Sports TurfManager

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The Real Economics of Athletic Field Construction

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All too often, the blast of an official's whistle signalling the start of an outdoor sporting event brings two opposing teams together on a barren field speckled with ragged tufts of green. Many of these tufts are the sad remnants of a once-proud turfgrass cover, intermingled with a variety of coarse, aggressive weeds—commonly knotweed, crabgrass and goosegrass.

In dry weather, the playing surface is hard from compaction, rough from previous activities, dusty from a lack of turf cover and resistant to the penetration of an athlete's spikes or cleats. If it rains a week before the event—or worse, during the event—the surface is slippery, muddy and soft, with virtually no traction.

Such conditions give natural turf playing surfaces a bad reputation and stimulate visions of miracle grasses, super products and other surfaces as alternatives. However, criticism of natural turf fields should be aimed at weaknesses in construction or maintenance, not the turfgrass itself.

Natural grass has been and will continue to be the best playing surface for a wide variety of outdoor sports and playground activities. Its characteristic resiliency and cushion not only contribute to the enjoyment of a specific sport, but also provide superior footing and reduction in sports-surface-related injuries when compared to plastic substitutes, however green and glossy they may be.

These advantages, combined with aesthetic and economic considerations, make natural turf and its management high priorities for sports in the coming years.

Success in providing superior natural playing surfaces requires serious and continuous attention to a combination of many factors in the establishment and subsequent maintenance of turf. It also requires overcoming or correcting errors in construction. Neglect, for even a relatively short period of time, jeopardizes previous investment in field construction and maintenance.

Using appearance as the primary criterion for a successfully managed field can be misleading and generate false impressions of natural playing surfaces. Appearance is undoubtedly important, but durability to intensive use under a wide range of conditions is more critical.

Athletic fields proven to be most successful are based upon similar principles of design, planning, construction and maintenance. Failure of these surfaces also is based upon a set of similar mistakes.

Failure of natural turf to provide the aesthetics for the spectator and a safe, firm surface for the players can be linked to the following causes:

Improper specifications. Too often in the original construction of an athletic field, standard specifications are used with little or no regard for the varying conditions peculiar to a specific site. Each proposed site should be evaluated critically before formulating accurate specifications. If this approach is not utilized, there exists a high potential for a field with "built-in" problems that are very difficult or impossible to correct with the best of maintenance procedures.

Enforcement of specifications. The best of specifications are of little or no value unless construction procedures adhere to the stipulated requirements developed for the site. Too often, construction is allowed to proceed without the "watchful eye" of a knowledgeable individual. Under such conditions, the temptation to bypass or eliminate critical procedures becomes too great for proper construction, particularily where contract responsibilities are awarded to the low bidder.

Improper or inadequate maintenance after successful establishment. Once a satisfactory turf of properly selected grasses has been established, its future performance depends upon the type and amount of attention devoted to a maintenance program.

The investment in establishing a turf cover is wasted unless proper provision is also made for maintenance. A well-planned program should include equipment, materials, personnel and an adequate budget. In addition, supervisory responsibilities should be entrusted to a conscientious individual knowledgeable in turfgrass management principles and techniques.

Abuse in field use. A well established and maintained turf can withstand a considerable amount of use without serious damage. However, there are limits to the tolerance of turf to continued intensive use.

Damage will be most serious where proper construction procedures have been bypassed, particularily in situations

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of excessive soil moisture. Under such conditions, use should be curtailed or minimized to reduce the damaging impact on the turf. Decisions of this nature, including the responsibility of determining the intensity of use of the field, should be delegated to the grounds superintendent.

Provision for inadequate facilities. Closely allied to field use is the surging interest in outdoor athletic activities and the resulting increased pressure on existing facilities. Because of economic reasons and/or unavailability of open space for the construction of additional fields, the use of existing facilities is intensified.

Most of the existing fields are improperly constructed. As a result, these fields are unable to accommodate more intensive use without exhibiting serious deterioration of the turf cover.

As the intensity of use increases, it becomes imperative for the survival and wear tolerance of the turf that the fields be properly constructed.

The single most influential factor of natural turf fields is improper drainage. Poor drainage not only affects the playability of the field, but also has a strong negative influence on the growth of the turfgrass and increases maintenance costs.

Various reasons can be cited for overlooking drainage as a critical factor in athletic field construction. Perhaps the most important is a lack of understanding or appreciation of the importance of drainage while formulating the specifications for the field or in the finalizing process before submitting for bids. Unfortunately, in many instances, adequate drainage is eliminated or reduced to inadequate by cost-cutters who do not realize the future cost of improper drainage.

In some cases, poor drainage conditions prevail in spite of efforts to improve these conditions. Such failures most likely can be attributed to improper specifications and/or other deficiencies in construction. Some of the common faults of ineffective performance of drainage systems include:

Provision for surface drainage only. A crowned or turtle-backed field with a few catch basins on the sidelines can facilitate removal of surface runoff, but will do little for improving internal drainage.

