CORNELL UNIVERSITY TURFGRASS TIMES

CUTT

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Putting Green Management Systems with Reduced Pesticides:

A Continuing Evaluation

This project provides information from the fourth year of a study assessing the feasibility and performance of golf course turf managed with an IPM approach utilizing population-based pest management to a system that utilizes biologically-based controls and reduced risk chemistry. The work was initiated on the Green Course at the Bethpage State Park, Long Island, New York in 2001. The Green Course is one of five public courses at the park and accommodates approximately 50,000 rounds of golf annually. The greens are push-up native soil greens that have been heavily sand top-dressed for the last six years, and are typical of a high-use public course in a northern metropolitan community. A more detailed discussion of methodology and results from 2001 through 2003 can be found at http://usgatero.msu.edu/.

Experiment Design

The experiment was designed as a 3 x 2 factorial, with three pest-management and two cultural-management regimes.

Pest Management: 1) Unrestricted: All legal and currently available chemical pesticides in New York State may be used. 2) IPM: Cultural and biological approaches to prevent and minimize pest problems were emphasized, but any legal practice or pesticide could be used. 3) Bio-Based Reduced Risk (formerly nonchemical treatment): Cultural and biological approaches to prevent and minimize pest problems were emphasized, but reduced risk chemical pesticides were used occasionally to prevent turf loss.

Cultural Management: 1) Current Standard: Cultural practices currently being employed at the golf courses of the Bethpage State Park. 2) Alternative: Modified cultural practices selected to reflect the most progressive practices that maximize turfgrass performance and minimize stress to the grass.

The experimental design resulted in six management systems. Each green served as a replicate, with all 18 greens of the Bethpage Green Course used to accommodate 3 replica-

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This Times

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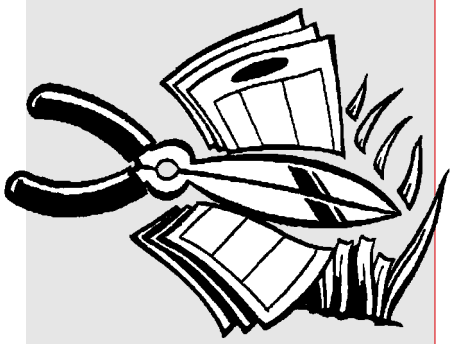
Clippings

Kevin Meredith is someone who is on that quest to reach his goals and is demonstrating the "and then some" spirit which is so much a part of Mr. Toma's approach to sports turf management.

Andy Sliwa was selected from a highly competitive field of applicants to be part of this exciting program, USGA Northeast Agronomist.



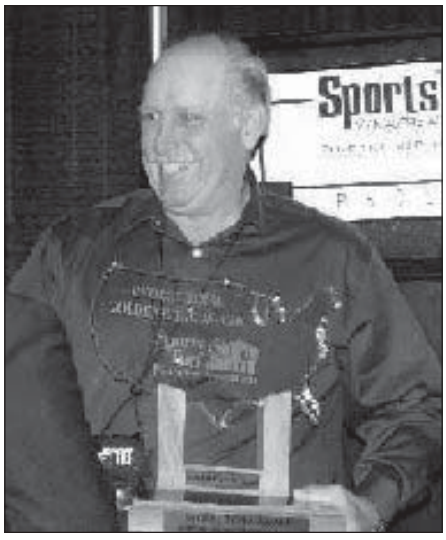
Meredith Wins Toma Award

Kevin Meredith of the National Soccer Hall of Fame received the George Toma Golden Rake Award from the Sports Turf Manager's Association (STMA), which acknowledges an individual's strong work ethic and job performance.

The George Toma Golden Rake Award was named for one of STMA's Founders, Mr. George Toma, whose work with the National Football League on Super Bowl field preparation has made him a legend. The recipient of this award is someone who is on that quest to reach his goals and is demonstrating the "and then some" spirit which is so much a part of Mr. Toma's approach to sports turf management.

Meredith is the Sports Turf Manager at the National Soccer Hall of Fame in Oneonta, NY, a position he has held for the past 14 years. His knowledge, expertise and dedication have been invaluable in the development of the Hall of Fame. In 2000, he won the STMA Soccer Field of the Year for a municipality. He volunteers for many organizations, including the Oneonta school system and Otsego County as an alcohol and drug abuse counselor and has been a credentialed alcoholism counselor for six years.

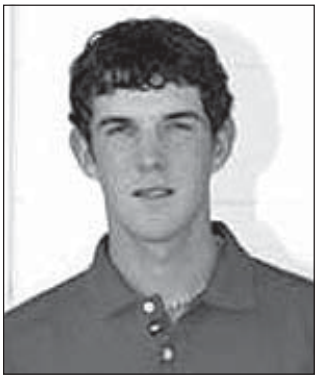
Meredith founded a local airplane club and the regional Leather Stocking EEA, and was an aerographer (weatherman) in the Navy. He is a member of the Golf Course Superintendents Association of America and has designed and built a par 3 golf course. He holds a bachelor's degree from the State University of New York at Oneonta.



