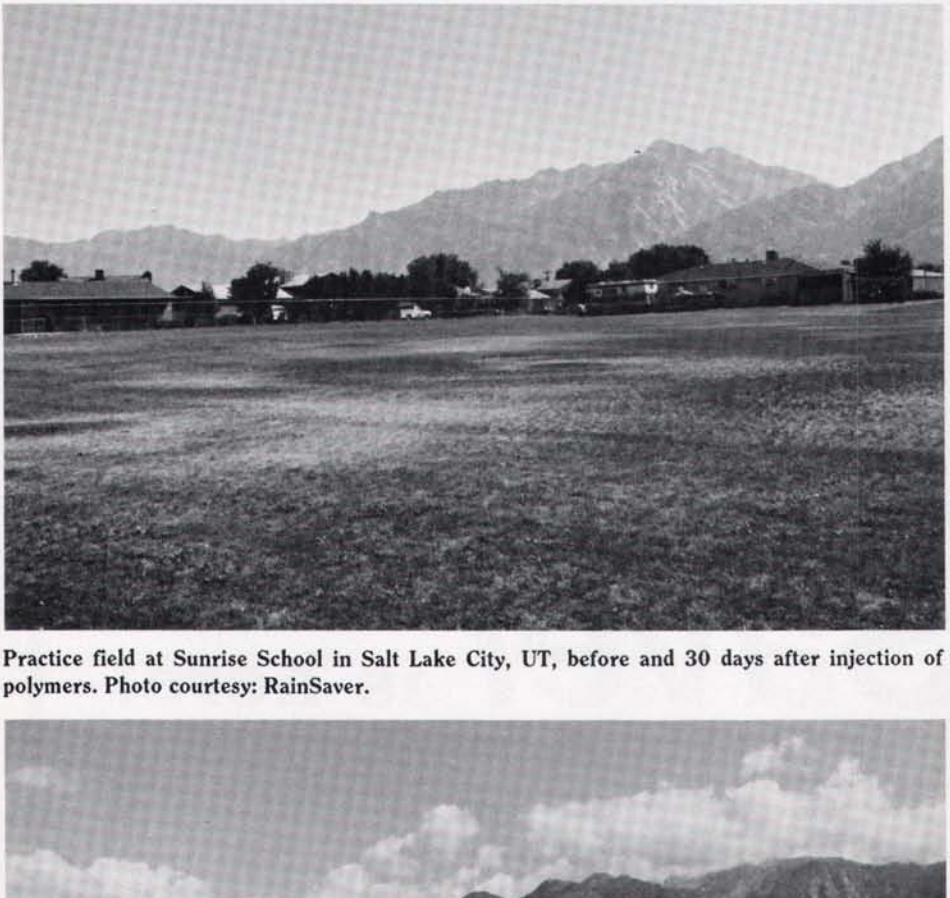
The Role Of Polymers In Water Management



Practice field at Sunrise School in Salt Lake City, UT, before and 30 days after injection of polymers. Photo courtesy: RainSaver.

Water management will be the top priority of the golf and sports turf industries in this decade. Turf managers are learning to manage water for irrigation to do their part in today's climate of heightened environmental awareness. Every tool that has the potential to save water must be put to work.

One such tool is a group of spongelike granules known to many in the industry as polymers. Long used in soil mixes for greenhouse and nursery production, the plastic- and starch-based particles have been tried by a number of golf course superintendents, sports field managers, and contractors to increase the water holding capacity of soils for turf.

The use of polymers in turf has largely been limited to seed coating, sod and sprig establishment, and incorporation into topsoil prior to seeding. However, the development of equipment to place the polymers into the rootzone of established turf is now opening up a whole new technology in water management.

Transferring polymer use from the nursery to parks, golf courses,and athletic fields has been controversial and hampered by a lack of university research. Without research data related specifically to turf use, the education process involved in explaining how polymers work and how they compare has been slow and arduous. That research is now underway at a handful of universities. However, a growing number of success stories and testimonials by turf managers who have tried polymers is now convincing municipalities, golf course architects, and sports field consultants to specify polymers for new construction.

