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An ACSP Environmental Case Study

Contained Chemical Mix/Load Facility Installation

I have been urging superintendents to enroll in the ACSP program as part of the Audubon International's 50-in-5 campaign to get 50 percent of the Florida golf courses in the program within the next five years. I also know that there are still a lot of skeptics out there just waiting for someone else to take the plunge first. One of the things you are required to do for ACSP certification is an Environmental Case Study on a subject that falls within the standard management practices of the ACSP, which are listed in the certification handbook. We are going to be submitting ACSP case studies done on Florida golf courses in the Florida Green as hands-on examples what some of your peers are doing to get their courses certified.

Our first case study in this series of "how-to" articles is from Kyle Sweet, golf course superintendent at the Sanctuary Golf Club on Sanibel Island. Kyle's case study is on the contained chemical mix/load facility recently installed on the golf course. According to Joellen Zeh, staff ecologist with AI, "This is a good example of a course that was already 'doing it all' because of the strict scrutiny that the development was given due to its location within a wildlife refuge, and yet, the Sanctuary's awareness and best management practices were strengthened even more due to their involvement in the ACSP."

Shelly Foy

By Kyle D. Sweet

The Sanctuary Golf Club did not have a contained chemical mix/load area. The original installed area was a 4-inch concrete pad poured level adjacent to the chemical storage building. This pad had no containment and had been used for mixing/loading for several years.

If a spill were to occur, there was great potential for the material to enter either of two nearby storm drains located in the maintenance facility's asphalt-paved areas. If a spill reached these storm drains, the contaminants could ultimately reach a nearby water body, which serves the 12th hole.

I proposed a project to eliminate this potential hazard. The contained chemical mix/load area project was chosen due to the liability of the potential hazard as well as the desire to comply with the necessary requirements of the Audubon Cooperative Sanctuary Program for Golf Courses.

The entire process began with gathering information on a portable containment skid and taking our proposal to a local structural engineering firm to put our ideas to work. The permitting process and engineering drawings took approximately two months to get completed so we could begin construction of the site.

The current mix/load site was the best location to build the new containment area. Demolition of the existing 4-inch-thick concrete slab was necessary, since the new slab needed to be 6 inches thick to be approved due to construction techniques. Once all of the old concrete was removed, proper reinforcing mesh was installed and the 6-inch slab was poured.

A concrete-block half wall was then constructed along two sides of the slab to protect the area from vehicle traffic as well as foot traffic that travels in and out of the facility area. The new slab was adjacent to the chemical storage building so, in order to cover it properly, an extension of the roof was necessary. The new roof to cover the mix/load area was actually fastened to the existing tie beam of the chemical building and became a large overhang for the area.

While the roofing and lighting were being installed to the new roof, we also had all electrical outlets, breaker boxes and light switches removed from the interior of the chemical storage building. Vapor-proof lighting was installed, which replaced previous insufficient lighting. All new construction of chemical storage buildings are permitted only in this way so I was glad to get us into compliance in this aspect also. In order to support the new overhanging roof, three large support posts needed to be installed along the outer edge of the slab inside of the half-wall. These support posts were buckled to the wall and fastened to the slab.

When the construction of the area was completed we sealed the slab with an impervious sealer and installed protection posts at the corners of the half wall. The posts are 6-inch PVC set and filled with concrete to prevent damage to the wall from vehicles.

This containment bay was built to accommodate a chemical mix/load skid that is constructed of aluminum and stainless steel by ESD Waste 2 Water manufacturing. This skid was placed on the new slab under roofing and had many advantages over other systems I have seen.

Demolition of the old slab outside the chemical room. Note containment around the fertigation tanks to the right.

Advantages

1. This mix/load skid is portable and could be moved and used throughout the property if needed.
2. The mix/load area could be used for something else in the future if needed. It is accessible with our large loader under roof and could serve as dry storage area.
3. All piping and working parts are visible and able to be worked on by our staff. There is no underground electrical or underground rinsate piping.
4. The system is very easy to empty and clean of rinsate material. Many staff members have been successfully trained in using the rinsate for small sprayer applications throughout the property.

