

**PROGRESS REPORT- 1996**  
USGA TURFGRASS RESEARCH FOUNDATION  
MIS #9010101045-1991

**CULTURAL CONTROL, RISK ASSESSMENT,  
AND ENVIRONMENTALLY RESPONSIBLE MANAGEMENT  
OF WHITE GRUBS AND CUTWORMS IN TURFGRASS**

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## Executive Summary:

### Goals:

- 1) Determine factors that affect the distribution and abundance of white grubs and cutworms on golf courses.
- 2) Reduce the use of insecticides by identifying methods to manage white grubs and cutworm insects through modified cultural practices.
- 3) Provide better information on the effects of pesticides on natural enemies of turfgrass pests and other beneficial species that live in golf course turf.

Research on the biology of black cutworms revealed ways that this pest can be more effectively managed. Nearly all of the eggs laid on creeping bentgrass putting greens are glued to the tips of grass blades, where they are removed by daily mowing and disposal of clippings. Most eggs can survive passage through the mower blades and will later hatch. We therefore advise golf superintendents to dispose of clippings well away from greens and tees. Cutworm moths also lay eggs on higher-mowed turf in fairways and roughs, but here, most eggs are laid lower down on grass plants, where they would not be removed by mowing. Thus, reservoir populations may develop in high grass surrounding greens and tees.

Night-time observations revealed that cutworms are most active on putting greens between midnight and 1 hour before sunrise. Thus, treatments are best applied toward evening. Young cutworms feed mainly by "grazing" on the putting surface, whereas larger ones feed mainly from aerification holes or self-made burrows. Contrary to expectation, cutworms were not attracted to aerified bentgrass, although they tend to occupy aerification holes when such holes are available. Sand topdressing seems to partially deter cutworms. Mowing an hour or so before dawn may provide substantial control by shredding. Our work shows that cutworms may crawl as far as 70 feet in a single night, and that they often invade greens from peripheral areas (Fig. 1). We therefore suggest that when treating for cutworms, a 30 ft buffer zone around the putting green should also be treated.

Perennial ryegrass and tall fescue were found to be as suitable for cutworms as creeping bentgrass, but Kentucky bluegrass was highly unsuitable as food (Fig. 2). Endophyte-infected cultivars did *not* provide significant resistance. Putting greens surrounded by creeping bentgrass, tall fescue, or perennial ryegrass may be at greatest risk from invasion from peripheral areas. None of the 14 cultivars of creeping bentgrass we tested was significantly resistant. Nevertheless, use of Kentucky bluegrass around greens and tees, coupled with daily mowing of greens and clipping removal should provide substantial cultural control.

The fraction containing the chemical sex pheromone of masked chafers was

pinpointed by gas chromatography and electroantennogram/behavioral analysis. The active compound was characterized by mass spectroscopy. Identification and synthesis of this attractant will provide means for monitoring these pests on golf courses and home lawns.

Insecticides that are applied to golf courses can adversely affect beneficial invertebrates such as predators and earthworms. This can sometimes aggravate pest outbreaks or thatch buildup. In 1996, we began studying the side-effects of two important new insecticides, halofenozide (Mach 2) and imidacloprid (Merit) on the turfgrass environment. Golf course turf was treated in May, and impact on beneficial species was monitored bi-weekly until fall. Our results suggest that these new insecticides provide excellent control of white grubs with minimal impact on beneficial species.

## PROGRESS REPORT: 1996

### OVERALL GOALS:

The goal of this project is to better understand the factors determining the distribution and abundance of white grubs and cutworms on golf courses. We seek safer, more economical and more effective methods for managing these pests with reduced use of broad-spectrum insecticides.