Improper design of the drainage system involving pipe spacing, depth, grade and outlet.

Installation of drainage pipe on improper grade.

Backfilling of drainage trenches with heavy textured material restricting percolation of water to the drainage pipes.

Improper physical properties of topsoil above the drainage system.

The physical condition of the topsoil is a major factor limiting proper functioning of a drainage system.

Soils containing excessive amounts of silt, clay and very fine sand are often used above the drainage system as the growing medium for the turf. Soils of this nature tend to restrict proper drainage due to slow percolation of water. Consequently, during rainy conditions such soils tend to be soft and soggy in spite of a properly installed drainage system.

Soils of this nature compact very readily when subjected to traffic. Compaction makes the drainage problem more pronounced. Air porosity tends to be reduced by both moisture saturation and compaction. The situation becomes increasingly complex, resulting in a less favorable environment for proper root growth as reflected in a shallow root system, weakened topgrowth, reduced wear tolerance and turf deterioration.

Results approaching miracles can be achieved in restoring improperly constructed or maintained fields.

Construction Costs of Athletic Fields

The cost figures for natural turf provide for a field which includes all the basics for a playing surface that will minimize compaction problems in the soil and provide drainage not only for proper growth of the turf but also to eliminate muddy conditions. A major objective in the proper construction of natural turf athletic fields is full moisture control—i.e. when it rains, its drains; when soil moisture becomes deficient the irrigation system responds.

The most interesting aspect of these comparative costs is the 4× differential in construction costs and payment of the debt which usually is incurred. It would be possible to build and annually completely strip and resod four natural turf fields for the price of a single synthetic field based on the assumption that the life span of a synthetic field is 20 years. Realistically, a 20 year life span for a synthetic field would be the exception, rather than commonplace. Replacement cost will be as high or possibly higher than the initial construction. Considering these differential costs, together with the potential for increased injuries on synthetic and associated insurance and litigation costs, the case for natural turf athletic fields is very strong.

1. Estimated Construction Costs - Natural Turf Athletic Field*

Phase	Cost Range
Excavate and replace - 12" soil	$ 67,000-$ 81,000
Rough grading	$ 8,000-$ 12,000
Drainage system	$ 30,000-$ 38,000
Sideline drainage	$ 10,000-$ 25,000
Automatic irrigation	$ 24,000-$ 32,000
Final grading	$ 3,000-$ 5,000
Sodding	$ 25,000-$ 30,000
Total Estimated Cost	$167,000-$223,000

*exclusive of architect and repairing costs.

2. Estimated Construction Costs - Synthetic Turf Athletic Field*

$500,000 - $1,500,000
Average - $1,000,000

*(Note - does not provide for internal drainage in field)

3. Construction Cost Based on 20 Year Loan at 12% Interest

Principal	Interest	Total	Average Annual
$ 250,000	$ 315,000	$ 585,000	$ 28,250
$1,000,000	$1,260,000	$2,260,000	$113,000

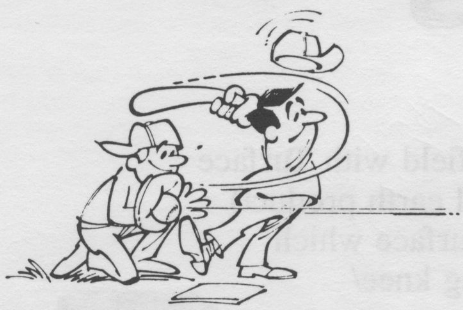
Natural turf is becoming increasingly recognized as a superior surface for sports fields. However, avoidable failures are a major deterrent to its increased popularity. Failure in recognizing and providing for the factors essential to establish and maintain a satisfactory natural turf playing surface is a sure path to failure.

Success, on the other hand, characterized by an aesthetically pleasing surface supportive of intensive use, is a realistic objective. It can be successfully achieved and ensured through adherence to essential basic principles involving planning, design, construction, maintenance and use.

Randy Hundley Talks Sports Turf

Randy Hundley grew up in Martinsville, Virginia, and signed a baseball contract with the San Francisco Giants directly out of high school. In 1965 Randy was traded to the Chicago Cubs and he played as their regular catcher for ten years before being traded to the St. Louis Cardinals. Currently, Randy lives in Palatine, Illinois, and conducts Fantasy Baseball Camps for adults 30 years and older, both for the Chicago Cubs and the St. Louis Cardinals. Randy was the Keynote Speaker at the 2nd Annual Midwest Sports Turf Institute held at the College of DuPage in Glen Ellyn, Illinois, June 24, 1987.

Randy Hundley spent 13 years as a major league baseball player and during his successful career he sustained four knee injuries, all of which required surgery. After he was traded to St. Louis, he had to give up playing in the lush natural grass at Wrigley Field for the hard, hot, synthetic turf at Busch Stadium. When the air temperature was 90°F, the synthetic turf was 140°F, and the hard surface tore Randy's knees and legs apart, and he played in pain and agony. He soon realized that he could not perform up to his potential as a back-up Catcher for the St. Louis Cardinals so he retired as an active player and became a coach. Unfortunately, due to the condition of his knees and legs while just standing for long periods of time on the synthetic surface while performing his duties as a coach, the severe pain forced him to prematurely retire. Randy is very emphatic that the synthetic turf cut his career short. It is possible that major league baseball lost a potential manager when Randy left baseball.