Sliwa Selected for USGA Internship

Andrew Sliwa was selected by the USGA to participate in an internship with USGA Northeast Agronomist. Andy is in his senior year at Cornell University studying horticulture with a concentration in turfgrass management under the supervision of Dr. Frank Rossi. Sliwa was selected from a highly competitive field of applicants to be part of this exciting program.

Andy is Captain of the Cornell Golf Team and has been playing the game of golf since the age of three. He has worked at the Turfgrass Research Center at Cornell, as well as the Links at Hiawatha Landing, Card Sound Country Club, and this summer at Westchester Country Club in New York.



Calendar of Upcoming Events

February 1, 2006
2006 Turfgrass Advocacy/NYSTA's Lobby Day
Empire State Plaza, Albany NY
Info: NYSTA (518) 783-1229 or (800) 873-8873

February 27, 2006
Southeast Regional Conference
Holiday Inn Suffern, Suffern NY
Info: NYSTA (518) 783-1229 or (800) 873-8873

March 6, 2006
Western Regional Conference
Buffalo/Niagara Marriott, Amherst NY
Info: NYSTA (518) 783-1229 or (800) 873-8873

March 30, 2006
Adirondack Regional Conference
Lake Placid Resort, Holiday Inn, Lake Placid NY
Info: NYSTA (518) 783-1229 or (800) 873-8873

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Scanning the Journals

Infilled systems perform similarly with regard to ball rebound. However, other measurements of velocity indicate the ball rolls significantly faster and further on synthetic turf than on natural turf.

As traction increases—either through improved field quality or more aggressively treaded footwear—the risk of ACL injury increases.

Synthetic Turf Performance

The popularity of synthetic turf surfaces is at an all-time high with the introduction of long pile fiber systems infilled with various combinations of crumb rubber and sand. Over 1,000 new synthetic turf systems were installed in 2003-2004 in the US.

The rapid popularity has lead to questions regarding surface performance relative to natural turf fields. Researchers at the Sports Turf Research Institute (STRI), Bingley, UK, measured several aspects of ball/surface (ball rebound, distance rolled, etc.) and player/surface interaction (traction, hardness, etc.) on eight synthetic surfaces and seven natural surfaces throughout England.

Ball rebound was measured by dropping a #5 FIFA approved soccer ball from 10 feet and measuring the percentage of rebound. Ball rebound on natural fields ranged from a low of 34 percent on a wet goal-mouth to 55 percent in the middle of a dry field. The lowest ball rebound on synthetic turf was 41 percent and highest of 54 percent. This suggests that the infilled systems perform similarly with regard to ball rebound. However, other measurements of velocity indicate the ball rolls significantly faster and further on synthetic turf than on natural turf.

The synthetic turf systems also proved surprisingly similar to natural turf fields regarding traction and hardness, leaving the authors to conclude that footwear selection is the governing issue with regard to traction. Surface hardness measures were not different.

Administrators and managers exploring synthetic turf options should keep in mind that synthetic turf systems require maintenance including grooming the infill, reducing static electricity by applying fabric softener and staph infection management by applying hydrogen peroxide. Of course there are well documented surface temperature differences with synthetic turf measuring temps as high as 150° F on a bright sunny 85° F day.

From: Baker, S.W. and A.R. Woollacott. 2005. Comparison of the playing performance of "third generation" artificial grass with natural turf used for professional soccer. ITRJ 10:15-26.

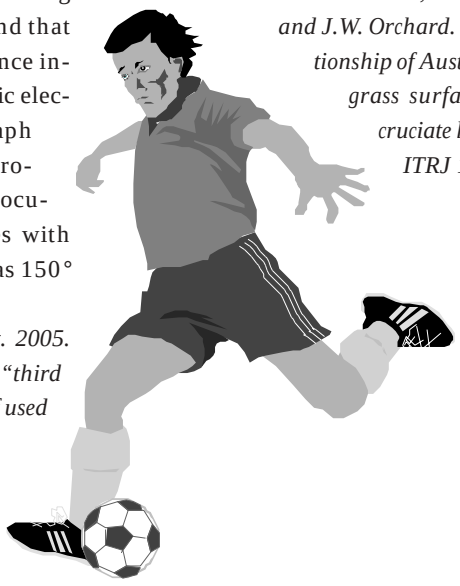
ACL Injuries and Field Measures

Anterior cruciate ligament (ACL) injuries are considered to be career-ending for many athletes. In fact, the Australian Football League (AFL) estimates that ACL injuries cost the league one million dollars (Australian) per year. There was some evidence that AFL players were hurt more often on fields outside of Melbourne, but no clear conclusion was drawn.

Ian Chivers of Racing Solutions Inc. collaborated with David Aldous of the University of Melbourne to determine specific field characteristics that could be linked with non-contact ACL injuries. No significant relationship was found to exist between ACL injury and surface hardness, moisture content or location. However, a significant relationship was found between injury and traction, especially with regard to amount of thatch and percentage of Bermudagrass. In essence, the more Bermudagrass present in the stand the more thatch, the more traction and consequently the more injury.