*OBJECTIVE 1. Examine the effects of environmental variables on the bionomics of white grubs and cutworms, and evaluate the potential for reducing populations of these pests through non-chemical, cultural manipulations.*

This Objective has yielded a great quantity of new information that has been prepared in the form of research manuscripts and articles for trade journals. Two of these papers were published or accepted for publication in 1996; the rest are in review. These are presented below as a series of Abstracts, with the citation to the article included:

**Potter, D.A., A.J. Powell, P.G. Spicer, and A.J. Powell. 1996. Cultural Practices Affect Root-feeding White Grubs (Coleoptera: Scarabaeidae) in Turfgrass. Journal of Economic Entomology 88: 156-164.**

**ABSTRACT.** Cultural practices were manipulated before or during seasonal flights of Japanese beetle, *Popillia japonica* Newman, and masked chafers, *Cyclocephala* spp., to study effects on grub densities in tall fescue or Kentucky bluegrass turf. Masked chafer grubs were consistently smaller and less abundant in turf that had been treated with aluminum sulfate to reduce soil pH and in high-mown turf. High mowing or application of aluminum sulfate before beetle flights reduced total biomass of white grubs in tall fescue by as much as 55 and 77%, respectively. However, where spatial gradients in soil moisture occur, the positive response of grub populations to moisture may override effects of those treatments. Grub densities were not affected by spring applications of lime or urea or by aerification of plots before beetle flights. Plots that were irrigated before beetle flights incurred significantly higher densities of both *P. japonica* and *Cyclocephala* spp. grubs than did nonirrigated turf. The use of a 2,247 kg roller to compact the soil before beetle flights did not affect subsequent grub populations, and the roller was not effective for remedial control of 3rd instars in the fall. Application of organic fertilizers (composted cow manure or activated sewage sludge [Milorganite®]) resulted in significant increases in grubs of green June beetle, *Cotinis nitida* L., in 1 of 2 yr. Cultural practices may have general or species-specific effects on densities of white grubs. This study suggests that withholding irrigation during peak flight of beetles, raising cutting height, and light application of aluminum sulfate in spring may help to reduce the severity of subsequent grub infestations.

**Williamson, R.C. & D.A. Potter. 1997. Oviposition of black cutworms on creeping bentgrass putting greens and removal of eggs by mowing. Journal of Economic Entomology In Press.**

**ABSTRACT.** Oviposition and egg location of the black cutworm, *Agrotis ipsilon* (Hufnagel), removal of eggs by mowing, and survival of eggs on grass clippings were evaluated on a creeping bentgrass (*Agrostis palustris* Hudson) golf putting green. Caged moths laid similar numbers of eggs on bentgrass maintained at 3.2, 4.8, or 13 mm cutting heights (1/8", 3/16", or 1/2", respectively). Nearly all eggs were laid singly on the tips of grass blades. Mowing of plots 48 h after oviposition removed an estimated 75--91% of the eggs at the 3.2 mm cutting height, and 81--84% at the 4.8 mm cutting height. These results were consistent over three trials. In another test, 97% of marked eggs on grass blades were removed by mowing and recovered on clippings in the mowing basket. Five to 10% of the eggs were dislodged from grass blades by the mower roller. Survival of eggs on grass clippings harvested with the greens mower was as high as 90% in the laboratory, and 50% in the field. This study suggests that daily mowing removes most black cutworm eggs from golf putting greens, implying that larger cutworms found on greens may originate from surrounding, high-mowed turf. Disposal of clippings away from greens may be important for reducing reinfestations by crawling larvae.

**Williamson, R.C. & D.A. Potter. 1997. Nocturnal activity and movement of black cutworms and response to cultural manipulations on golf course putting greens. Journal of Economic Entomology Submitted and in review.**

**ABSTRACT.** Nocturnal activity, feeding behavior, and movement of black cutworms, *Agrotis ipsilon* (Hufnagel) and response of larvae to cultural manipulations were evaluated on creeping bentgrass (*Agrostis palustris* Hudson) golf putting greens. Larvae were active throughout most of the night with the greatest activity between midnight and about an hour before sunrise. Small larvae (3rd and 4th instars) were active on the surface of putting greens, whereas large larvae (5th and 6th instars) fed mainly from burrows or tunnels in the putting green surface. Larval tracks in the dew averaged  $8.8 \pm 0.7$  m (29 ft), indicating that black cutworms can move considerable distances on putting greens in a single night. Many larval tracks originated from the peripheral areas, suggesting that many larvae found on putting greens originate from higher-mowed turf surrounding the green. Top dressing with 100% sand or a silica sand/peat moss mix did not affect survival of cutworms in creeping bentgrass turf cores. Contrary to the common belief of golf course superintendents, black cutworms were not attracted to aerified over non-aerified creeping bentgrass. However, most larvae occupied aerification holes as burrows when such holes were available. Putting green surfaces topdressed with sand consistently deterred black cutworm larvae. Manipulating the timing of top dressing may be one means of reducing cutworm populations on putting greens.