Now that the area is completed and working, it has served us very well. It has proven to provide us with a water savings in our use of our small hand-held and electrical 15 gallon sprayers by using the rinsate water instead of additional potable water. Most of the small sprayer use is for non - selective spraying with Round-Up herbicide. It has been very easy and dependable for our IPM manager to work with and has removed the worry of a spill from chemical mixing entering into any of our surrounding storm drains or waterways.

Portable 400-gallon-capacity containment skid with portable sump pump located on sealed concrete floor in protected mix-load area. Photo by Kyle Sweet.

Goals

The goals for this project:

1. Prevent the possibility of pesticides from entering maintenance facility storm-drainage basins and surrounding water bodies from a spill while mixing and loading chemicals.
2. Keep the project as cost efficient as possible.
3. Install a system that is easy to maintain for our IPM manager and that will last for many years without costly maintenance.
4. Have the ability to re-use the chemical rinsate water to carry out non-selective herbicide spraying on the golf course rather than using costly city water supplies.

Implementation And Maintenance

In order to implement this project several steps had to be taken:

1. Proper permitting through the City of Sanibel Planning and Building departments.
2. Engineering drawings done to illustrate our ideas so the project could be bid on and permits could be acquired.
3. Measuring of the area to make sure that the additional construction of a covered area would not interfere with the necessary delivery and maintenance traffic that must travel throughout our facility each day.
4. Keeping the area as close as possible to the chemical storage building. Since there was a pre-existing slab (without containment) adjacent to the building this was not a difficult decision.
5. Separating the area from normal facility operations. This was done with the use of a concrete half-wall. Once the area was constructed we instructed our maintenance staff to treat this area the same as the chemical storage area. No access into the area unless instructed to do so.
6. The size of the rinsate storage had to be large enough to facilitate our largest sprayer. Our largest volume sprayer is 300 gallons and the drive-on skid will hold 400 gallons of liquid when empty.
7. The pumping system to extract the rinsate needs to be maintained. A filtering system was installed and has to be monitored to filter out unwanted grass and soil that might enter the holding area of the skid. This filter will catch the solid material before entering the pump, which will help the performance and life of the pump.
8. Sealing the new 6-inch slab was done to pre-

vent any material entering the concrete flooring that surrounds the drive-on skid system.

Results

The environmental and employee safety level has been substantially increased because if any mixing/loading spills occur, they will be contained in the sump area of the newly installed mix/load skid.

Golfer/Employee Response

The project was originally proposed to the Greens and Grounds Committee of The Sanctuary Golf Club in coordination with the Audubon program as well as the Best Management Practices for Golf Courses published for the state of Florida. We had to have capital money approved to complete the project and stressed the importance of this project to everyone involved in the budget process.

As the project progressed I publicized our progress and was able to meet with members at the site and show them what was being done. Once completed, I toured the committee through the operation of the area and they were very impressed with the project. I also walked through the area with the assistant fire chief of Sanibel during their inspection of the building add-on. They also were impressed with the operation and the fact that we were being proactive to prevent accidents.

Perspectives and Recommendations

My first recommendation is to have staff that can handle a spill if one occurs. For the past three years our department has trained five individuals to act as a Spill Response Team. Our IPM manager, Fred Fulford, is a trained OSHA Level V Incident Commander, while four other staff members are trained to assist him in the event of a spill. All personal protective equipment is on hand to handle a spill. We can react immediately to an incident within the full scope of the law pertaining to Hazardous Spill Cleanup. I feel this is very important as the amount of time a spill is uncontained can increase the risk of harm to the environment. Also, the services of outside contractors are at a premium cost. Our club can be assured that the problem will be handled as safely and cost efficiently as possible.

With our existing facility size restrictions and chemical storage building location, I feel we did the best we could to improve our situation. I would not do anything differently. I would certainly recommend that golf courses of all types consider this type of mix/load area containment system. The flexibility and simplicity of the system will be a winner for anyone involved in chemical mix/load containment.

Costs and Benefits

How much did it cost to implement this project?
$ 21,050
What are your anticipated or actual financial savings?
Immeasurable.
Information
Yes, I am willing to take calls regarding this project.
Yes, photos are included with this Case Study.

Stewardship Notes

Another Outreach And Education Idea

By Shelly Foy

We have all heard the expression, "practice what you preach." You practice environmental stewardship on your golf course, but does that extend to your family and your own home? Where better to start employing good sound environmental practices than in your own backyard?

