e]	0.0	0.0	0.0	0.0	0.0	0.0	NA	NA

[a] Means reported are from 12 traps placed in 3 evenly spaced rows of 4 traps each (interior).
[b] Means reported are from 4 traps on the outside of each field border (exterior).
[c] N = 1 cooperator; [d] N = 3 cooperators; [e] N = 2 cooperators; [f] N = 6 cooperators.

on each side in the middle of a field margin. At the end of the growing season, traps were collected from each cooperator, and the number of western corn rootworm beetles caught per trap per day was determined for each sampling period. The number of females captured was determined for a subsample of at least 50 western corn rootworms per trap. For sample sizes of more than 50, the percentage of females in a 50-beetle subsample was multiplied by the total count.

In Table 2, counts of rootworm adults for 1996 are compiled by county. This summary illustrates the increase in the numbers of rootworm adults we witnessed throughout August. As the number of beetles increased, so did the percentage of females. Male western corn rootworms usually emerge before females. The increasing percentage of females in soybeans throughout August closely resembles the population dynamics of western corn rootworm in first-year corn reported by Godfrey and Turpin (1983).

At the time this manuscript was prepared, we were gathering the traps used in 1997. During the winter (1997-98), we will process all 1,200 traps and develop predictions regarding which fields are at economic risk of rootworm larvae in 1998.

Development of a Preliminary Threshold

By correlating the 1997 root ratings in untreated check strips with the 1996 beetle counts from Pherocon AM traps, we can begin to develop a preliminary threshold. The threshold is preliminary because only one cycle has been completed. Correlations and subsequent regressions will allow us to assess the value of counts of western corn rootworms in a soybean field for predicting root injury the following season. In Table 3, we report Pearson correlation coefficients (r) (PROC CORR, SAS Institute, 1997) to indicate the degree of correlation between the two described variables. A coefficient of 1.0 suggests that the two items being compared are highly correlated. The correlative parameters (date, number of traps, total beetle number, number of females) with the highest r values were used to determine the most appropriate linear regression employed for the development of a threshold.

Results

In 1996, the mean counts of western corn rootworms on traps in soybeans during the first three weeks of the trapping period (July 22 to August 12) were the best predictors of root injury to first-year corn (Table 3). After the third week (August 5 to 12), mean beetle captures no longer were correlated significantly with root injury measured in 1997.

These results were unexpected. In 1996, not only did trap average numbers of beetles per trap increase consistently as time progressed, but so did the percentage of females (Table 2). We anticipated that these high densities later in the season, comprised largely of females, would be the best predictors of root injury.

Hein and Tollefson (1985) used Pherocon AM traps in continuous corn in an effort to predict larval

injury. They sampled throughout August through the first week of September. They reported correlation coefficients that increased throughout August and then decreased slightly in September.

In addition to sampling rootworms with Pherocon AM traps, we also used sweep nets and vial traps to estimate densities of western corn rootworms in soybeans (O'Neal et al., 1997). In 1996, data collected with the sweep net and vial traps indicated that densities of western corn rootworms peaked around or on August 13. The increase in numbers of western corn rootworms captured with yellow sticky traps after August 13 (Table 2) may not be as reliable an indicator of seasonal beetle densities as are sweep nets or vial traps (Table 2). The yellow color of the Pherocon AM trap may be more attractive later in the growing season as corn becomes less attractive as a food source. So even though the number of beetles captured on Pherocon AM traps increased throughout August, an increase in egg-laying activity has not been proven.

If anything can be inferred about the timing of western corn rootworms laying eggs in soybeans, it would be that egg laying occurs during the first and second weeks of August. The significant correlation of beetle counts throughout the first three weeks of our trapping period (especially the second week, July 29 to August 5) suggests that most eggs are deposited within a soybean field during that time frame. Surprisingly, this time frame occurs well before western corn rootworms deposit most of their eggs in continuous corn. Hein and Tollefson (1985) showed that most egg laying occurs during the last week of August and early September.