**Williamson, R.C. & D.A. Potter. 1997. Turfgrass species and endophyte effects on survival, development, and feeding preference of black cutworm larvae. Journal of Economic Entomology Submitted and in review.**

**ABSTRACT.** Growth, developmental rate, and survival of black cutworms, *Agrotis ipsilon* (Hufnagel), were compared on six cool-season turfgrasses commonly used on golf courses, including cultivars with or without fungal endophytes. We also studied feeding preferences

of neonates and 5th instars, including possible effects of induction of feeding preference, to clarify likely patterns of movement of larvae between creeping bentgrass putting greens and peripheral areas. Performance of black cutworms was much poorer on Kentucky bluegrass, *Poa pratensis* L., than on all other turfgrasses. Further evaluation of several diverse cultivars confirmed that Kentucky bluegrass is an unsuitable host for *A. ipsilon*. Tall fescue, *Festuca arundinacea* Schreb., and perennial ryegrass, *Lolium perenne* L., were generally as suitable for cutworms as creeping bentgrass, *Agrostis palustris* Huds., the standard grass used on putting greens. Infection of tall fescue by the endophyte *Acremonium coenophialum* Morgan-Jones and Gams did not significantly reduce larval performance parameters. Infection of perennial ryegrass by its endophyte, *A. lolii* Latch, Christensen, and Samuels, had only small adverse effects on cutworms compared to the same cultivar without endophyte. In laboratory choice tests, young, first instars consistently fed more on creeping bentgrass than on other turfgrasses, regardless of which grass they had fed during the preceding 24 h. Preferences of 5th instars in the laboratory were more variable, but creeping bentgrass was consistently preferred over Kentucky bluegrass. Endophyte infection did not consistently deter feeding. Field tests in which large cutworms encountered an interface between two established turfgrass species corroborated the laboratory results. This study suggests that use of Kentucky bluegrass in higher-mowed areas surrounding putting greens would prevent development of a reservoir population that might later invade the greens. This, coupled with daily mowing and clipping removal, should give substantial cultural control of cutworms. In contrast, we predict that putting greens surrounded by perennial ryegrass or tall fescue may be at higher risk of invasion by black cutworms. Contrary to what has been assumed by many entomologists, endophytic turfgrasses do not seem to provide significant resistance to *A. ipsilon*.

**Williamson, R.C. and D.A. Potter. 1997. Oviposition and feeding site preference of first-instar black cutworms, *Agrotis ipsilon* (Hufnagel) on four cool-season turfgrasses. *Journal of Turfgrass Management*. In manuscript form.**

**ABSTRACT** Oviposition of black cutworms, *Agrotis ipsilon* (Hufnagel) was studied on four cool-season turfgrasses commonly used on golf courses. We also studied the location of neonate larvae within grasses. All eggs were laid on the leaf blades regardless of the grass species; none were found on the leaf sheaths. Moths deposited eggs mostly singly on nearly all turfgrasses except for Kentucky bluegrass, *Poa pratensis* L. Most eggs were laid on the tips of creeping bentgrass blades, *Agrostis palustris* Huds. while the majority of eggs were deposited on the middle or lower portions of leaf blades of the higher-mowed perennial ryegrass, *Lolium perenne* L., tall fescue, *Festuca arundinacea* Schreb., and Kentucky bluegrass. The location of *A. ipsilon* neonates varied among turfgrass species. First-instar cutworms were rarely located on the abaxial side of leaf blades. Most neonates were located on the basal (lower 50%) portion of creeping bentgrass leaf blades. Nearly all 1st instars were found in the soil of tall fescue and perennial ryegrass. However, on Kentucky bluegrass, neonates were equally distributed on the lower 50% of leaf blades, leaf sheaths, thatch, and soil. This study suggests that black cutworms will lay eggs on all common cool-season turfgrasses used on golf courses. When turfgrasses are mowed at fairway height or higher, many eggs and neonate larvae occur below the terminal 1/3 of the leaf blades that would be removed at each mowing. Thus, bagging and disposal of clippings in fairways and

roughs would probably not eliminate most young cutworms, as it does on putting greens. This helps to explain the origin of reservoir populations that can develop in favorable turfgrasses (creeping bentgrass, tall fescue, perennial ryegrass) surrounding putting greens.