Polymers are created by chemical reactions which combine two or more small molecules (monomers) to form a larger, different type of molecule. Natural polymers include proteins and starches. The

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Fertilizer placed three inches below the surface by Yeager-Twose Bottom Dresser.

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first synthetic polymers were developed after World War I and were later perfected into various types of plastic.

Pipe, valves, and sprinkler heads made of plastic are widely used today for turf irrigation. Plastic is also used for drainpipe, liners and covers, fibers for rootzone stabilization, and a growing number of lightweight components on turf equipment.

During the 1960s, chemists discovered that certain types of polymers in granular form could absorb very large amounts of liquid, in some cases hundreds of times their weight. In the process, the polymers swell up many times their original size with moisture, while still retaining their integrity. Their absorbency was eventually put to use in products such as baby diapers, wound dressings, kitty litter, and hazardous material collectors. As a result, a huge market for absorbent polymers has evolved.

Agricultural chemists began to explore uses for polymers in crop production. Their emphasis was not only on storage, it was also on how much of the stored water polymers would release and how easily. By providing a source of moisture for seed during germination, sprigs or seedlings during establishment, or roots of plants once established, the health and productivity of many crops has been enhanced.

When placed in the rootzone, polymers could conceivably reduce the amount of water lost through percolation and evaporation, decrease the frequency of irrigation, and therefore reduce both water and labor costs. Furthermore, dissolved nutrients, herbicides, or pesticides absorbed by some polymers would remain where they were needed, and not be lost to leaching or evaporation. Finally, the expansion and contraction of the polymer granules within the rootzone helps create spaces for aeration and improves the texture of soils.

These concepts held so much promise that the United States Department of Agriculture (USDA) has carried out its own research into polymers for many years. The polymers developed by the USDA have been designed to be economical and to break down within a growing season. To accomplish this, starch was grafted to a synthetic polymer. The final product is approximately half starch and half synthetic polymer. Soil organisms break down the starch copolymer at a rate depending upon moisture and temperature. Biologically active soils in warm weather can break it down in a matter of weeks. However, starch copolymers may persist for more than a year in sterile soils in cooler climates. Dr. William Doane continues to work on polymers with the USDA Agricultural Research Service in Peoria, IL.

When compared to completely synthetic polymers, starch copolymers are softer when swollen and give up water more easily, according to Cliff Marshall of International Absorbent Products in Smelterville, ID. The company's Polysorb is a starch-based copolymer developed and licensed by the USDA that holds roughly 150 to 180 times its weight of tap water and swells up to 40 times its original size, Marshall reveals. He adds that Polysorb is roughly 60 percent starch and 40 percent synthetic polymer.

During production, Polysorb is treated with either sodium hydroxide or potassium hydroxide in a process called saponification, Marshall explains. The potassium-treated polymers are generally preferred for turf applications since a potassium residual of about one percent remains.

To further extend the life of polymers, chemists developed totally synthetic versions. These can vary widely in their chemical makeup, but may be loosely divided into two groups, cross-linked polyacrylates and cross-linked polyacrylamides.

The chemical reaction used to make synthetic polyacrylate polymers produces its own energy, explains David Keen, national sales manager for agricultural chemicals for American Colloid in Stuart. FL, maker of Hydrozorb. Because of this, production costs are lower than for polymers requiring more energy to produce. Keen adds that his polymer holds up to 260 times its weight in tap water and releases it to the soil as well as to roots coming into contact with the polymer. Hydrozorb is approximately 15 percent potassium. Depending upon the soil, it lasts from seven months to nearly two years before breaking down.

Many polyacrylamide polymers perform for five to seven years or longer depending on salts in the soil.