AI's Treasuring Home program offers a guide to environmental stewardship for homeowners. "Valuing and caring for the natural resources and unique landscapes in places we call home is critical to creating a healthier and more sustainable environment for the future," says Jean Mackay, Audubon International's director of educational services.

It occurred to me that golf course superintendents can use the Treasuring Home program and accompanying guide as another Outreach and Education program for their Audubon Cooperative Sanctuary Program. This is an excellent tool for introducing your golfers/members to AI and getting them interested in supporting the same type of projects on the golf course.

The booklet, Treasuring Home, which is available to all donors to Audubon's Earth Fund, not only is filled with great indoor and outdoor environmental projects you can do at your home, but also includes a pledge to fill out and return which allows homeowners to make a commitment to good environmental stewardship. You can obtain a copy of the guide, or purchase multiple copies by contacting AI at 518-767-9051, or e-mail jmacky@audubonintl.org. You can also view the Treasuring Home guide and take the pledge online at www.audubonintl.org/homepledge.

Below is a list of some of the projects you can learn more about in the Treasuring Home booklet.

Outdoor Projects:

- Landscape primarily with native plants
- Incorporate food and shelter for wildlife and protect natural habitats
- Maintain water for wildlife
- Become more familiar with local natural areas, plants and wildlife
- Add a variety of trees, shrubs and herbaceous plants
- Use water wisely to maximize efficiency and minimize waste
- Protect water quality
- Maintain healthy soils for a healthy lawn
- Mow the lawn at the proper height and with sharp blades
- Reduce or eliminate the use of harmful chemicals

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Indoors:

- Get all family members into the habit of daily conservation
- Save water by shutting it off during teeth brushing and shaving; take shorter showers and run appliances on full loads
- Make inexpensive upgrades such as installing low-flow aerators
- Replace older, large-tank toilets with low-flush models
- Conduct a home energy audit
- Switch to compact florescent light bulbs
- Improve insulation and purchase energy-efficient appliances
- Reduce waste
- Choose reusable products
- Recycle paper, glass, plastic and metal

Beyond Your Backyard:

- Pass along the Treasuring Home guidebook to family and friends
- Encourage others to participate in environmental stewardship at home
- Work with a local homeowner or neighborhood association to implement neighborhood environmental stewardship projects
- Purchase locally grown and produced products and recycled goods
- Offer to help a local school get involved in environmental education and stewardship
- Get involved in organizing community-wide environmental improvement projects
- Support the protection of local natural areas
- Participate in local planning efforts in support of local conservation and environmentally sensitive growth
- Participate in AI's Sustainable Communities Program

Justifying a Full-time Environmental Technician

By Katie Benway

If you have ever considered becoming involved with Audubon International's Audubon Cooperative Sanctuary Program for Golf Courses, one of your first dilemmas may be to justify the manhours needed to implement the program. Many golf course managers feel that the ACSP program is not only valuable for internal and external public relations but also a way to learn and execute responsible management practices that do in fact help the environment.

In a recent NGF survey 93 percent of the avid golfers surveyed responded that they believed in the need to protect the environment and 85 percent of them responded that they thought golf courses are friendlier to the environment than they were 10 years ago. The ACSP certification program is an inexpensive and relatively simple and easy way for golf courses to demonstrate and document that they are environmentally responsible and are interested in doing the right thing.

ACSP Update

New ACSP Members since April 2003
Ft. Walton Beach GC, Ft. Walton Beach
Grey Oaks CC, Naples
Red Stick GC, Vero Beach
Ritz-Carlton Grande Lakes GC, Orlando
Seminole GC, Tallahassee
Sugar Mill CC, New Symrna Beach
Vasari CC, Bonita Springs

Fully Certified since April 2003
Long Marsh GC, Englewood
Pelican Sound GC, Estero
Sanctuary GC, Sanibel Island

For most superintendents the idea of completing the paperwork, research, and fieldwork required for the Sanctuary Site certification is more than they themselves have time for. Furthermore, they may not be willing to pull their assistants off their normal routine in order to devote time to this project. Therefore, one solution is to hire or appoint someone and create a new position to fulfill this requirement. While each course will have a different situation, at the Interlachen C.C. in Winter Park, where I worked, they have made the position a permanent part-time staff position, or it can be handled as an internship. I was an environmental science major at the University of Central Florida and worked part-time at the golf course.