What is it going to take, he asks, for baseball to wake up and reassess the synthetic turf situation? The National Football League Player's Association (NFLPA) has declared synthetic surfaces detrimental to the health and welfare of its football player members. They have even discussed possible compensation for players who must perform on synthetic surfaces. Baseball has not taken an active stand on the synthetic turf situation.

Shortly after taking over the job of Baseball Commissioner, Peter Ueberroth stated that if and when expansion teams are brought into major league baseball, the stadiums would be required to install natural grass surfaces and no new synthetic surfaces would be allowed. However, no further information on this subject has been released.

Just within the past year two notable baseball players have made it clear that they will only play for teams who play their home games on natural grass fields. Eddie Murray of the Baltimore Orioles has a clause in his contract which stipulates that if he is traded, it must be to a team with a natural grass playing field. Super-star, Andre Dawson, took a severe pay cut and left the Montreal Expos to sign with the Chicago Cubs so he could play regularly on natural grass. Andre has a history of knee problems which he feels are directly attributed to the synthetic turf in Montreal.

Randy Hundley further discussed the great need for quality maintenance of baseball facilities. He stated that the fans and most of the players really do not realize just how important the Grounds Personnel are to the team. Neither do these people realize that the grounds staff is really looking out for all the players on the team, nor do they realize or understand just how much work is involved to put a field into good playing condition. The players do not understand the science of growing grass, the concepts with soil drainage or the techniques of fertilizing, watering, aerifying, topdressing or preventing disease.

In conclusion, Randy said, "the groundperson only gets recognition when he/she screws up. Otherwise when everything is fine their job is taken for granted." Further, "encourage all sports turf managers to construct and build natural grass fields. Keep your nose to the grindstone. The Challenge- promote, encourage and insist that every field, and every playing surface, where feasible, should be natural grass."

Weed Control in Infields, Fences and Parking Lots

J. Derr, Virginia Tech

Selective herbicides are available for turf weed control. Longlasting control of goosegrass and crabgrass can be accomplished through preemergence applications of Betasan or Ronstar. Postemergence broadleaf weed control can be attained through the use of 2,4-D, dicamba, mecoprop or mixtures of the three. Roundup provides total vegetation control. This strategy is used for control of such weeds as nimblewill and is followed by reseeding.

Control of vines such as honeysuckle, poison ivy and trumpet-creeper is accomplished through the use of Amitrole, Banvel or Roundup applied postemergence. Multiflora rose is controlled by Banvel, Krenite, Tordon and Spike. Care must be taken to avoid spraying these chemicals near desired trees and shrubs or severe injury could result.

Numerous chemicals are available for total or nonselective weed control. Paraquat, MSMA and Ammate are contact-type herbicides. Repeat applications are generally required for control of perennial weeds with these knockdown chemicals.

Banvel, 2,4-D, Oust and Roundup are foliar systemic herbicides. Roundup and 2,4-D have little to no soil activity while Banvel and Oust have a short residual. Repeat applications of each chemical would be required for season long weed control.

Soil residual herbicides, also called soil sterilants, provide season long or longer weed control. Karmex and Princep are more effective on annual weeds. Hyvar, Velpar, Pramitol and Spike control annuals, herbaceous perennials and woody plants. Mixtures of these chemicals provide broader spectrum weed control. Spike, Pramitol, Casoron and Hyvar can be applied under asphalt for weed control. Do not apply any soil sterilant herbicide where roots of desired trees could absorb the chemical.

New Ideas for Maintaining Athletic Fields

Kent W. Kurtz, STMA Executive Director

The athletic field segment of the turfgrass industry is on the brink of bursting into the limelight and moving to the forefront in the turf management profession. The groundskeeper in sports turf, like his counterpart the greenskeeper in golf some 50 years ago, is becoming known as a sports turf manager. Eventually, the sports turf manager will share the same prestige, status, opportunity and professionalism as the golf course superintendent, the nation's golf course manager. The golf course superintendent has had to work hard for several years to cast off the image of being an urban farmer; the sports turf manager will have to work even harder to remove the stigma of being a janitor or custodian.

In the early 1960s, football on all levels of competition consisted of "five yards and a cloud of dust." When it rained, these worn-out, over-used pastures turned into mud bogs. Unfortunately, during this era, technology advancements and research on athletic turf lagged far behind the developments and accomplishments taking place in the field of golf course management. As a result of this passive period in sports turf history, great inroads were gained on all levels of athletic competition by manufacturers of synthetic surfaces. Consequently, for nearly 20 years the sports turf industry, and in particular natural grass, has been attempting to recover and regain its lost prestige. Recently, however, due to the mounting number of severe injuries and overwhelming opposition to artificial turf by more than 80 percent of the National Football League players, natural grass is once again gaining favor and is being looked on as the salvation and future hope.