The most durable polymers are cross-linked polyacrylamides. Companies marketing polyacrylamide polymers say they perform (hydrate and dehydrate) for five to seven years. They point out cases where polymers still work to some degree after ten years. They absorb from 100 to 300 times their weight in soil moisture and swell up more than 40 times in size, as noted by Wally Boilek, national sales manager of Terra-Sorb for Industrial Services Interna-

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RainSaver injects a gel of starch-based polymers into the rootzone.

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tional, Inc., in Bradenton, FL. The company has marketed polymers since the late '70s and also makes a starch copolymer.

Broadleaf P4 is a cross-linked polyacrylamide from Broadleaf Industries, San Diego, CA. Since 1984, the company has employed Dr. Dean Piper, a retired professor from California Polytechnic University in San Luis Obispo, to gather and refine information on superabsorbents. Much of his focus has been on determining proper application rates for polyacrylamides in soils.

With proper selection and installation, Piper reveals that synthetic polymers can store an extra inch of rainfall or irrigation in turfgrass rootzones, and release 95 percent or more of this water upon demand. Figuring an evapotranspiration rate of .25 inch per day, this extra storage amounts to nearly a four-day supply of water. This does not account for reduced losses to evaporation, runoff, and drainage.

To achieve such storage, figuring absorption of 150 times by the granule, more than 30 pounds of polymer should be uniformly mixed into the top six to eight inches of soil in a 1,000-square-foot area. That is roughly 1,300 pounds per acre, which is far higher than rates currently used for injection equipment on established turf.

"You get more impact than the amount of polymer you use," points out Dr. Garn Wallace of Complete Green in Los Angeles, CA. "There is a synergistic effect brought about by improved soil porosity and a deeper root system." However, Wallace feels that a rate of three pounds per 1,000 square feet is "bare bones" if the intent is to increase water storage capacity in many soils. Technically, at the same absorption rate as above, three pounds per 1,000 square feet represents less than 1/10 inch of stored water. Complete Green markets a different type of polymer designed to improve water infiltration in turf and landscaping.

Getting water to the polymers is essential to their performance. "The crystals only absorb free water," says Jerry Curtice, technical services manager for Aquatrols Corp., which markets Supersorb. Thatch or hydrophobic soils can cause runoff and prevent moisture from ever reaching polymers in the rootzone. Curtice believes that wetting agents can enhance the effectiveness of polymers by getting water to them.

Another factor in absorption is soil pressure, according to Ron Salestrom, national sales manager for Hydro Resources Southwest in Mesa, AZ. The granules can swell more in sand than they can in compacted clay soils, he says. The company's Hydro-Hold is a cross-linked polyacrylamide.

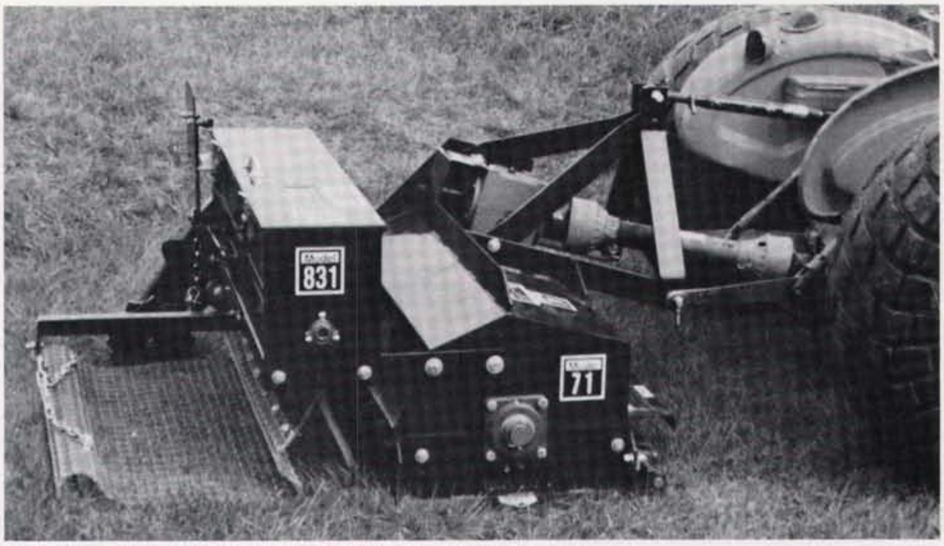
Agrosoke is a tightly linked polyacrylamide that absorbs some 40 times its weight in water. Janet Curry, president of Agrosoke, Inc., Fort Worth, TX, says the polymer does not absorb salts, as do those with higher absorption rates. As a result, it resists salt-induced degradation. She credits this characteristic for permitting the polymer to perform longer than eight years in tests. The tighter bond with water also limits losses to evaporation.