Other courses have found individuals on the crew who have a sincere interest in doing environmentally related work in more detail. At some clubs, club members or members of the Resource Committee that must be formed have taken on the responsibility for conducting most of the projects thereby minimizing the labor hours needed from the maintenance staff. The possibilities are endless.

If you do decide to create a new position on the staff, the job description is that of an environmental technician/administrative assistant. Because this position is unique, it is important to mention the fact that the position can be designed to incorporate the added responsibilities of administrative assistant for the golf course maintenance department.

The ACSP certification itself has a great deal of research and paper and computer work involved. At the same time, the individual would be able to perform additional tasks within the office. The advantage to the superintendent is that this person is performing dual roles and is therefore more easily justifiable. However, in some cases this may require the position to be maintained at a full-time status. A full-time employee would also be able to attain the certified sanctuary status more quickly and plan more extensive projects.

The following is a list of the responsibilities for the environmental technician that I performed while at the Interlachen C.C. Tasks and responsibilities include:

- Care and maintenance of all gardens related to certification (i.e. butterfly and wildflower gardens)
- Research of plants to be used in specific garden types
- Make recommendation and prepare purchase orders for approval of plants for gardens
- Place and fill birdfeeders every 2 days
- Purchase birdseed
- Purchase and place nest boxes
- Conduct research for any project. (Example: Installing nest boxes - determine which boxes to build or purchase and where they should be placed for maximum effectiveness.)
- Monitor and document wildlife populations and species on the golf course property
- Monitor nest box activity
- Coordinate and/or host bird counts during migration or breeding season, including local birdwatching and Audubon clubs
- Transport any injured or orphaned wildlife to rehabilitation center
- Write "wildlife of the month" informative articles for the club newsletter.
- Assist in writing of course maintenance section of monthly newsletter
- Purchase and maintain library and/or bulletin board of environmental education materials where members can see them
- Complete all paperwork required for certification levels and update paperwork every two years to maintain certification status
- Complete all backup documentation required for certification (mapping, photos, water tests, records of soil tests, etc)
- Re-vegetate shorelines with native aquatic plants
- Re-vegetate and supervise maintenance of naturalized areas with native trees and plants with value to wildlife research for plants needed and native to area/benefits to wildlife
- Select and purchase those aquatic and native plants
- Educate co-workers with posters and bulletin boards explaining the program and identifying native plants and animals
- Answer all questions from both co-workers and members concerning any element of the program or wildlife related information
- Research any issue that is unfamiliar or requires specific information, such as location of local eagle nests, endangered or threatened species

Additional duties outside sanctuary site program:

- Act as assistant to superintendent and assistant superintendent by making pickup and delivery of small tools, chemicals, and equipment
- Enter all purchases and purchase orders
- Keep record of expenditures and costs of products
- File all records
- Assist in correspondence for meetings, conferences, purchases and large-scale projects
- Answer incoming phone calls and take messages
- Distribute job applications
- Type out weekend schedule and office/break room clean-up duties
- Perform additional miscellaneous duties such as painting the office, making travel arrangements, etc.
- Make local parts runs as needed

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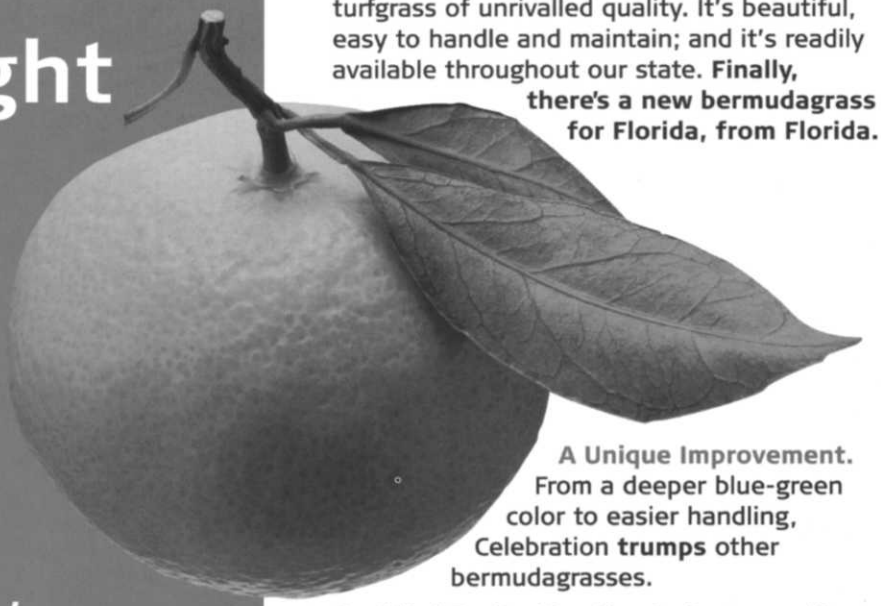