This study leaves many questions unanswered, especially for the northern sports turf manager. One thing is clear: as traction increases—either through improved field quality or more aggressively treaded footwear—the risk of ACL injury increases. Interestingly, the authors published a separate paper evaluating player perception of fields and looking at both data sets they concluded that the high traction fields that players prefer to play on are the ones on which they are most likely to incur an ACL injury.

From: Chivers, I.H., Aldous, D.E. and J.W. Orchard. 2005. The relationship of Australian Football grass surfaces to anterior cruciate ligament injury. ITRJ 10:327-333.



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Putting Green Management

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tions of the 6 management systems. After the first season, the greens in the alternative culture, nonchemical (now "reduced risk") system were regrassed with velvet bentgrass (SR 7200) sod. In 2004, the nonchemical treatments were modified to reduced risk in recognition of the challenges in maintaining the integrity of the nonchemical treatments.

After three years of attempting to manage 70 year old mixed stands of bentgrass and annual bluegrass without synthetic pesticides, in this climate, it became apparent this was not sustainable with current technology. We felt that a viable interim approach was to avail the project of tools designed to select very low risk products, even if the treatments were no longer technically "nonchemical".

In 2004 we introduced a significant change in the project, the use of the "Environmental Impact Quotient" (EIQ), to select the lowest-impact pest management products and practices in the IPM and reduced risk treatments. The EIQ model provides information on pesticides that will have the least harmful effects on non-target organisms, applicators and golfers. The superintendent chooses the lowest risk product amongst the legal products expected to be efficacious under the specific circumstances encountered.

This year, using the EIQ as a selection tool, preemptive strategies were used to prevent severe quality loss in the reduced risk treatments, including the use of reduced risk pesticides such as Endorse and Alude from Cleary Chemical Co.

In addition to reduced risk chemistry, an intensive biologically based program was initiated utilizing *Pseudomonas aureofaciens* TX-1 through the Bio-Ject System from TurfLabs of California. The TX-1 was applied to the poa/creeping bentgrass greens three times weekly in the evening. Other biological products included EcoGuard (*Bacillus lichenoformis*) from Novozymes, Sustane organic fertilizer, and kelp-based fertilizers to enhance microbial activity.

Turf Quality

Two significant weather-related issues influenced the project in 2004. First, severe winter injury resulted from prolonged ice cover and ensuing desiccation killed significant portions of several greens in the study, as well as other areas of the park. Secondly, cool wet weather delayed spring recovery of the winter-injured areas and reduced some pest pressures while increasing others.

Quality in all treatments improved in 2004 as compared to the first three years. Quality did not differ significantly among treatments at any sampling time (see Table 1). Severe winter injury reduced overall visual quality ratings for several greens throughout the season, most notably on #3, an IPM standard culture green. In addition, the microenvironment around the 9th green (unrestricted pm, alternative culture) was significantly altered by tree and understory removal that appeared to result in season-long chlorosis of the annual bluegrass. This response is typical of an annual bluegrass population that has adapted to a light and air deficient environment. Average visual quality ratings were only below the acceptable in the early season, when damage from winter injury lingered.

Ball roll measurements showed a significant increase from previous seasons where they rarely exceeded eight feet. In 2004 the velvet bentgrass greens produced some of the highest ball roll measurements (see Table 2). However, there were only two dates where the differences between the treatments could be realistically distinguished by the average golfer.

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Table 1. Turfgrass Quality* of Putting Greens, 2004.

Treatment#	5-Apr	12-May	10-Jun	24-Jun	8-Jul	22-Jul	19-Aug	6-Oct
#1 UNRS	5.7	6.1	6.5	7.1	7.7	8.0	7.3	6.7
#2 UNRA	5.6	6.9	6.3	7.5	7.6	7.5	6.9	6.7
#3 RRS	5.6	5.8	6.4	7.1	7.4	7.5	6.9	6.7
#4 RRA	5.7	6.1	6.5	7.0	6.2	6.8	6.8	6.3
#5 IPMS	5.4	6.1	6.4	7.2	6.8	7.2	7.0	6.6
#6 IPMA	5.9	6.4	6.5	7.6	7.8	8.1	7.8	6.9
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

UNRS= unrestricted pest mgt and standard culture; UNRA=unrestricted pest mgt. alternative culture; RRS=reduced risk pest mgt standard culture; RRA=reduced risk pest mgt. Alternative culture; IPMS=IPM pest mgt and standard culture; IPMA= IPM pest mgt and alternative culture.

*Turfgrass quality ratings on a scale of 1-9 where 1= poorest quality, 9= highest quality and 6= acceptable quality.

Labor and Pest Populations

Overall, increased labor resources allowed for more consistent implementation of cultural management—most notably nutrient management. In addition, light frequent rates of Primo (trinexapac-ethyl) a plant growth regulator, known to enhance annual bluegrass health were applied throughout the season.