Viterra Gelscape by Aglukon Agriproducts in Congers, NY, is a unique type of polymer. It is a combination of acrylamide, potassium acrylate, and an adjuvant. Gelscape was designed to release moisture easily to plants based upon need. It holds approximately 200 times its weight of tap water.

Fernando Erazo, president of Aglukon, explains that Gelscape maintains its absorption and release properties for two to three years, but the polymer itself does not biodegrade. "Basically, its absorption capacity [after this period] drops to that of clay or peat moss, about 20 times its weight in water," he states. Recommended rates range from 1/2 to 3/4 pound per 1,000 square feet, or roughly 20 to 30 pounds per acre. "The focus of our product is to improve the speed and uniformity of establishment through seed coating, and then maintain good soil texture and porosity in high-wear areas, with subsequent periodic applications in topdressing or as an amendment during core aeration," Erazo says.

Most polymer companies offer two or more sizes of granules. The size of the granule is important, stresses Daniel Wofford, general manager of Western Polyacrylamide, Inc., Castle Rock, CO. Fine crystals (less than 500 microns) are best suited for root dipping and seed coating. Larger crystals (between 500 and 1,500 microns) are better for soil amendment.

"They are identical products, yet their properties are so different in use that we should consider them dissimilar," says Wofford. "The standard [larger] crystals hydrate to form large, individual lumps of gel with resulting high pore space, while the fine material forms a sticky mass." He warns that larger granules should be uniform in size and free of fines or dust. The company markets HydroSource, another cross-linked polyacrylamide.



Olathe's Polymer Planter is designed for dry polymers.

He has been gathering data on polymers from more than 30 universities and describes some of the benefits revealed to date. Improved root development and stress reduction may account for dramatic results with a number of crops, including turf. There is some evidence that polymers have a cooling effect on soils, as well as improving texture and aeration. Furthermore, dissolved fertilizers, root stimulants, and micronutrients are temporarily ab-

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sorbed and released by some of the polymers. Used on slopes, they may reduce runoff of water and nutrients.

In addition to storing water, polymers mixed into soil appear to act as a cap for water moving toward the surface by capillary action. By holding capillary moisture beneath the surface, it is not exposed as much to evaporation caused by wind and heat. This effect can backfire in sites with poor drainage, impervious subsurface layers, or perched water tables. Capillary water will keep the polymers swollen and render the area too soft. But the right combination of drainage and polymer may soften hard soils enough to reduce the potential for sports-related injuries. All these areas are being studied at various universities at the present time, and preliminary results are promising.

One researcher involved in polymer studies is Dr. Jeff Nus, assistant professor of turf science at Kansas State University in Manhattan. He points out that the useful life and water-holding capacity of most synthetic polymers is reduced by salts and/or poor-quality water, such as effluent. Soil pH is also a factor in their performance.

Nus is one year into rate determination studies for low-maintenance sports fields. He has also begun researching polymer rates and types for United States Green Section (USGA) spec greens. Various polymers were incorporated into the top six inches of a green profile after the bentgrass sod was removed. The sod was then placed back over the amended rootzone. Unfortunately, heavy rainfall this spring has hampered initial results.

Dr. Anthony Koski has been studying the effects of incorporating polyacrylamide polymers into the rootzones of Kentucky bluegrass and tall fescue turf at Colorado State University in Ft. Collins. Koski is looking at four different areas, including rooting, water infiltration, compaction resistance, and irrigation reduction. Last July, different brands of polymer were rototilled into the top eight inches of soil at rates up to 80 pounds per 1,000 square feet.