**Williamson, R.C. and D.A. Potter. 1997. Suitability of creeping bentgrass cultivars for the black cutworm, *Agrotis ipsilon* (Hufnagel). In manuscript form.**

**ABSTRACT.** Twelve diverse cultivars of creeping bentgrass, *Agrostis palustris* Huds., that have been highly rated for use on golf putting greens were evaluated for resistance to the black cutworm, *Agrotis ipsilon* (Hufnagel). Clippings were harvested from replicated field plots and used to rear larvae from egg hatch to adulthood. Larval growth was fairly similar on all cultivars tested, and most cultivars appeared to be suitable hosts. However, survival was highly variable between trials, possibly due to confounding effects of dollar spot disease or other stress factors. The cultivar G-2 seemed to be less suitable than the others.

**OBJECTIVE 2.** *Identify the sex pheromone of northern and southern masked chafers (*Cyclocephala* spp.) and explore practical uses for the pheromone in golf courses settings.*

Identification and synthesis of this pheromone has several potential applications. The lure will provide a tool for monitoring beetle flight, allowing better timing of treatments. Timing is especially critical with the newer grub control products (e.g., insect growth regulators; microbial insecticides) that work best against newly-hatched larvae. Masked chafers have localized flights, so there should be a good correlation between activity of beetles at a site and subsequent grub densities. Superintendents could employ simple traps to target "high-risk" sites.

Grubs of the northern and southern masked chafer are morphologically indistinguishable. Thus, we know little about their relative importance geographically, and within particular golf course habitats (e.g., roughs, tee banks, fairways, or particular grass species). The two chafers co-occur throughout much of the Midwest. Because they respond to the same pheromone, a synthetic lure would provide a means for studying their distributions and habitat preferences. If the species differ in susceptibility to insecticides (which is likely), being able to distinguish between them could be important in management.

Identification of the sex pheromone is proving to be particularly challenging for two reasons. First, active fraction is present in very minute amounts, making it difficult to get enough material for analysis. It is, however, extremely potent. Second, the structure seems to be quite different from other, known insect pheromones. Nevertheless, there was significant progress in 1995-96. During fall 1996, we collected, extracted, and shipped about 7,000 masked chafer grubs to collaborators at Cornell University. The chemical peak representing the active compound was pinpointed by simultaneous gas chromatography and electroantennogram analysis. The active compound has Kovat's indices of 1790 and 2356 on nonpolar and polar columns, respectively. The compound was purified and subjected to infrared and mass spectroscopy. The molecular weight is 246. The compound appears to be

a secondary or tertiary alcohol. It appears to have an aldehyde functional group. Fractionation in combination with GC-MS and behavioral bioassays has pinpointed the specific peak with biological activity, and we now can obtain a clean enough active fraction to concentrate on chemical characterization. The compound has been concentrated and is being analyzed by several spectrometric methods. In this way, we hope to determine the molecular weight of the compound, its degree of unsaturation, and the functional groups present in the molecule. With this information in hand, a chemical structure for the molecule can be determined. Once identified, the molecule will be purchased if it is available from a commercial source (e.g., Sigma, Aldrich) or else synthesized by the Cornell group. The Kentucky group will test the synthetic pheromone on golf courses to verify its activity in the field.

A preliminary experiment was run to determine if *Tiphia*, a parasite of masked chafer grubs, is attracted to the pheromone. Sticky traps baited with crude extracts of grubs or virgin females were set out in areas where parasitized grubs were found. No wasps were captured. This may have been the result of an inefficient trap design, improper timing, or the short life of the crude extract in the field. We know that *Tiphia* is able to locate and discriminate between chafer grubs and Japanese beetle grubs underground. Identification of the sex pheromone will allow a better test of the hypothesis that this is guided by chemical cues. As soon as the pheromone is identified, we can begin a new study of the relative abundance and distribution of the two masked chafers on golf courses.