Is the turfgrass industry ready to meet this challenge? We hope so, but its going to take an all-out effort by everyone involved to bring the technology, ideas, research, innovations and products into alignment with what is needed and expected in the next decade. Researchers, sports turf managers and commercial affiliates will need to join hands to protect the future. The establishment of the National Sports Turf Council (NSTC), a subsidiary of the Musser Foundation, will be composed of sports turf-affiliated organizations, universities and commercial subscriber members. The immediate objective of NSTC is to coordinate turfgrass forces in research and education to promote the development of safer sports turf where it is needed. The goal is to prevent injuries by helping those in charge of sports fields maintain the kind of playing surface that will minimize injuries. Well-maintained natural grass turf is a powerful factor in reducing injuries to athletes.

New ideas for maintaining athletic fields for the safety aspect, and also for the functional and aesthetic qualities of the grass, are available or are on the horizon for the sports turf industry.

Geotextiles

Probably one of the most significant advancements on the sports turf market has been the introduction of a series of fabrics known as geotextiles. The geotextiles, in most instances, consist of non-woven, needle-punched, uniform fiber polyester. These polyester materials have three applications on sports fields: 1) They can be used when installing drainage systems to keep fine soil particles out of drain lines or to separate coarse aggregates from medium or fine particles, 2) they can be used for warming covers to raise soil temperatures over 10°F to accelerate seed germination or to encourage stolon growth, and 3) they can be used to protect turfgrasses from serious wear tolerance.

The third area has caused much excitement for coaches, athletic directors and sports turf managers. Heralded as one of the biggest advancements in the sports turf field, other uses may be found for this "magic carpet." At present, the geotextiles are being used to protect the sideline and bench areas from excessive wear and to protect entire fields from concerts, motocross and mud bogs.

Pre-Germination of Seed

Many sports turf managers need to get new grass growing rapidly and don't have time to wait during cool weather for grass to germinate naturally. Several techniques are available to pre-germinate seed, and each individual has his own method or recipe. However, one of the most successful procedures is to place the loose seed into a drum or container of warm water, change the water every four to six hours, and bubble air through the water using a compressor and hoses. The air provides oxygenation, which is necessary for the seed as it gives off carbon dioxide. Perennial ryegrass seed will swell, and the young plant will emerge in three to five days compared with 7 to 10 days, if the water is changed daily but not oxygenated. The pre-germinated seed is then combined with a carrier such as sand and is then topdressed onto the field (four parts sand, one part pregerminated seed).

Black Turfgrass Colorants

A sod grower had less than four months to plant hybrid bermudagrass stolons and have mature sod available for an athletic field. A black turfgrass colorant was formulated and sprayed over one section of the sod nursery. Use of the black colorant resulted in 15 to 20 percent better and faster stolon coverage and consistently warmer soil temperatures (4-6°F down to 4 inches in the soil). This technique may result in better growth of stolons planted directly on an athletic field in the early spring.

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Maintaining Athletic Field
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Green Turf Colorants

The use of turfgrass colorants came about to color brown fields for television. However, a new colorant has been perfected on the West Coast that is colorfast, will not rub off on uniforms, has a natural blue-green color and has been known to break the dormancy of warm season grasses two to three weeks early.

New Grasses and Varieties

Many new cultivars of perennial ryegrasses that have improved characteristics to the environment are available to sports turf managers. In California, a soon-to-be-released zoysiagrass, "El Toro," shows good wear tolerance, fast spreading characteristics and acceptable late season color. A seed mixture combining Korean-grown zoysiagrass and new cultivars of tall fescue shows excellent potential for the transition zone for year-round color on sports fields.

Sand Topdressing

The use of sand topdressing has been practiced in golf for many years. However, on other sports surfaces, it is a relatively new technique. On many fields it is used in combination with core aerification, particularly where clay is on or near the field surface. In such a case, the clay cores are removed and the sand topdressed and worked into the surface of the turf and into the aerification holes. The sand improves the firmness of the field surface and enhances the internal drainage of the field.

Sand Slitting—Vertical Drainage

An old technique has resurfaced with a new name—sand slitting. It is an ideal approach to solving the problem of poor drainage on older compacted fields. A few sports turf contractors have machines that excavate deep grooves into the soil and then backfill the grooves with sand. Sand slitting improves vertical drainage, and, when combined with core aerification and sand topdressing, an older field can be vastly improved.

Solid Time Core Anchorage

The technique of solid tine core anchorage requires closing the hollow tines on a standard coring aerifier. The tines are either filled with metal or welded closed. It is used where newly laid sod is required to be anchored when there is no time for natural knitting by the root system. By aerifying the sod with the solid tines, clay or soil balls are forced into the field 2-4 inches deep the sod anchored firmly so it won't slip or tear up easily. It was used in 1985 for the Rose bowl to fasten new sod securely into the end zone.