"We want to find out which polymers and rates will allow turf managers to reduce irrigation to 50 percent of the ET rate," he explains. Koski will also be testing the plots for compaction resistance, using a penetrometer and a Clegg impact monitor. His initial data will be produced this summer.

"Comparative polymer testing programs, such as those at Kansas State and Colorado State, are absolutely essential to the successful, widespread adoption of polymers within the turf maintenance industry," Wofford points out. "If the right combinations of equipment, comprehensive testing, and polymers are worked out, this will happen."

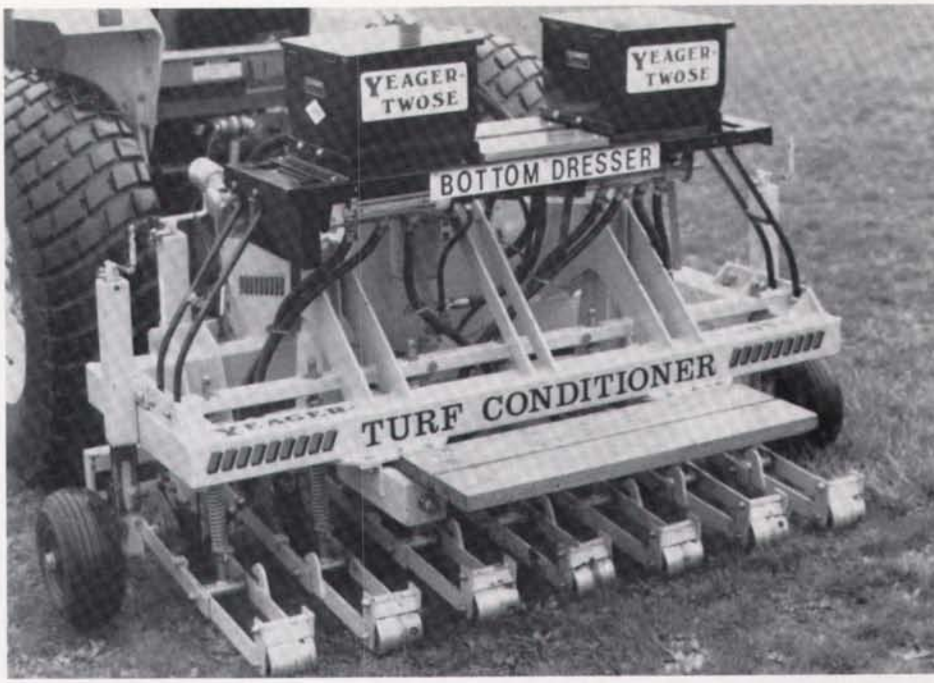
The greatest potential for polymers appears to be for established turf. Polymer companies and equipment manufacturers are searching for economical methods to inject them from one to six inches below the surface. At the present time, three companies have polymer injectors on the market. At least another three companies hope to introduce theirs within the coming months.

Two basic methods are being tried. The first involves placing a band of dry polymer crystals in the soil, using a modified seed drill or vibratory plow. Olathe in Industrial Airport, KS, Yeager-Twose in Hillsboro, OR, and Hydro Resources Southwest have injectors working in the field.

Olathe's Model 71/831 Polymer Planter cuts grooves on six-inch centers with rotating blades as deep as 4-1/2 inches, before the polymer is fed into the slits through chutes. The rate of injection ranges from 20 to 250 pounds of polymer per acre. The company is exploring new versions, including one that will cut grooves on closer centers. The current model covers a four-foot-wide swath on each pass and requires a 40-hp tractor.

"Higher rates are possible by going over an area more than once," Olathe's Tom Melton explains. He adds that more information is needed on rates according to soil types and drainage. That is why the company is supporting Nus' research at Kansas State.