Intriguingly, dollar spot and *Rhizoctonia* incidence and severity were lower than previous seasons suggesting that an overall shift in less susceptible populations may be underway as dollar spot levels were severe throughout the northeast region and specifically in other areas of the park. Cutworm populations were also remarkably low, with damage exceeding threshold levels only on the velvet greens.

While major foliar diseases seemed to subside in 2004, root infecting pathogens that thrive in wet soils, such as summer patch, appeared to infect annual bluegrass early and plague the surfaces throughout the season. Although summer patch incidence was not widespread enough to warrant graphing, it contributed to quality loss at times on two IPM greens that were not sprayed preventively.

The average percent of days scouted when any area of the green had any area over threshold, for six different pests or problems indicates a myriad of challenges. For example, algae incidence was high in all treatments, especially reduced risk and IPM greens. Dollar spot levels that the were the lowest of all four years of the experiment were highest on the reduced risk poa/creeping bentgrass greens and never over threshold on the unrestricted alternative culture greens. Fairy ring and *Rhizoctonia* incidence were notable only on the reduced risk poa/creeping bentgrass greens whereas goosegrass has encroached in both the reduced risk treatments—a sign of the thinning that has occurred. Annual bluegrass was only considered a weed on the velvet bentgrass greens and was over threshold 79% of the year.

Pesticide Use

The total number of pesticide applications to the reduced risk (formerly nonchemical) greens indicates an interesting difference between velvet bentgrass and annual bluegrass/creeping bentgrass greens. Pesticides were considered reduced risk if classified as such by the EPA. Four to five chemical fungicides, and five to ten reduced risk fungicides, were applied to both the standard culture (poa/creeping bentgrass) and alternative culture (velvet bentgrass) greens. In addition, the poa/creeping bentgrass greens received 37 bio-fungicides, 95% of which were *Pseudomonas aureofaciens* TX-1 (applied three times weekly).

The number of pesticide applications to IPM and unrestricted greens indicate the heavy reliance on standard fungicides. Chemical pesticide applications were reduced by 54-57% in the IPM treatments, significantly better than previous years, largely due to shifting to reduced risk and bio-pesticides. If all pesticides are included with the standard chemical pesticides, the reduction is only 3-6% in the IPM treatments. To measure the value of this reduction in terms of environmental impact, we have calculated the EIQ values of each system.

Dollar spot continues to be the main target of pesticide applications in the unrestricted treatments, and among the top three for all other treatments. Dollar spot occurrence was lower than all other years. It appears that dollar spot management was more effective than in previous years in all treatments, and that the high number of applications in the unrestricted treatments may be unwarranted.

Environmental Impact

Comparing the number of pesticide applications is a fairly arbitrary method for assessing pesticide use when a variety of products are being used, and does not account for the impact of those applications. However, we and many other researchers have used that method

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Table 2. Ball Roll Measurements From 2004 Treatments.

Treatment	10-Jun	24-Jun	8-Jul	22-Jul	19-Aug
#1 UNRS	8.2	7.8	8.2	8.2	8.1
#2 UNRA	7.6	8.0	8.5	8.5	8.1
#3 RRS	7.9	8.0	8.1	8.3	8.1
#4 RRA	8.2	8.6	7.9	9.1	8.5
#5 IPMS	7.9	8.0	8.2	8.4	8.2
#6 IPMA	8.1	7.5	7.7	7.8	8.0
LSD (0.05)	NS	0.6*	NS	0.7**	NS

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Irrigation Multi-Tasking

Program Spotlight

I could argue that fertigating is more efficient in that the fertilizer is applied in enough water to penetrate the soil and avoid atmospheric loss. It is also applied uniformly and at known rates from proper head design. Best of all, there is limited labor and additional energy expended to achieve the same results as what is currently being conducted.

Modern irrigation systems are technological marvels, combining design with function and durability. Systems designed to deliver precise amounts of water with uniform distribution affords the turfgrass manager significant management flexibility regarding soil types, topography and turf species.

With all this sophistication and flexibility, irrigation systems should not be confined to delivering water. The ability to uniformly distribute fertilizers, pesticides and biological organisms could provide significant benefits. Applying materials without tying up an employee or engaging the use of spray equipment provides labor and equipment savings. If the system is flexible enough to provide site-specific watering it should be capable of other site-specific applications.

Your Daily N

It is common practice to "spoon-feed" putting greens with light amounts of nitrogen fertilizer on a weekly basis. Turfgrass managers can maximize performance and minimize growth surges that result in slow greens. In many ways it provides control over growth in an effort to maximize green speed.

Fairway, tee and even rough fertilization are typically achieved by applying granular fertilizer that is some form of slow release nitrogen. Turfgrass managers don't feel they need as much control over growth in these areas and rely on the release technology for even growth.

Irrigating with nutrient enhanced water (fertigating) and light amounts of nitrogen every few days in association with irrigation needs provides the same result. In fact, I could argue that it is more efficient in that the fertilizer is applied in enough water to penetrate the soil and avoid atmospheric loss. It is also applied uniformly and at known rates from proper head design. Best of all, there is limited labor and additional energy expended to achieve the same results as what is currently being conducted.