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By S. Chandramohan, Carol Stiles and, R. Charudattan

Many grasses, because of their beneficial uses as forage, landscape, or groundcover plants, have been spread around the world for economic development and use. However, during the past century several grasses have turned out to be quite invasive and weedy, for example, tropical signalgrass (*Urochloa subquadripara*).

Tropical signalgrass has been identified as one of the most troublesome weeds in sod farms, golf courses and lawns in Florida (Busey, 2001). In the northern part of the state, tropical signalgrass is sensitive to frost, but in southern Florida it continues to spread vegetatively in successive years.

Tropical signalgrass is particularly troublesome in sod farms. It is difficult to control because of its tolerance to several chemical herbicides or its ability to outgrow control measures. It is essentially resistant to atrazine and asulox, two commonly used turf herbicides. The lack of selectivity of many chemical herbicides precludes their use to control tropical signalgrass in bermudagrass and St. Augustinegrass sod farms (Busey, 2001).

Chemical Control of Signalgrass in Florida Turf.

Currently, MSMA, Illoxan (diclofop-methyl), Drive 75DF (quinclorac), and Sencor (metribuzin) are being evaluated in various combinations for postemergence control of tropical signalgrass (Busey, 2001). Two applications of MSMA at 1.5 Kg a.i./ha at 13- to 14-day intervals have been found to reduce tropical signalgrass canopy to less than 10 percent, compared with up to 100 percent in untreated plots.

Tank mixing with Sencor does not enhance signalgrass control. Teuton et al. (2002) have identified a few preemergent herbicides including some that control tropical signalgrass when applied early postemergent. Although MSMA is effective in bermudagrass, there are no postemergent herbicide treatments available for St. Augustinegrass, because the herbicides are either ineffective against the tropical signalgrass or cause damage to the St. Augustinegrass (Brecke, pers. comm.)

Need for An Alternative Technology for Control of Tropical Signalgrass.

Sod growers, golf course managers, and lawn care managers in Florida depend on chemical herbicides because of their effectiveness and ease of use. Concerns about groundwater contamination by agricultural chemicals and build up of resistance to chemical herbicides in use necessitate environmentally-safe, alternative technology to complement existing weed management options.

Conventional weed management strategies, relying largely on chemical herbicides, are in need of refinements to make them more sustainable (Mersie and Singh, 1989). Refinements can be in the form of improved application efficiency of chemical herbicides, use of adjuvants to enhance efficacy, and selective spraying of only weed-infested areas in a crop.

Nonchemical weed control methods, such as biological control (bioherbicides), if they can be deployed in an integrated approach, can help enhance the effectiveness and sustainability of weed-management practices.

A Multiple-Pathogen Bioherbicide System With Potential To Manage Signalgrass In Turf And Sod In Florida

BIOHERBICIDE

Figure 1. *A germinating spore of Exserohilum rostratum, one of three fungi used in a bioherbicidal mixture tested on tropical signalgrass.*

Figure 2. *Tropical signalgrass uninoculated (left) and inoculated with a mixture of three fungal pathogens. In greenhouse tests, up to 90 percent of the shoots were blighted on inoculated plants.*

Bioherbicide Strategy.

The bioherbicide strategy, a form of biological control, consists of using certain highly virulent native pathogens of weeds that are mass-produced, formulated, and applied like a pesticide to obtain rapid development of disease and a high level of weed kill. Typically, these pathogens are registered as bioherbicides by the EPA and are used in accordance with their labels. They are applied when environmental conditions and weed-growth stages are conducive for disease development.