***OBJECTIVE 3. Provide better understanding of the effects of pesticides on natural enemies of turfgrass pests and other beneficial species that live in golf course turf.***

A field study to determine how long it takes for populations of beneficial invertebrates in turf to recover following application of a broad-spectrum, organophosphate insecticide has been completed. Ethoprop (Mocap 5G) was applied to large (12.5 x 12.5 meter) or small (4 x 4 m) plots of Kentucky bluegrass in spring 1994. Recovery of earthworms, soil microarthropods, and predators was monitored for up to a year after treatment.

Ethoprop eliminated 100% of the earthworms at 1 week after treatment. Populations were still reduced in large treated plots 30 weeks after treatment. Earthworms appear to have slow recuperative potential, even near plot edges. Impact on most groups of predatory arthropods was surprisingly slight. There was no reduction in abundance of two of the most important groups, Carabidae (ground beetles) or ants (Formicidae). In contrast, Staphylinidae (rove beetles) and spiders did not return to normal levels in large treated plots until late in the growing season. Sorting of samples from this project took almost 1 year. Data are now fully analyzed, but submission for publication will be delayed until D.A.P. finishes writing his book on managing turfgrass insects.

In 1996, we began a study to examine the effects of two novel soil insecticides, imidacloprid (Merit<sup>®</sup>) and halofenozide (Mach 2<sup>®</sup>), on beneficial invertebrates in turf. Imidacloprid belongs to a new class of insecticides called chloronicotinyls, characterized by long residual activity and relatively low toxicity to vertebrates. Halofenozide, an insect growth regulator (IGR), also has long residual and a favorable environmental toxicity profile.



Registration of halofenozide is expected in time for the 1997 growing season. It is the first IGR developed for use on turf. Both products have excellent activity against white grubs, and together they are likely to become the most commonly used grub insecticides on golf courses. There is presently no information on the potential side effects of these compounds on beneficial invertebrates.

Replicated plots in golf roughs were treated at labeled rates in May, and populations of earthworms, soil microarthropods, and predators were monitored throughout the growing season. Preliminary sorting of samples suggests that halofenozide had no effect on any beneficial species. Imidacloprid caused slight reductions in abundance of earthworms and certain predators, but effects were much less severe than with bendiocarb, a carbamate insecticide used as a standard. Sorting and data analysis will continue through the winter. Additional experiments, including work on specific routes of exposure (direct contact, residual toxicity, feeding on poisoned prey) are planned for spring.

### PUBLICATIONS AND PRESENTATIONS

The following publications from the funded research either appeared in print during 1995-96, or were submitted for publication in 1996. Previous scientific papers were listed in earlier progress reports. All papers include acknowledgment of USGA funding. Additional papers are submitted or in preparation (see above):

#### A. Refereed Scientific Papers and Book Chapters (1995-96):

1. Crutchfield, B.A. & D.A. Potter. 1995. Tolerance of cool-season turfgrasses to feeding by grubs of Japanese beetle and southern masked chafer (Coleoptera: Scarabaeidae). *Journal of Economic Entomology* 88: 1380-1387.
2. Crutchfield, B.A. & D.A. Potter. 1995. Irrigation and fertilization affect injury by root-feeding white grubs in Kentucky bluegrass and tall fescue turf. *Crop Science* 35: 1122-1126.
3. Crutchfield, B.A. & D.A. Potter. 1995. Damage relationships of Japanese beetle and southern masked chafer (Coleoptera: Scarabaeidae) grubs in cool-season turfgrasses. *Journal of Economic Entomology* 88: 1049-1056.
4. Crutchfield, B.A. & D.A. Potter. 1995. Survival, growth, and feeding impact of Japanese beetle and southern masked chafer grubs on common lawn weeds. *Crop Science*. In Press.
5. Davidson, A.W. and D.A. Potter. 1995. Response of plant-feeding, predatory, and soil-inhabiting invertebrates to *Acremonium* endophyte and nitrogen fertilization in tall fescue turf. *J. Econ. Entomol.* 88: 368-379.
6. Redmond, C.T. and D.A. Potter. 1995. Lack of efficacy of in vivo- and putatively in vitro-produced *Bacillus popilliae* [milky disease bacteria] against field populations of

Japanese beetle grubs in Kentucky. *J. Econ. Entomol.* 88: 846-854.