Table 3. *Correlation coefficients (r) for total (male and female) counts of western corn rootworm beetles from Pherocon AM traps in soybeans and subsequent larval damage to first-year corn, 1996-1997.*

	Number of traps[b]			
Sampling period[a]	***16***	***12***	***6***	***4***
July 22-29 (14)	0.56*	0.55*	0.54*	0.47
July 29-Aug 5 (17)	0.71**	0.72**	0.73**	0.67**
Aug 5-12 (17)	0.49*	0.51*	0.49*	0.49*
Aug 12-20 (9)	0.29	0.28	0.23	0.32
Total 4 weeks combined	0.64**	0.65**	0.64**	0.64**

* $P < 0.05$; ** $P < 0.01$

[a] The number of fields varied by date and is included in parentheses in the first column.

[b] The number of traps used for the correlation is indicated along the top row. All 16 traps were used in the first correlation followed by 12, 6, and 4 interior traps.

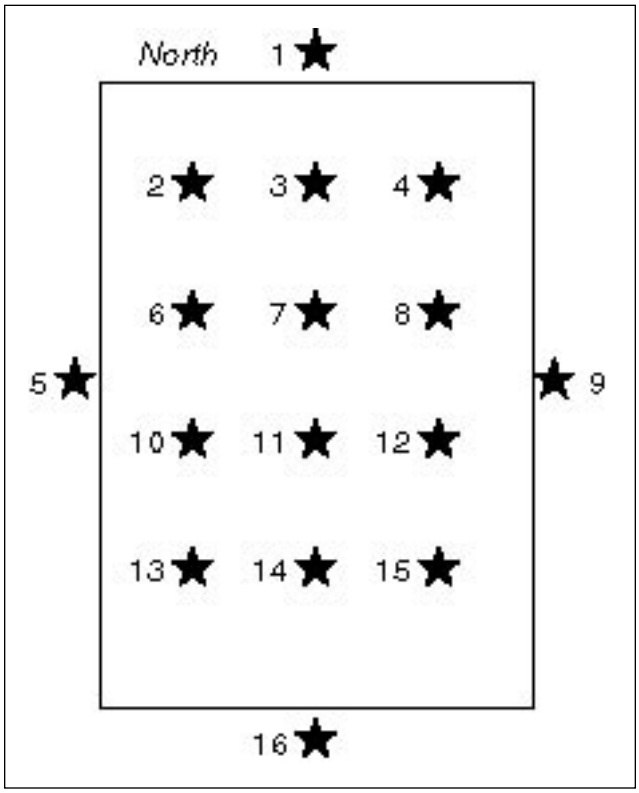

Figure 1. *Array of Pherocon AM traps deployed in a soybean field. The four traps numbered 1, 5, 9, and 16 were placed around the perimeter of the field and the other 12 traps were deployed in the interior. Traps 2, 4, 13, and 15 were designated as the interior four, and traps 6, 7, 8, 10, 11, and 12 were designated as the interior six.*

Number of Traps

Increasing the number of traps used to estimate beetle densities did not significantly improve the correlation with root injury (Table 3). Subsets of 4, 6, and 12 traps were derived from the 16 Pherocon AM traps placed in the interior of soybean fields (Figure 1). Except for the first week of sampling (July 22 to July 29), for which the correlation coefficient from four traps is not significant statistically, the mean trap counts of beetles from these three subsets all were equally significant in their correlation with

Table 4. *Correlation coefficients (r) of western corn rootworm beetles from Pherocon AM traps placed in the interior (In) and around the perimeter (Out) of a soybean field and subsequent larval damage to first-year corn, 1996-1997.*

	Location of traps[b]			
	Male and Female		*Females only*	
Sampling period[a]	*4 (Out)*	*4 (In)*	*4 (Out)*	*4 (In)*
July 22-29 (14)	0.48	0.47	0.42	0.18
July 29-Aug 5 (17)	0.60**	0.67**	0.69**	0.64**
Aug 5-12 (17)	0.45*	0.49*	0.50*	0.46[c]
Aug 12-20 (9)	0.26	0.32	0.11	0.23
Total 4 weeks combined	0.56**	0.64**	0.62**	0.62**

* $P < 0.05$; ** $P < 0.01$.

[a] The number of fields varied by date and is included in parentheses behind the date.

[b] The number of traps used for the correlation is indicated along the top row; four outer traps were placed in the middle of each field margin and four interior traps were placed 30 to 40 paces inside.

[c] $P = 0.0748$.