Yeager-Twose recently adapted its Turf Conditioner to create the Bottom Dresser. Vibrating blades spaced ten inches apart open a channel from two to eight inches deep. A chute on the back of each blade deposits a row of dry polymer at rates from five to 500 pounds per acre. The machine can plant up to three acres of polymer per day.



Yeager-Twose Bottom Dresser injects rows of dry polymer.

Hydro Hold Applicators by Hydro Resources Southwest extend the width of the polymer band by lifting the sod and blowing the crystals underneath. The lifting action is created by horizontal V-shaped blades spaced 28 inches apart. The blades create a cavity at any desired depth between 2-1/2 inches (for Kentucky bluegrass) to 4-1/2 inches (for bermudagrass). Polymer from a hopper on the tractor is blown into the cavity through a fan-shaped nozzle behind each blade. In this way, polymer reaches a distance of 12 to 14 inches on both sides of the blades.

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The company's 90-inch-wide applicator powered by a 60-hp four-wheel-drive tractor can treat up to four acres of turf per hour, says Salestrom. It also makes a 30-inch-wide model which can cover about one acre per hour when attached to an 18-hp, four-wheel-drive tractor. Salestrom has found that rates between 100 and 200 pounds per acre are effective. His equipment is designed to apply only the cross-linked synthetic polymers, not starch-based ones.

Two other dry-polymer injectors are in the final stages of development. GreenCare International in Huntington Beach, CA, has designed its version in conjunction with Broadleaf P4. Tye Manufacturing in Lubbock, TX, has been working with Agrosoke on an injector. Jerry Hutchinson, president of Turf Specialists Corp. in Holbrook, NY, has also developed an injector by adding a Gandy Air Flow machine to a Moore Uni-Drill. His contracting company has used the device to inject starch copolymers on low-maintenance sports fields on Long Island.

"The potential for this type of equipment is tremendous, since it puts turf chemicals below the surface, where they are not exposed to players or weather," Hutchinson states. "We've seen instances where lower rates of chemicals have achieved excellent results."

Hydro-Hold Applicator lifts soil and sprays a 28-inch-wide band of dry, synthetic polymer.

The second approach is to use a pump to spray polymer gel beneath the surface. RainSaver, Inc., of Walla Walla, WA, has pioneered this technology. A starch copolymer gel is pumped under low pressure through tubes into slits made by colter blades cutting as deep as 2-1/2 inches. The injectors are spaced either three or six inches apart. The rate of application recommended by RainSaver so far is about 25 pounds per acre. Despite the comparatively low rate, company founder Richard (Dean) Culbertson says his customers report water savings between 20 and 50 percent.

The company makes three models, two self-powered and one trailer version. Culbertson envisions his product as having applications beyond polymer injection. He sees a growing need to inject insecticides below the surface to reduce exposure and lower rates. "A large portion of surface-applied pesticides are tied up by thatch before they reach the pest in the soil," he adds. "Many times they need to be watered in. By injecting insecticides, you can apply lower rates and reduce exposure."

"We have discovered that the polymer planter is a better aerifier than coring machines," says Nus. "Some of the improvement in the soil can be linked to the aerifying effect of the devices." Nus has just installed plots to test rates up to 2,500 pounds of polymer per acre. Each plot has independent irrigation to enable him to evaluate water retention and irrigation frequency.

"Each time a polymer granule expands and contracts it is providing a form of aeration," Salestrom explains. "If you aerify mechanically, the improvement lasts for a few months. The polymers continue to aerate the soils for years. You are providing two forms of aeration with polymer planters."

The bulk of experience in polymer injection is with rates from 25 to 200 pounds per acre. Calculated at an absorption rate of 150 times the weight of polymer, 200 pounds of polymer will store nearly 5,000 gallons of water per acre. This is the equivalent of .18 inches of water. If the daily ET is .25 inches, technically the polymer provides less than one day's reserve. However, test results have shown considerably longer effects.