Fibers and Synthetic Wear Tolerance Materials

Researchers are investigating various substances placed in the root zone or on top of the soil to reduce surface wear. In England, plastic netting, rubberized fabrics and solid plastic plates are being evaluated to reduce surface wear on the turfgrasses. In this country, 2-inch cut strands of fiber to curb wear tolerance are being tested. It is hoped the strands will provide durability and stablize the surface of the field.

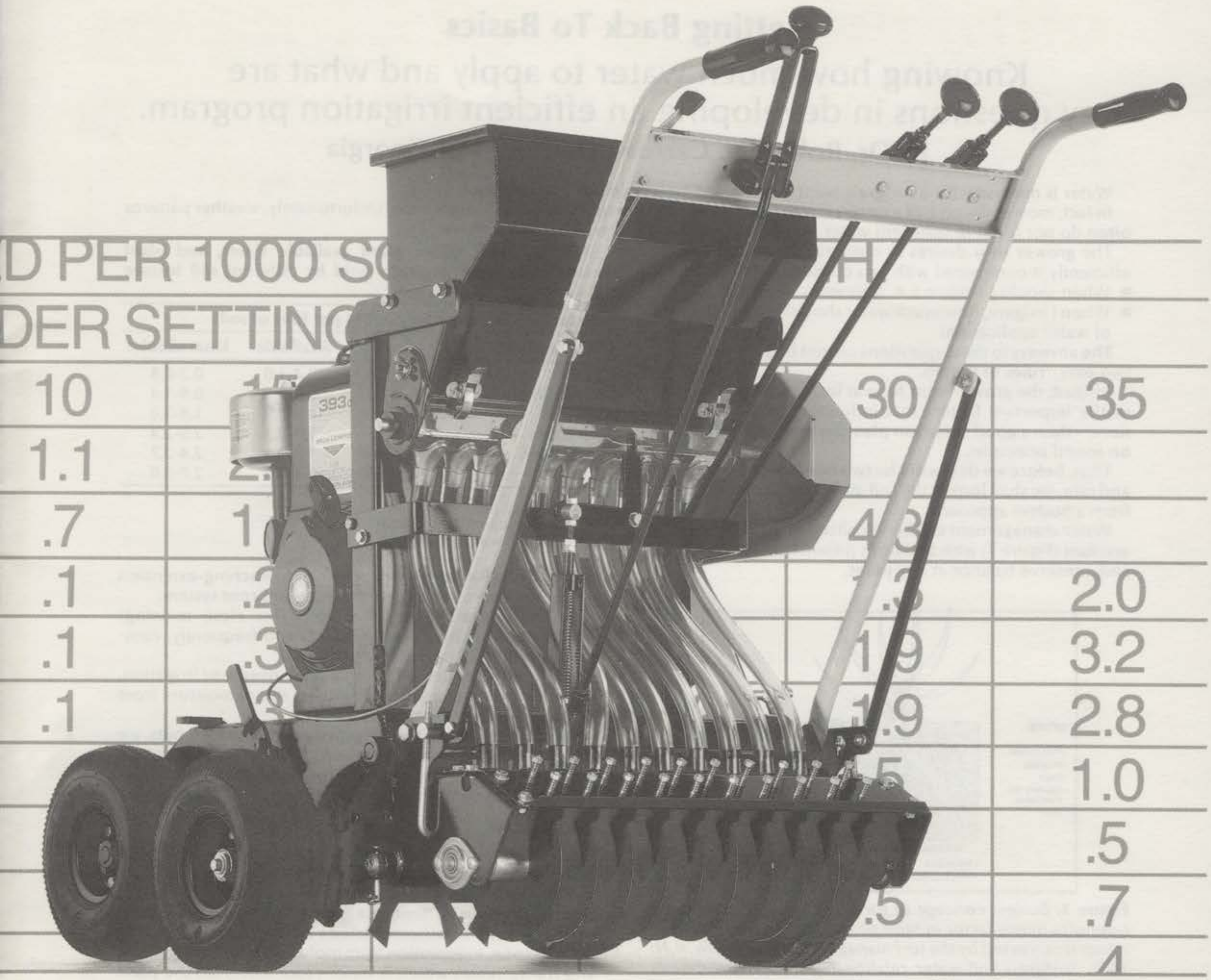
Other Ideas and Materials for Maintaining Sports Turf

Many other ideas and products are being evaluated by sports turf managers in an attempt to save time and money, and provide safer sports turf. Several new formulations of field marking paints that are less toxic, less hazardous, and easier to apply and remove are being investigated. New colors are needed for painting end zones and logos that do not harm or kill the grass. Some formulations are available in a latex paste that are designed to give longer lasting lines; sideline stripes; end zone motifs; and other white or colored marking effects on grass, soil, composition and concrete surfaces.