The use of host-specific plant pathogens as bioherbicides could be a practical weed management method for signalgrass control. Bioherbicides can be used as a supplement to conventional herbicides or as a component of integrated control. Bioherbicides can be highly effective in terms of efficacy, environmental benefit, and economics (Charudattan, 2001). Currently, six bioherbicides are registered in Canada, Japan, South Africa, and the United States (Charudattan, 2001). Among these is a bacterial bioherbicide, Camperico, registered in Japan for the control of annual bluegrass (*Poa annua*) in turf.

An example of a registered bioherbicide in the United States is DeVine", the first bioherbicide registered by the EPA. It is used for the control of milkweed vine, *Morrenia odorata*, a major weed in Florida citrus groves. DeVine consists of a pathotype of the fungus *Phytophthora palmivora*, which is capable of killing both seedlings and fully grown vines. On the basis of extensive host range and efficacy studies, this pathogen was found to be a safe biocontrol agent for use in citrus. Abbott Laboratories, Chicago, registered the bioherbicide in 1980 and it is now produced and sold by Encore Technologies, Minnetonka, Minn., on an as-needed basis.

Multiple-Pathogen Bioherbicide System for Broad-Spectrum Weed Control

Among the major challenges facing bioherbicide technology is economics. Since bioherbicidal pathogens developed as bioherbicides are highly host specific, a bioherbicide typically can control only one out of many weeds affecting the crop. This limits the commercial potential of the bioherbicide and consequently there is little economic incentive to develop and register bioherbicides.

Inadequate or incomplete level of weed control is another problem.

However, these problems may be overcome by using mixtures of pathogens that are effective against several weeds. All susceptible weeds can be controlled simultaneously without loss of efficacy and host-specificity of the pathogens. Chandramohan and Charudattan (2001) have shown that several weedy grasses, including those that affect agricultural crops

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as well as natural areas, could be controlled by using a mixture of three fungal pathogens applied with suitable adjuvants.

The use of a mixture of pathogens is advantageous in that if one of the pathogens in the mixture fails the others may compensate. Also, using a pathogen mixture may reduce the chances of development of resistance in weeds that is possible if a single pathogen is used repeatedly. In addition, it may be possible to take advantage of possible synergistic interactions among pathogens in the mixture, which will enhance the efficacy of the bioherbicidal mixture. The level of weed control can be further improved with repeated applications.

Discovery and Development of a Bioherbicide System for Control of Several Grasses.

In 1994, we isolated three fungal plant pathogens, *Drechslera gigantea, Exserohilum longirostratum*, and *Exserohilum rostratum* (Figure 1), which were isolated from naturally infected large crabgrass (*Digitaria sanguinalis*), crowfootgrass (*Dactyloctenium aegyptium*), and johnsongrass (*Sorghum halepense*), respectively (Chandramohan, 1999; Chandramohan, and Charudattan, 2001).

These fungi occur in several Florida counties and are therefore indigenous to this state. These fungi were tested for pathogenicity to various grasses and determined to cause severe disease on many weedy grasses. Some grasses were killed, while some were moderately susceptible, and others immune.

The range of grasses that were infected and killed was also determined in greenhouse trials. Thirty-six economically important crop plants were tested to ascertain the potential risks to nontarget plants; however, none of these plants was harmed by the pathogens, whether they were used individually or in a mixture.

The crop plants tested were bean, beet, blackeye cowpea, broccoli, brussels sprouts, cabbage, cantaloupe, carrot, cauliflower, cliantro, collards, corn, cucumber, eggplant, endive, green pepper, head lettuce, Indian mustard, oat, okra, onion, parsley, pea, peanut, radish, romaine lettuce, rye, sorghum, spinach, squash, sweet corn, tomato, turnip, watermelon, wheat, and zucchini. Also, the pathogens did not damage orange and grapefruit, crops in which the bioherbicides are intended to be used.

The pathogens were then field-tested at two locations in Florida - Lake Alfred and Ft. Pierce. (Chandramohan, et al., 2002).