There are clear health effects associated with daily nitrogen use, as well. Professor Dan Bowman at North Carolina State University investigated the difference between intermittent applications of nitrogen, similar to slow release technology and daily applications of soluble nitrogen.

Bowman showed how daily nitrogen applications, similar to fertigation, resulted in stable leaf growth and nitrogen levels in the tissue. In contrast, intermittent nitrogen applications showed wide fluctuations in leaf tissue and nitrogen levels that could lead to additional stresses.

Clearly, no turfgrass manager is going to apply nutrients to the turf daily with conventional spray technology. Using the strengths of

the irrigation system to deliver the nutrients is technology already available at your fingertips.

Alternative World

Current trends in pest management with new chemical pesticides, less chemical pesticides or biological pesticides suggest that we will be spraying more frequently. Research with biologicals, such as the BioJect™ system indicates that frequent applications of the TX-1 organism are required to maximize disease control. Research with other reduced-risk pesticides indicates that when pest pressures are high more frequent application is required.

There is some history with using the irrigation system to deliver pest management products and it was not positive. The BioJect™ was plagued with system performance issues for more than a decade. There was not enough organism being generated, it was not being distributed in the system properly and the system required too much oversight.

Turf Science Labs has identified methods for enhancing performance through the irrigation system, making use of the BioJect™ easier than ever. However, many who tried early BioJect™ systems abandoned them and cast dispersion on the entire idea of injecting into the irrigation system. Turf Science Labs needs to get their story out there and we need to get over negative perceptions of the use of irrigation to deliver product.

We are currently working with a Green Side Injection (GSI) unit from BioSafe Systems, Glastonbury, CT, that allows us to inject Zerotol (it could be used to inject any soluble chemical) at a specific green. The chemical does not mix with other parts of the irrigation system, can be applied daily and, depending on your green irrigation system, with good uniformity.

I often hear turfgrass managers lament having the sprayer out for more time than is absolutely necessary. This usually comes on the heels of a conversation about using higher spray volumes to enhance product performance. Injecting product into a high volume system (such as an irrigation system) solves this problem and can be site-specific with an innovation such as the GSI unit.

Another benefit of product injection into the irrigation system is evening application. Research at Cornell University has shown how certain disease organisms are more susceptible to fungicides applied in the evening. In fact, excellent control was achieved in one case with less than a quarter of the lowest use rate. Evening applications with your irrigation system would be ideal for this benefit.

Challenges to Consider

There are challenges in using an irrigation system to deliver products. The biggest is that it challenges you to consider your product needs and your water needs. Often these needs can conflict, i.e., if you want a drier surface or if there is significant rainfall and you have poor drainage. In these cases it may not be practical to deliver product with your system, but there are plenty of instances where it is perfect and will expand your options.

In the end, the best systems allow for flexibility to meet your changing needs. Perhaps, it's time to consider that in-ground investment for more than just delivering water.

Frank S. Rossi, Ph.D.

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because of a lack of better tools for assessing and comparing impact.

In 2004 we used the EIQ for both selecting low impact products and to assess the cumulative impact of all products applied during the season in each of the six management systems. The EIQ uses 13 criteria including acute and chronic human toxicity, soil and leaf persistence, toxicity to nontarget organisms, and leaching and runoff potential to determine worker, consumer/user, and ecological impact—which are combined into one final quotient number. The model balances factors such as toxicity to fish with the probability for the pesticide to leach from the initial application site. The final EIQ number is produced for all pesticides assessed, and is multiplied by the actual rate of use to give a field EIQ.

The field EIQ for each treatment differed significantly by cultural management strategy only in the reduced risk treatments. For pest management systems, unrestricted treatments had significantly higher field EIQs than both the IPM and reduced risk treatments (see Figure 1).

Nitrogen levels were significantly higher in 2004 for all treatments. This was an unusually wet year and with high sand content root-zones it is not uncommon to need more N to sustain quality and growth; N could be used by more actively growing plants due to the lack of heat that would normally cause some slowing in growth.

Labor resources in 2004 appeared to be allocated substantially different than in previous years where fertility and pesticide applications showed greater differences. In 2004 labor differences were significantly different for cultural management (see Table 3). However, it appears that the unrestricted treatments had the highest cultural labor hours that translated into the greatest amount of total labor as compared to the other treatments.

In 2004, labor differences were significantly different for cultural management. However, it appears that the unrestricted treatments had the highest cultural labor hours that translated into the greatest amount of total labor as compared to the other treatments.

When asked how they felt about pesticide use on public golf courses, the majority of golfers surveyed chose the IPM answer: "Keep greens at reasonably good quality, using pesticides judiciously, only as needed."