One sports turf manager uses marble dust with water to make foul lines, on-deck circles and the batter's boxes on his baseball field. Skinned infield, baselines, pitcher's mound and home plate areas seem to vary in composition depending on the area of the country. Sports turf managers are using stone or rock dust; brick dust; ground limestone; sand; clay or clay composition; calcined aggregates; or a combination of calcined clay and soil, sand or clay.

Training Future Leaders

To fill the void created by the resurgence of concern for sports turf fields, training of new sports turf managers is essential. For the past two decades, most of this nation's turfgrass students have entered the golf course profession. We need to begin thinking about educating sports turf managers. In addition, we need to find and identify professionals who are willing to teach, train and develop young people for the future. One of the only professionals currently providing internships and extensive training is Harry Gill at Milwaukee County Stadium. If the sports turf industry and profession are to advance, more people need to get involved and trained. There is no substitute for education, whether it is formal or in the context of field days, seminars, conferences, trade shows or workshops.



Getting Back To Basics

Knowing how much water to apply and what are key questions in developing an efficient irrigation program.

By Dr. Robert N. Carrow, University of Georgia

Water is necessary for a turfgrass plant to grow and be physiologically healthy.

In fact, most of the cells of a turfgrass plant contain 80 to 90 percent water on a weight basis. Unfortunately, weather patterns often do not result in sufficient water for good growth and the grower must irrigate.

The grower who desires to conserve water and irrigate efficiently is confronted with two questions:

- When should I irrigate (i.e. frequency of irrigation)
- When I irrigate, how much water should I apply? (i.e. rate of water application)

The answers to these questions cannot be given in one or two easy "rules of thumb."

Instead, the grower must have at least a basic knowledge of the important factors that influence plant water relations—then a good irrigation plan can be developed based on sound principles.

Thus, before we deal with the two questions of frequency and rate, we shall look at the soil-plant-atmospheric system from a budget approach.

Water management can be visualized as a bank checking account (Figure 1) with additions (inputs), losses (outputs), and a reserve balance at any point.

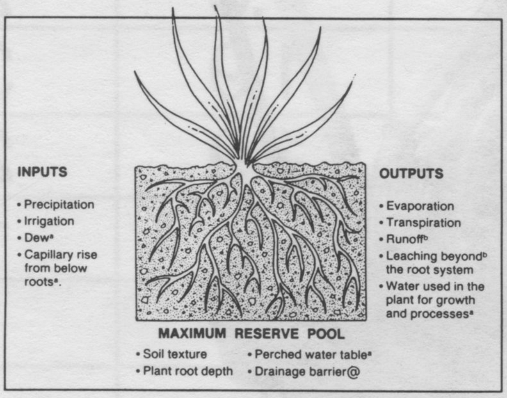


Figure 1. *Budget concept of turfgrass water management ([a]denotes minor factor in most situations; [b]These should be minor if corrected by the turf manager). After: Carrow, R.N. 1985. Turfgrass soil-water relationships. In V.A. Gibeault (Ed.). Turfgrass Water Conservation. ANR Pub., Univ. of Cal., Oakland, CA.*

The wise turfgrass grower should think about how to maximize inputs, minimize outputs, and maintain as large a reserve pool as possible.

The maximum reserve pool of plant-available moisture, depends primarily on soil texture and extent of the plant's root system. Thus, unlike a checking account which can hold unlimited funds, the "reserve water account" has a maximum limit determined by soil and plant factors.

Table 1 illustrates how soil texture influences plant-available moisture, which is the fraction of total water held in the soil that the plant can potentially extract. Some water is unavailable for plant uptake because it is held so tightly by adhesion and cohesion forces in the soil.

Sometimes a turf manager may increase the plant-available moisture fraction by adding organic wathenter which holds much water to a sandy soil. The turf manager can greatly expand the maximum reserve pool of water by using cultural practices favoring maximum root development.

A plant with a 12-inch root system has twice as much water available to it compared to one with a 6-inch root system. This illustrates why our research-teaching-extension personnel stress management for a good root system.

TABLE 1. Total water, plant available water, and plant unavailable water typically held by different soil texture classes.

Water-holding capacity (inches per foot of soil)			
Soil Texture	**Total**	**Available[a]**	**Unavailable[b]**
Sand	0.6-1.8	0.4-1.0	0.2-0.8
Sandy loam	1.8-2.7	0.9-1.3	0.9-1.4
Loam	2.7-4.0	1.3-2.0	1.4-2.0
Silt loam	4.0-4.7	2.0-2.3	2.0-2.4
Clay loam	4.2-4.9	1.8-2.1	2.4-2.7
Clay	4.5-4.9	1.8-1.9	2.7-3.0

[a]Available for plant uptake
[b]Not available for plant uptake
From: see reference, Figure 1.

Major factors that limit rooting are: close mowing; excessive nitrogen, irrigating lightly and frequently, compacted soils, and root feeding insects.

Inputs of moisture are precipitation, overhead irrigation, dew, and in some situations, capillary rise of moisture from below the root system.