At Lake Alfred, it was possible to control four-week-old plants of large crabgrass (*Digitaria sanguinalis*), crowfootgrass (*Dactyloctenium aegyptium*), johnsongrass (*Sorghum halepense*), guineagrass (*Panicum maximum*), southern sandbur (*Cenchrus echinatus*), Texas panicum (*Panicum texanum*), and yellow foxtail (*Setaria glauca*), which were transplanted randomly into replicated field plots.

The grass seedlings were sprayed with spore suspensions of each pathogen alone or a mixture of the three pathogens in equal proportion of their spores. The fungi were applied as foliar sprays at the rate of 500,000 spores per ml in one of three carriers: water, 0.5 percent aqueous Metamucil", or an emulsion (Sunspray" 6E 80 ml, paraffin oil 20 ml, and spores in water 100 ml). Appropriate controls were included, and the fungi were applied two or three times at two-week intervals.

The emulsion-based inoculum preparation of each pathogen as well as the pathogen mixture yielded the best level of weed control (nearly 100 percent) of all the grasses tested, and the control lasted for more than 12 weeks.

At Fort Pierce, the pathogens were tested on a natural population of guineagrass. The emulsion-based inoculum of individual pathogens as well as the mixture of three pathogens gave nearly 100 percent control, and the control lasted for a period of 10 weeks.

We have also field-tested the bioherbicidal system to manage guineagrass in Florida sugarcane in two field trials. The pathogen mixture caused a high level of disease on guineagrass and an 82-99 percent reduction in panicle numbers per square meter. Currently, the pathogen mixture is being tested to control torpedograss (*Panicum repens*), an invasive weed species threatening native plants in Lake Okeechobee.

Bioherbicidal Control of Signalgrass in Florida

A mixture of the above-mentioned fungal pathogens applied twice to tropical signalgrass in greenhouse tests blighted up to 90 percent of the shoots (Figure 2) (Chandramohan, et al., 2002a, b). In a separate study, these pathogens were tested in a greenhouse for nontarget effects on various species of cultivated turfgrasses.

However, the cultivated grasses tested under the same experimental conditions as for tropical signalgrass were immune or resistant to each of the pathogens as well as the pathogen mixture. Bermudagrass (*Cynodon dactylon*) (cvs. FloraTex, Floradwarf, Tifway, and Sahara) sustained some injury from the pathogen/emulsion mixture, but recovered.

Bahiagrass (*Paspalum notatum*) (cv. Pensacola), creeping bentgrass (*Agrostis stolonifera*) (cvs. Crenshaw, Pencross), centipedegrass (*Eremochloa ophiuroides*), and seashore paspalum (*Paspalum vaginatum*) (cv. Sea Isle 1) were immune.

St. Augustinegrass (*Stenotaphrum secundatum* (cvs. Floratam, 1996-7, Palmetto, Seville, and TXF) and zoysiagrass (*Zoysia japonica*) (cv. Empire) were resistant.

The susceptible weedy grasses included in this study (large crabgrass, guineagrass, tropical signalgrass) continued to remain diseased, while the cultivated grasses continued to grow and remain healthy if they were immune. If resistant, they recovered from the initial hypersensitive response and remained healthy. These results indicate that the pathogen mixture could be further developed as a biocontrol for tropical signalgrass in turf and sod in Florida.

In the case of cultivated grasses that are immune or resistant, for example St. Augustinegrass sod or lawn, the pathogens could be used as an over-the-top application. In bermudagrass, spot treatments of the tropical signalgrass with the bioherbicidal mixture may be necessary because of the potential for slight injury from the pathogens in the emulsion mixture. From our earlier field tests, we have observed that the pathogens are confined to the treated area (Chandramohan et al., 2002).

Novelty and Future Potential

In summary, we have developed a practical biocontrol system with potential to manage several grasses including tropical signalgrass, a problematic weed in Florida turf and sod. This multiple-pathogen approach offers the possibility to custom-blend various pathogens to suit particular groups of weeds. This is a novel approach to weed control, and the University of Florida has been issued a U.S. patent (U.S. Patent No. 6,265,347. Issued, July 27, 2001. Chandramohan, S., and Charudattan, R. "Enhanced Bioherbicidal Control of Weeds using Multiple Pathogens"). We are exploring the possibility of commercial development of this bioherbicide system.

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For information about the authors, see page 32.

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