Golfer Satisfaction Survey

One hundred and seventy seven golfers were surveyed in 2004 about their perceptions of putting green quality and pesticide use. The survey was purposely conducted in mid-August, to capture golfer perceptions during the most stressful time of the year for the putting greens involved in the study. However, as described above, August greens quality was unusually high this year due to a more favorable growing season, i.e. lack of heat and adequate moisture. Survey results were similar to 2003.

The average rating for the visual quality of all greens was between good and very good, and differences by treatment were slight. When asked how they felt about pesticide use on public golf courses, the majority of golfers surveyed chose the IPM answer: "Keep greens at reasonably good quality, using pesticides judiciously, only as needed." Only 6% of golfers wanted pesticide use reduced if it meant reduced quality. When asked how the Green Course putting greens compared to those of the adjacent Blue and Yellow courses, 28% of golfers considered them to be better or much better.

Outreach and Impact

Results from this study have been publicized in a number of formal and informal settings, in addition to reporting to the USGA. To date we have given over 40 presentations and written 15 reports and articles, reaching several thousand golf course superintendents and environmental advocates. Discussion of this project has opened new dialog in many arenas where interested parties were previously adversarial.

Final Thoughts

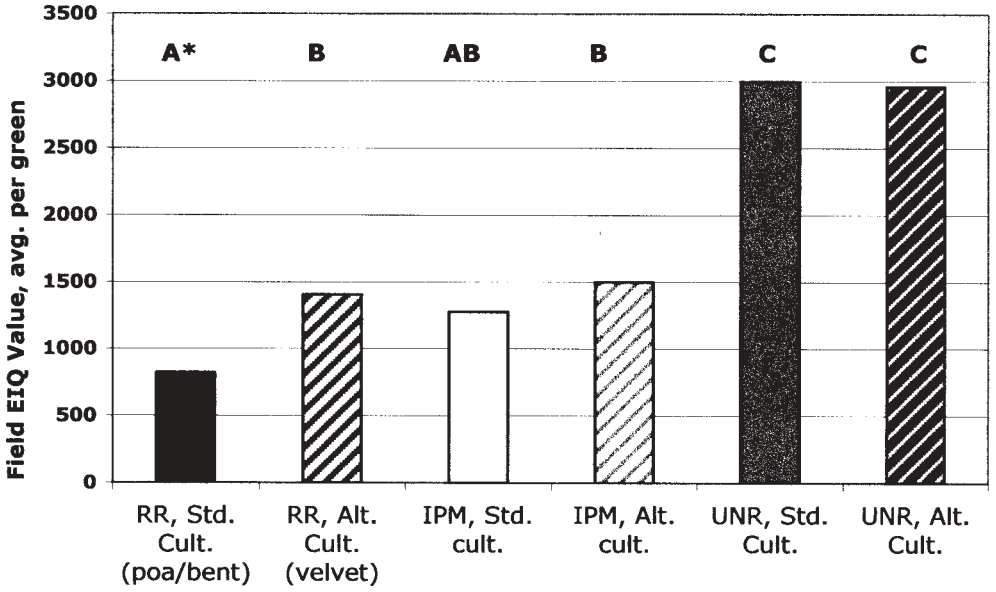
Culture and Growth: The 2004 growing season was one of the top five wettest seasons in history as well as significantly cooler than previous seasons. Poor weather resulted in sig-

Table 3. Labor Hours Expended, Extrapolated to 18 Greens, 2004.

Treatment	Cultural	Fertility	Pest	Total
#1 UNRS	752.3	72.8	40.8	865.8
#2 UNRA	859.2	85.0	142.2	1086.4
#3 RRS	758.7	60.0	74.1	892.8
#4 RRA	694.0	76.8	20.8	791.6
#5 IPMS	732.8	68.9	41.6	843.3
#6 IPMA	693.1	55.2	33.2	781.5
LSD (0.05)	83.5	NS	NS	110.6

*Treatment totals with the same letters are not significantly different (p=0.05).

Figure 1. Environmental Impact of Pesticide Applications Expressed as Field EIQ, 2004.



* Treatments with the same letters are not significantly different, p=0.05.

nificant reductions in total number of rounds on the course that could have contributed to less stress from traffic.

The greens maintained active growth throughout the season and clearly benefited from regular fertility and PGR applications that improved overall plant stress tolerance as evidenced by the reduction in pest problems compared to previous seasons.

The elimination of the nonchemical treatments does not indicate a surrender but rather a recognition of the lack of alternative controls that are practical in a real world setting as compared to a research plot environment. However, there is string evidence that alternative technologies that are properly integrated can lead to overall reductions in pesticide use.

Pesticide Use: A successful transition to more environmentally compatible putting green management should begin with slight alterations in existing programs for superintendents to fully embrace them. The use of the EIQ is an excellent first step that has already demonstrated some acceptance among project coordinator, Andy Wilson. Wilson currently utilizes the EIQ approach for his decision-making and finds it easy to work with.

As the data clearly indicates, the unrestricted treatments where traditional pesticide technology is used has higher EIQ ratings compared to either population based decisions in the IPM approach or strict use of RR materials.