7. Haynes, K.F. and D.A. Potter. 1995. Sexual response of a male scarab to larvae suggests a novel evolutionary origin for a sex pheromone. *American Entomologist* 41: 169-175.

8. Crutchfield, B.A. and D.A. Potter. 1995. Feeding by Japanese beetle and southern masked chafer on common lawn weeds. *Crop Science* 35: 1681-1684.

9. Potter, D.A. 1995. Ecological side effects of pesticides on beneficial invertebrates in turf. pp. 101-105, *in* Brandenburg, R. & M. Villani (eds.) *Handbook of turfgrass insect pests*. Entomol. Soc. Amer., Lanham, MD.

10. Potter, D.A. 1995. Biology of masked chafers. pp. 70-72, *in* Brandenburg, R. & M. Villani (eds.) *Handbook of turfgrass insect pests*. Entomol. Soc. Amer., Lanham, MD.

11. Haynes, K.F. & D.A. Potter. 1996. Chemically-mediated sexual attraction of male *Cyclocephala lurida* (Coleoptera: Scarabaeidae) and other scarabaeid beetles to immature stages. *Environmental Entomology* 24: 1302-1306.

12. Potter, D.A., A.J. Powell, P.G. Spicer & D.W. Williams. 1996. Cultural Practices Affect Root-feeding White Grubs (Coleoptera: Scarabaeidae) in Turfgrass. *Journal of Economic Entomology* 88: 156-164.

13. Williamson, R.C. and D.A. Potter. 1997. Oviposition of black cutworm on creeping bentgrass putting greens and removal of eggs by mowing. *J. Econ. Entomol.* *In press*.

## **B. Scientific Presentations:**

### *Invited Symposium Papers:*

- a. Advances in integrated pest management for white grubs. Entomol. Soc. Amer. National meeting, 1995. D.A. Potter
- b. Sexual attraction of male masked chafers to grubs suggests novel evolutionary origin for a sex pheromone. Internat. Conf. On Biology of Scarabaeidae, Mopani, South Africa, 1995. D.A. Potter & K.F. Haynes
- c. Black cutworms on golf courses: behavioral insights reveal new management options. Entomol. Soc. Amer. National meeting, 1996. C.T. Williamson & D.A. Potter
- d. Ecology and management of cutworms on golf courses. Internat. Conf. on soil insect biology, Brisbane, Australia, 1997. D.A. Potter & C.T. Williamson.

### *Submitted papers:*

Four additional submitted papers supported by the USGA grant were submitted at

scientific conferences

**B. Dissemination of Research to Golf Industry:**

*Applied Articles:*

Williamson, R.C. and D.A. Potter. 1997. Does aerification actually promote black cutworm infestations? *Golf Course Management*. March 1997. *In Press*.

Williamson, R.C. and D.A. Potter. 1997. Resistance to cutworms: Not all turfgrasses are created equal. *USGA Green Section Record*. March/April 1997. *In Press*.

Williamson, R.C. and D.A. Potter. 1997. Survival of black cutworms on different turfgrass species and cultivars. *Golf Course Management*. August 1997. *In Press*.

*Presentations (1995-96):*

Coping with cutworms. *Golf Course Superintendent's Assoc. Amer. Annual meeting*, San Francisco, 1995.

Ecological side effects of turfgrass pesticides. *Ohio Turfgrass Council Annual Conference*, Columbus, OH. 1995.

Cultural controls for white grub pests of golf courses. *Ibid*, 1995.

Behavior and ecology of the black cutworm on golf courses. *National Turf Entomology Workshop*, Omaha, 1995.

Innovative management of cutworms on golf courses. *Wisconsin Turfgrass Assoc. Turf and Greenscape Expo*, Madison, WI, 1996

Ecological side effects of pesticides in the turf environment. *Ibid*, 1996.

Managing cutworms on golf courses. *Rutgers University Annual Turfgrass Conference*, 1997.