Table 5. *Correlation coefficients (r) for counts of female western corn rootworms on Pherocon AM traps in soybeans and subsequent larval damage to first-year corn, 1996-1997.*

	Number of traps[b]			
Sampling period[a]	*16*	*12*	*6 (inside)*	*4 (inside)*
July 22-29 (14)	0.33	0.27	0.26	0.18
July 29-Aug 5 (17)	0.74**	0.73**	0.73**	0.64**
Aug 5-12 (17)	0.50*	0.50*	0.49[c]	0.46[d]
Aug 12-20 (9)	0.16	0.18	0.09	0.23
Total 4 weeks combined	0.64**	0.63**	0.60**	0.62**

* $P < 0.05$; ** $P < 0.01$

[a] The number of fields varied by date and is included in parenthesis in the first column.

[b] The number of traps used for the correlation is indicated along the top row. All 16 traps were used in the first correlation followed by 12, 6 and 4 interior traps.

[c] $P = 0.0741$; [d] $P = 0.0748$.

root injury. This significance is constant, despite the minor decreases in correlation coefficient values as the number of traps decreased.

The correlation coefficient values for 16 traps were not always greater than correlation coefficients for 12 traps, possibly because of the four trapx(that were placed around the perimeter of each soybean field. As we reported last year (O'Neal et al., 1997), more beetles were caught consistently by the outside four traps than by the interior 12 traps (Table 2). When we compare trap captures by the four exterior traps to trap captures by the interior 12 traps, they are highly correlated ($r = 0.86$, $p = 0.001$), suggesting that perimeter traps predict root injury as accurately as beetle counts on interior traps. Correlation coefficients for the weeks of July 29 to August 5 and August 5 to 12 also substantiate the potential usefulness of the four perimeter traps as predictors of root injury.

But more is not always better. Even though the outer four traps collected more beetles, they were not a better predictor of root injury than the subset of four traps in the interior (Table 4).

In the best of all possible worlds, every producer would have both the resources and the time to deploy 16 traps, or at least 12 traps, in the manner we have suggested. However, one of our volunteers pointed out that it took him two hours every time he replaced the 16 traps in one field. Although he suggested that this was not an unreasonable amount of time per week to spend on the protection of his future crops, he also indicated that he would have to do this for each one of his ten soybean fields. Sampling all ten soybean fields would be a half week's work, not including the travel time to each field.

We deduce from Table 3, that the most efficient approach to estimating populations of western corn rootworms in a soybean field would be to use six Pherocon AM traps. Four traps would be the easiest and least costly, but we have a concern about the potential loss of accuracy when sampling during the first week, July 22 to July 29. If a producer wishes to use only four Pherocon AM traps, they should be deployed at each corner, approximately 20 to 30 paces inside the soybean field, and not around the perimeter of the field.

Knowledge of the Sex Ratio: Does It Improve the Threshold?

We did not observe a significant improvement in the correlation between root injury and mean female counts for any date using any number of traps (4,

12, or 16; Table 5). Once again, the best correlations occurred for counts taken during the first and second weeks, following the same trend as the correlations for total beetle counts. This result was not surprising. Hein and Tollefson (1985) tried to correlate the number of females collected on yellow sticky traps with root injury. They also found that the best predictor of root injury was total numbers of beetles. The reason why the larger numbers of female beetles trapped later in the season does not correlate well with root injury remains unclear. As argued earlier, these large numbers of female beetles may be brought into the soybean field by the attractive yellow color of the Pherocon AM trap.

Preliminary Threshold

By using the most significant correlation coefficients to help identify critical regression variables from one cycle of beetle numbers (1996) and root injury (1997), we can offer a preliminary threshold. Two preliminary thresholds are presented. One threshold is based upon a regression equation created from the mean beetle counts (12 traps, males and females) deployed from July 29 to August 5. The best fit regression equation (Figure 2) from this week had a coefficient of determination (R^2) of 0.51 ($P > F = 0.0026$). Using the regression equation for this time period and an economic injury index of 3.0 (root rating of 3.0 is equivalent to several roots eaten off to within 1.5 inches of the plant, but never the equivalent of an entire node of roots destroyed; Hills & Peters, 1971) results in a calculated economic threshold of 10.3 beetles per trap per week, or 1.5 beetles per trap per day. If an economic injury index of 4.0 (equivalent of one node of roots destroyed) is used as proposed by Sutter et al. (1991), then the threshold increases to 40.4 beetles per trap per week, or 5.8 beetles per trap per day. This latter threshold is interesting because it is approximately the same value (6 beetles per trap per day) as reported by Hein and Tollefson (1985) for western corn rootworms trapped in continuous corn. Hein and Tollefson set the economic injury index at 3.75 from a 1-9 scale (Apple et al., 1977). A root rating of 3.75 on the 1-9 scale is approximately equivalent to a rating of 3 on the Iowa State scale.