Also, while a significant effort is invested in disease management, major reductions in insecticide and herbicide use have been achieved and adhered to during the four years of the study. This suggests that many preventative treatments for insects and weed pests may not be needed to further improve the environmental compatibility of the programs.

The regular applications of biological control using TX-1 seemed to have a profound effect on reducing certain foliar pathogens, such as brown patch and dollar spot as compared to other areas on the course and historical infestation levels. There were several occasions when signs of the pathogen were noted previous to an application and then they dissipated following applications where they were clearly visible in adjacent areas.

Velvet Bentgrass: The velvet bentgrass greens seem to be responding differently depending on location. For example, the 10th green is small and receives a significant amount of ball marks when compared to the other two greens. During the season, even in 2004 with limited environmental stress, it becomes chlorotic and thins. The 15th green being a par 3 also receives significant ball mark damage but due to its size does not seem to suffer as much traffic stress compared to 10, however the annual bluegrass populations on both greens is increasing. An early season preventative application of Prostar for fairy ring management completely eliminated what was otherwise a chronic problem with these surfaces.

Jennifer A. Grant, NYS IPM Program and Frank S. Rossi, Cornell University
Cooperators at Bethpage State Park: Andrew Wilson, Kathie Wegman, Craig Currier, and David Catalano

Major reductions in insecticide and herbicide use have been achieved and adhered to during the four years of the study. This suggests that many preventative treatments for insects and weed pests may not be needed to further improve the environmental compatibility of the programs.

CUTT

Understanding Pesticide Risk

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A major finding—one that correlates with previously existing data—is that this population of farmers experiences lower overall cancer rates than the general population.

In an AHS analysis of exposure to chlorpyrifos, one of the most widely used insecticides in the US, researchers found an association between the use of this pesticide and the incidence of lung cancer, but not with any other cancer.

Job characteristics more common among those who reported a high pesticide exposure event included repairing pesticide application equipment oneself and having first used pesticides more than 10 years ago.

The AHS is now at the stage at which disease rates can be assessed, and the study is producing some important cancer findings. These findings reflect about five years of follow-up, following several years of enrollment and data collection. The two ways in which cancer rates are analyzed in the AHS are: 1) the comparison of cancer rates amongst enrollees with those of the general population, and 2) the comparison of cancer rates of those using specific pesticides with those who do not.

A major finding—one that correlates with previously existing data—is that this population of farmers experiences lower overall cancer rates than the general population. The rates found thus far of all cancers except prostate cancer were lower. However, early findings do suggest an association between the use of specific pesticides and an increased risk of specific cancers. It is important to note that discovering these associations does not mean a causal relationship has been found. The AHS employs a rigorous strategy of criteria for causal inference.

Chlorpyrifos and Lung Cancer

In an AHS analysis of exposure to chlorpyrifos, one of the most widely used insecticides in the US, researchers found an association between the use of this pesticide and the incidence of lung cancer, but not with any other cancer. In the highest exposure group, there was a 2.18 relative risk of lung cancer. This finding is of particular interest because farmers in general, and also those within the AHS cohort, have lower rates of lung cancer than the general population, probably because of lower smoking rates. (The chlorpyrifos-lung cancer association in this analysis was determined controlling for all other known cancer risk factors, including smoking.) In addition to its agricultural uses, chlorpyrifos was widely used in US households until 2000, and exposure to chlorpyrifos is the focus of an intensive exposure study within the AHS.

New Insights Regarding Pesticide Exposure

One of the major challenges in studying the effects of pesticide exposure on human health is the difficulty in precisely assessing real-life exposures. Pesticides are widely used without a detailed understanding of all the various ways they might enter the body and in what quantities they do so. As part of its study of the Iowa and North Carolina farming populations, the AHS has prioritized the improvement of scientific methods to better understand pesticide exposure. This work has revealed much information that enables scientists to more accurately determine potential health effects of pesticide exposure, and also assists in the development of better controls and practices to decrease exposure.

For example, early on in the study members of the research team looked closely at the characteristics of people who self-reported a "high pesticide exposure event." Closely examining this 14% of the study population enabled the epidemiologists to determine what home and farm features or practices are associated with incidents or experiences leading to unusually high personal exposures. These characteristics ranged from how, where and when work clothing was laundered and the types of pesticides being used, to whether the family was experiencing financial stress. After taking into account education and the total number of lifetime applications made, researchers saw that women had significantly fewer events than men who applied pesticides.

Job characteristics more common among those who reported a high pesticide exposure event included repairing pesticide application equipment oneself and having first used pesticides more than 10 years ago. While the demographic, work practice and job characteristics identified in this investigation were not necessarily the cause of the high pesticide exposure, identifying these factors is a first step in the eventual prevention of these potentially hazardous events. Computer modeling—used as a tool in the AHS for exposure estimates and analyses, in addition to biological measurements—showed that following all pesticide label requirements could prevent many of these high exposure events.