Also, - about 8 Green-industry oriented presentations in Kentucky.

**GRADUATE STUDENTS SUPPORTED:**

*The main use of our USGA funding has been to train graduate students with expertise in turfgrass entomology:*

B.A. Crutchfield (Ph.D., Oct. 1994) is now employed as Plant Pest Biologist, West Virginia Department of Agriculture, Charleston, WV.

R. Chris Williamson is presently being supported. Mr. Williamson is expected to receive his Ph.D in December 1996 and is seeking employment as a Turfgrass Entomologist.

Dacelle Peckler (non-thesis M.S. degree, Dec. 1995) completed an independent study project on ecological side effects of pesticides in turf.

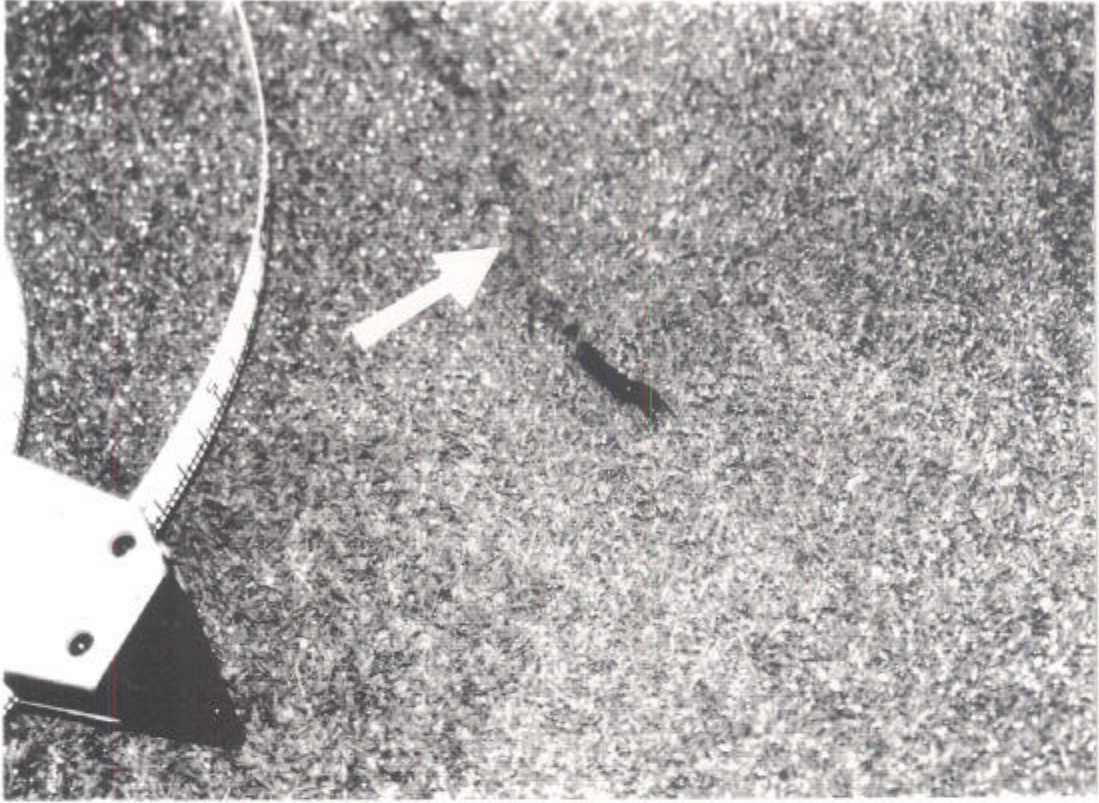
Brian Kunkel (MS expected Dec. 1997) is currently working on the research described under Objective 3 (above).

**Figure Legends (Potter et al.; USGA Progress Report, 1996):**

Figure 1. (Upper photo) Black cutworm crawling on surface of putting green about 1 hour before dawn. Arrow points to track left in the dew. (Lower photo) Path followed by black cutworm that crawled from peripheral area to feed near center of a putting green.

Figure 2. High survival of black cutworms reared on creeping bentgrass (CB), perennial rygrass (PR) and tall fescue (TF), and lack of suitability of three diverse cultivars of Kentucky bluegrass.

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