Since precipitation and irrigation are the major inputs, we will only discuss these in this article. The grower cannot control the rate or frequency of precipitation but he or she has complete control of irrigation inputs.

Keeping Tabs

Accurate rainfall and snowfall records should be kept so that the irrigation program can be adjusted for precipitation.

Also, the irrigator must know how much water his system applies per unit of time (i.e. inches of water per hour). Losses of water or outputs include runoff, leaching beyond the rootzone, evaporation from moist soil and plant surfaces, and transpiration which is water vapor lost from the plant leaves through the stomates.

Runoff can be reduced or eliminated by cultivating (coring, slicing) sloped areas, dethatching if needed, and applying water at slower rates on sloped areas.

Over-watering causes water to move beyond the root system and become unavailable for plant up-take. Leaching losses can be reduced by monitoring the depth of turfgrass root growth and then irrigating with sufficient moisture to wet the soil to just below the root system; one or two inches below the roots.

This can be observed by looking at the depth of water penetration a few hours after irrigation relative to the rooting depth.

Assuming that the turf manager has corrected runoff and leaching losses, the remaining losses of water are evaporation and transpiration. These are often combined into the term evaportranspiration (ET).

It is the ET losses of water from the soil and plant that must be replenished by precipitation or irrigation if turf growth is to be sustained. Most of the water taken in by a plant's roots is used in the transpiration (90 percent or more) process. The remainder of the water taken up by a plant is used for cell growth and physiological processes.

Transpiration, the vaporization of water from inside the plant leaves through the open stomata, removes heat from the plant and is important for prevention of high temperature stresses.

The evaporation component of ET should be minimized but cannot be totally eliminated. Water lost by evaporation from moist soil and plant surfaces cannot be used for the beneficial processes of transpiration or growth.

Immediately after irrigation the evaporation component will be high but will decrease rapidly as the soil and plant surfaces dry. Thus, avoiding light, frequent irrigation will reduce evaporative losses.

Also, maintaining a dense, higher cut (within the recommended cutting height ranges) will shade the soil surface and reduce evaporation.

Since evaporation and transpiration are both vaporization processes, the grower can visualize how climactic conditions influence ET. Weather conditions that increase ET are:

- low humidity
- high temperatures
- clear and bright days
- high winds

However, if ET exceeds the ability of a plant to absorb enough soil moisture, the plant's stomata will close which greatly reduces transpiration as well as transpirational cooling.

Greatest Efficiency

From this brief discussion of the soil-plant-atmospheric system as a water budget, the grower is encouraged to start thinking of how to control different parts of the system to efficiently irrigate.

No one factor alone will result in maximum water use, but by adjusting several factors the grower can irrigate better and have a good quality turfgrass.

Frequency of irrigation depends on many factors:

A rate of ET
B Turfgrass species, and
C management-mowing, fertilization
D irrigation, traffic level, etc.

This is why it is impossible to give absolute frequencies of irrigation to a grower. Frequency of irrigation changes dramatically with time of year even if you are dealing with only one species and one management regime.

ET rates for turfgrasses are commonly in the 0.10 to 0.25 inches of water per day but may be as much as 0.45 inches of water per day for a well-watered turf exposed to high ET conditions.

If a grower has a turf with a 12-inch root system, a loam soil, and an average ET rate of 0.25 inches per day, then from Table 1, we can see that irrigation would be needed every four days (1.3/0.25) to eight days (2.0/0.25).

If the soil was a sand, irrigation frequency would be every 1.5 to four days. Turfgrass species and cultivars of a species vary greatly in water use because they differ in leaf area, shoot density, rooting depth, growth rate, and other aspects that influence water use.

Table 2 gives a general ranking of turfgrasses as to their frequency of irrigation, assuming each has a fully developed root system.

In a home lawn situation with a good cultural regime for the particular species management practices have a profound influence on how often irrigation is needed because they affect the growth and development of the plant.

A few examples will illustrate this principle:

A *Mowing Height* - mowing too close for the species will result in a much reduced root system and an open turf. The reduced rooting decreases the "maximum reserve pool of water" while the open turf results in higher evaporation versus transpiration losses.

B *Excessive Nitrogen* - applying nitrogen beyond the plant's needs will cause a decline in rooting and promote excessive leaf growth - more leaves for transpirational losses. This results in transpirational water use beyond the real needs of the plant.

C *Irrigation* - if a grower irrigates more frequently and at a lower rate i.e. more lightly than necessary, the turfgrass plant does not develop its full potential for rooting depth.

D *Traffic* - recreational turf is subjected to wear on the above-ground plant parts and to soil compaction. Wear of the turfgrass shoots causes the grower to force a faster growth rate with more nitrogen and water. Also, recreational turfs are often mowed closer because of their use.

As previously discussed, these all increase water use. Soil compaction reduces rooting and thins out the turf so that more frequent irrigation is often applied. Also, reduced infiltration under compaction encourages the irrigator to

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TABLE 2. Relative need for frequency of irrigation under home lawn conditions.