Whether or not polymers are holding a significant amount of irrigation or rainfall does not prove or disprove their value. Superintendents have used them successfully to improve the condition of turf around sand traps and on slopes. Sod growers and park superintendents have increased the speed and germination rate of seed during renovation. Groundskeepers have noticed a reduction in the hardness of high-wear areas of sports fields. Reduced water consumption is essentially a bonus to an already useful product.

"If you doubt whether polymers work," says Salestrom, "put in a test strip in a turf area. Then turn the water off. Watch to see which area stays green longer."

The evidence of water conservation has been convincing enough for a number of municipalities to try polymers on parks and golf courses. "When an area is hit with a water shortage, the local government has to do more than implement restrictions for residents," Salestrom adds. "They have to set an example. Successful use of polymers by municipalities has been a big help in educating others that they work."

"Education is the greatest hurdle that polymer and polymer injector manufacturers have to clear," Wofford points out. "We need to realize that modern 400x cross-linked polyacrylamide polymer for horticulture has been around less than ten years. It's not easy to understand how and why they work. Universities are now carrying out the type of research needed to clear up

"Each time a polymer granule expands and contracts it is providing a form of aeration."

doubts, determine rates, and quantify savings. There is a mounting base of evidence to document the effectiveness of these products. We need to get this information out to the sports turf industry."

The evidence is showing that, when used properly, polymers can be an important tool for water management in the future. When combined with other water-saving technology and the utilization of improved, drought-tolerant turfgrasses, billions of gallons of water could conceivably be saved without sacrificing the quality, playability, and safety of recreational turf facilities.

TURF ENDOWMENT CREATED AT MSU

The Michigan Turfgrass Foundation has pledged $1 million to the Michigan State University (MSU) turf program, creating an endowment to fund faculty and graduate student research.

"This gift continues a long-standing partnership between the university and the state's turf industry," said John DiBiaggio, president of MSU, located in East Lansing, MI. "We are extremely grateful to the Michigan Turfgrass Foundation for this gift, and for the support of its members over the past 60 years."

The gift is largest given to MSU by the foundation and will be used to establish the Michigan Turfgrass Research Endowment Fund. Annual income from the new endowment will enable MSU to attract more graduate students. "Our research is so labor-intensive that bright, dedicated graduate students are absolutely vital," explained Joseph M. Vargas, a professor of botany and plant pathology at the university.

Vargas is investigating alternative pest-management strategies, using biological methods to control pests and diseases and to minimize pesticide use. Developing environmentally safe methods is both time-consuming and expensive, observed. "The endowment will give us the flexibility to pursue this type of research."

The Michigan Turfgrass Foundation will solicit contributions to the endowment from its 1,000 members and from others interested in turfgrass research. Members include golf course superintendents, landscapers, lawn sprayers, sod growers, parks and recreation directors, schools, and cemeteries throughout Michigan.

Gordon LaFontaine, executive secretary of the foundation, reported that ten percent of the $1 million has already been raised.

PENNSYLVANIA COUNCIL HONORS WADDINGTON

Dr. Donald V. Waddington has received the Distinguished Service Award from the Pennsylvania Turfgrass Council for his outstanding leadership and contributions to the turfgrass industry. The award is the highest honor given by the organization.

Waddington is a professor of soil science in the Pennsylvania State University department of agronomy. He has been a faculty member for 25 years. Prior to joining Penn State, he taught at the University of Massachusetts for five years.

Waddington is widely recognized for his research in fertilization, soil modification, and surface characteristics of athletic fields. His courses cover soil-related problems in turfgrass areas, as well as other aspects of turfgrass management. A number of his former graduate students are active in research, teaching, and extension at other universities.

Waddington is editor of the American Society of Agronomy monograph on turfgrass science. He has also chaired the Turfgrass Division in the Crop Science Society of America. In 1986, he was elected fellow in the American Society of Agronomy, an honor based on professional achievements and meritorious service.

Waddington is a member of the Pennsylvania Turfgrass Council Technical Advisory Committee. He is on the planning committees for the Eastern and Western Pennsylvania Turf Conferences, which are cosponsored by the Turfgrass Council and Penn State.