The proper application of this threshold is for traps deployed only during the first week of August. To illustrate how limited this threshold is, note that Hein and Tollefson's (1985) threshold is applicable for the last three weeks of August. Our second preliminary threshold includes trapping data from a four-week period (July 22 to August 20), with a coefficient of determination (R^2) of 0.43 ($p > F = 0.006$;

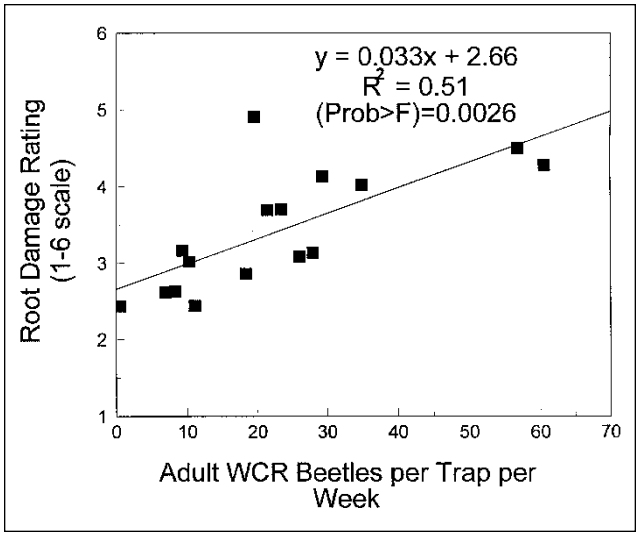

Figure 2. *Relationship between the mean numbers of western corn rootworms (WCR) (males and females) caught with 12 Pherocon AM yellow sticky traps per week in a soybean field and subsequent larval injury to first-year corn. Beetles were collected from July 29 to August 5, 1996.*

Figure 3). When this second regression equation is used, the threshold increases to 2 or 7 beetles per trap per day, depending upon whether a root injury index of 3 or 4 is used, respectively.

We encourage growers to employ the second threshold, based on the mean counts from the four-week trapping period. This threshold, unlike the first, is not dependent upon a mean trap count for a single week that occurs before densities of western corn rootworms in soybeans. However, to use the second threshold properly, a grower must use a combined four-week mean, even if the density of beetles in a single week is greater than the threshold.

Another caveat about this preliminary threshold concerns the type of decision that can be made on the basis of this preliminary threshold. Our protocol was designed to construct a threshold that only predicts root injury to rotated corn. Although we have speculated from our trapping data about the changing oviposition behavior of western corn rootworms, our threshold does not predict when egg laying occurs.

After the root injury in 1998 has been evaluated, we can expand our data set and further investigate which combination of trap location and deployment date will consistently provide the best correlation. We hope to find a combination that is both sufficiently effective to predict root injury and practical enough for growers to use. To develop a threshold that is highly correlated throughout the emergence