Other analyses looked at exposure hazards of families of pesticide applicators. The design of the AHS takes into account that farmers "living where they work" presents potential exposures for spouses and children. Researchers found that 21% of homes are within 50 yards of the pesticide mixing area, that 27% of appli-

cators store pesticides in their homes (including attached garage or basements), and that most pesticide-contaminated clothing is washed in the same machine as other laundry. At least half of the wives reported working the fields, 40% reported mixing or applying pesticides, and more than half of the children over age 11 did farm chores, some of which may have put them into contact with pesticides.

Researchers are taking this farm, home and work practice information and developing ways to determine the health implications of the resulting exposures. For example, scientists at the EPA conducted a five-day continuous sampling of a group of volunteers in the AHS population in order to gain a detailed understanding of exposure to two pesticides, 2,4-D and chlorpyrifos. Biological samples from volunteering spouses and children were also collected. Exposure to these two pesticides is also being analyzed in a project that compares average exposures between different subpopulations in the AHS, for example between the two states, between male and female, and between farmers and commercial applicators. All of these data will enable a more complete analysis of exposures to these two widely used pesticides and any subsequent health outcomes.

Studies like these both refine exposure information for the AHS specifically, and develop methodologies for future pesticide exposure research. AHS computer models predicting pesticide exposure have already been found to be an effective predictor of exposure in a non-AHS population. AHS efforts also include comparisons between African-American farmers' and white farmers' pesticide use practices in North Carolina, and analyses of the use of protective equipment and application method. Comparisons of work practices and attitudes toward risk between the two states are proving to be instructive. All of this research also clearly contributes to improved health and safety education and communication tailored to the farming community.

Information on the Web

The AHS Web site, www.aghealth.org, contains information for enrollees and others in the format of frequently asked questions as well as agricultural health resources for both states and national links. Much of the web site, while geared toward a scientific readership, is accessible to lay persons wanting to read AHS related journal articles, which are all available in abstract or full text format. Watch the web site for the wealth of information expected to be published in the coming years, during AHS's intensive five-year period (2004-2008) of assessing disease rates and risk factors.

The Agricultural Health Study is supported by: the National Cancer Institute (NCI), the National Institute of Environmental Health Sciences (NIEHS), the US Environmental Protection Agency (EPA), and the National Institute for Occupational Safety and Health (NIOSH); the National Center on Minority Health and Health Disparities (NCMHD) funds an effort to study cancer and non-cancer disease outcomes among African-American farmers in North Carolina.

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Program on Breast Cancer and Environmental Risk Factors

Researchers are taking this farm, home and work practice information and developing ways to determine the health implications of the resulting exposures.

Exposure to 2,4-D and chlorpyrifos is also being analyzed in a project that compares average exposures between different subpopulations in the AHS, for example between the two states, between male and female, and between farmers and commercial applicators.

CUTT

A Healthy Ecosystem

Fifty pesticides were selected based on their widespread use or if previous studies indicated their potential association with health risks, and 30 more were added based on participant "write-ins."

Understanding Pesticide Risk

In 1993 enrollment began for the largest health study of the US farming community, the Agricultural Health Study (AHS). Twelve years later, data from the 89,658 enrollees in Iowa and North Carolina are beginning to generate the most comprehensive assessments of the link between individual pesticides and cancer risk ever published. The risk of various cancers is just one set of health endpoints monitored in this ground-breaking study; other health problems addressed include diseases of the nervous system, as well as respiratory and reproductive health.

There have been various epidemiological attempts to better understand the relationship between pesticide exposure and cancer risk. These, together with laboratory work, have presented a patchwork of data linking some pesticides with increased risk of some cancers. The large scale and comprehensive design of the AHS are meant to specifically address the weaknesses and gaps in prior research.

Enlisting the long-term support of a large portion of the farming communities of two states, Iowa and North Carolina—both with strong agricultural sectors with diverse agricultural methods and products—enables researchers to employ the strengths of prospective cohort studies. The chemical exposure and lifestyle information that is collected from these participants is the most detailed ever: participants responded to about 250 questions in the initial survey.

Fifty pesticides were selected based on their widespread use or if previous studies indicated their potential association with health risks, and 30 more were added based on participant "write-ins." Follow-up surveys every five years provide scientists with updated information. Including spouses in the research is an important aspect that is providing data on women and pesticide use and exposure never before collected. There is also a small percentage of female certified (North Carolina) and licensed (Iowa) pesticide applicators included in the study. Overall, two-thirds of participants are applicators and one-third are spouses. With children also registered, the understanding of the health of farm families is being greatly enhanced by the AHS.

Cancer Findings

Previous research indicates that farmers experience some cancers to a lesser extent than the general population and some cancers to a greater extent. Fewer farmers die from lung, esophagus, bladder, and colon cancers, possibly the result of smoking less, eating a healthier diet and getting more physical exercise than the average American. But studies also suggest that farmers as a group experience higher rates of Hodgkin's disease, leukemia, multiple myeloma, non-Hodgkin's lymphoma, and cancers of the lip, stomach, prostate, skin, brain, and connective tissue.

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