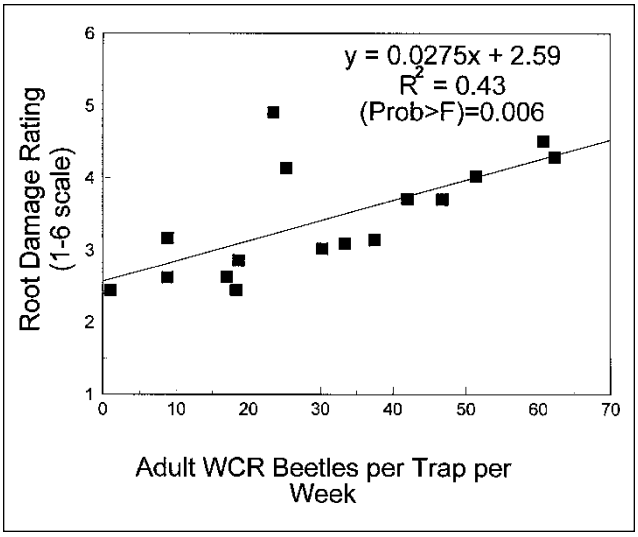

Figure 3. *Relationship between the mean numbers of western corn rootworms (WCR) (males and females) caught with 12 Pherocon AM yellow sticky traps per week in a soybean field and subsequent larval injury to first-year corn. Beetles were collected from July 22 to August 20, 1996.*

season of western corn rootworm, next year's data need to be included in our regression analysis. Although we have a new tool for managing rootworms in first-year corn, some fine-tuning is necessary.

Acknowledgments

We thank the following cooperators in east central Illinois, whose assistance made this research possible: Dave Bossert, Bruce and Brad Baker, Jay Carlson, Marion Chestnut, John Clark, Chuck Down, Jerry Gourely, Larry Knox, Keith Knapp, William Langellier, Dean Peterson, Greg Pool, Gordon Von Qualen, Gene Rademacher, Denny Rich, Jean Stewart, Jeff Strachan, and Harlan Ziebart. We also thank the following people for technical assistance on this project: Dick Bonham, Brett Robertson, Ryan Johnson, James Finger, Kerrylynne Benner, Cesar Velasquez, Silvia Rondon, and Maria Venditti. We also gratefully acknowledge the financial support from the Illinois Council on Food and Agricultural Research (C-FAR). Last, but not at all least in our appreciation, we thank Jacob and Gerald Redman, who provided us with data from western Illinois.

References

Apple, J. W., Chiang H. C., English, L. M., French, L. K., Keaster, A. J., Krause, G. F., Mayo, Z. B., Munson, J. D., Musick, G. J., Owens, J. C., Rasmussen, E. E., Sechriest, R. E., Tollefson, J. J., & Wedberg, J. L. (1977). *Impact of northern and western corn rootworm larvae on field corn.* North Central Regional Research Publication No. 239. Research Division, College of Agricultural and Life Sciences, University of Wisconsin-Madison.

Godfrey, L. D., & Turpin, F. T. (1983). Comparison of western corn rootworm (Coleoptera: Chrysomelidae) adult populations and economic thresholds in first-year and continuous corn fields. *Journal of Economic Entomology*, 76, 1028-1032.

Gray, M., Steffey, K., & Weinzierl, R. (1997). Alternatives in insect management: Field and forage crops. In *Illinois agricultural pest management handbook*, 37-61. Cooperative Extension Service, University of Illinois at Urbana-Champaign.

Hein, G. L., & Tollefson, J. J. (1985). Use of the Pherocon AM trap as a scouting tool for predicting damage by corn rootworm (Coleoptera: Chrysomelidae) larvae. *Journal of Economic Entomology*, 78, 200-203.

Hills, T. M., & Peters, D. C. (1971). A method of evaluating postplant insecticide treatments for control of western corn rootworm larvae. *Journal of Economic Entomology*, 64, 764-765.

Levine, E., & Gray, M. 1996. First-year corn rootworm injury: East-central Illinois research progress to date and recommendations for 1996. In *Proceedings of the Illinois agricultural pesticides conference*, 3-13. Cooperative Extension Service, University of Illinois at Urbana-Champaign.

O'Neal, M., Gray, M., Spencer, J., Steffey, K., & Levine, E. (1997). Western corn rootworm in corn after soybeans: Efforts towards an economic threshold. In *Proceedings of the Illinois agricultural pesticides conference*, 66-72. Cooperative Extension Service, University of Illinois at Urbana-Champaign.

SAS Institute. 1989. SAS/STAT user's guide (version 6, 4th ed., vol. 2). Cary, NC: SAS Institute.

Sutter, G. R., Branson, T. F., Fisher, J. R., & Elliott, N. C. (1991). Effect of insecticides on survival, development, fecundity, and sex ratio in controlled infestations of western corn rootworm (Coleoptera: Chrysomelidae). *Journal of Economic Entomology*, 84, 1905-1912.