Species[a]	Frequency of Irrigation
COOL SEASON	
Tall fescue	Least frequent
Red/chewings fescues [b]	
Perennial ryegrass, improved	
Kentucky bluegrass, common	
Kentucky bluegrass, improved	
Creeping bentgrass	Most
Rough bluegrass	

[a] *Cultivars within a species vary; thus some cultivars may rank better than the species as a whole.*
[b] *Red/chewings fescues may go easily dormant if irrigated too infrequently.*

Managing a Soccer Showcase with Premium Soccer Fields

Gary Fichter, Ann Arbor, Michigan

The renovation project at the city of Ann Arbor's Fuller Soccer Fields was a major project including complete rebuilding and regrading the area, reseeding and installation of an automatic irrigation system.

Originally, the Fuller Soccer Fields were an 18-hole golf course, later reduced to nine holes in the 1960's. The golf course was abandoned in 1974, and the area was kept as a low maintenance turf area. This was reduced to zero maintenance and the area went to mostly weeds.

In 1978, the area was taken over for play by the Ann Arbor Soccer Association. But, maintenance only returned to a minimal level. Because the terrain was still contoured as a golf course, many of the greens and tees were evident, and it was difficult and unsafe for soccer.

Lobbying by the association for better fields provided the impetus for a major renovation during the larger Fuller/Glen, University of Michigan Hospital construction project.

Monies realized from the sale of some of the park land for the relocation of Fuller and Glen Roads, provided financing for the soccer field renovation.

Our department's park planning staff and outside design consultants provided a regrading and soccer field design plan, and construction was begun August 18, 1982.

The topsoil was removed and stockpiled for reuse on the fields, no other topsoil was brought in. This was a very poor quality topsoil consisting of Wasepi and Boyer loamy sands. This soil is very drought and has a C.E.C. of only 8.1, creating many problems for turf establishment.

The seeding was done crossways by a brillion seeder on October 8. The seed mixture was 25 percent Adelphi, Kentucky Bluegrass, 25 percent Parade Kentucky Bluegrass, 25 percent Galway Tall Fescue, 25 percent NK200 Perennial Ryegrass at a rate of 150 lbs./A. Straw mulch at a rate of 2 tons/A was applied. A 12-12-12 fertilizer was specified for application before seeding.

Germination was only slightly satisfactory by Spring of 1983, turf cover was approximately 50 percent and about 95 percent ryegrass.

For 1983, funding was available for an irrigation system and play was scheduled to begin July 1984. With this in mind, we developed a maintenance plan to provide quality turf by the July starting date.

Compaction of the topsoil from construction seemed to be a major problem, so aerification by a Deddoes trailer type aerifier was completed in May, 1983, four fertilizer applications were prescribed, three applications of 28-0-14 at 1# of N/1000 sq. ft. and a late fall application of potassium at K20/1000 sq. ft.

No herbicide applications were prescribed for 1983, allowing for germination of any existing dormant seed.

At the end of 1983, Toro normally open hydraulic irrigation system was installed, providing irrigation of the entire area including areas between fields through Toro 640 heads.

With the irrigation in place, our maintenance plan for 1984 included overseeding with Kentucky Bluegrass and annual and broadleaf weed control.

In early May, overseeding of the entire area with a bluegrass mixture of Adephy, Baron, Eclipse and Glade at a rate of 1#/1000 was completed, immediately followed by an application of Tupersan for annual weed control at 12#/A rate. An application of 29-0-14 @ 1#N/1000 was applied in late May.

Problems encountered in the pumping system for the irrigation resulted in delaying startup until late July. This resulted in losing approximately 50 percent of the overseeding.

Once the irrigation system became fully operational, turf quality improved immediately. In late August, an application of Trimec was applied for broadleaf weed control and applications of 29-0-14 at 1½#N/1000 in August and 1#N/1000 in September was completed. By the end of the season, we and had 95 percent cover of quality turf with 50 percent being Kentucky Bluegrass.

In 1985, maintenance included aerification, continuous overseeding of high wear areas such as goal mouths with perennial ryegrass using at least two of these varieties: Manhattan II, Yorktown II, Palmer, Gater Prelude, Blazer, Premier. Fertilization consisted of three applications of 26-0-14 at 1½#N/1000 each. Soil testing every two years monitors soil fertility levels and adjustments will be made if necessary. Broadleaf weed control was applied in September. The turf is maintained at 1½" cutting height mowed with a Brower 7 gang reel mower.

1986 maintenance included Spring overseeding with ryegrass. Fertilizer applications in April of 1½#N/1000 in August of 1#N/1000 using a 26-0-13 fertilizer, 50 percent area 50 percent SCU and 100 percent potassium sulfate. Finally, an application at the end of October of a 10-11-31 fertilizer applying 1½ of potassium/1000 sq. ft. Soil test results show an improvement in pH and an increase in potassium levels. Micronutrient levels are low requiring supplemental applications next spring.

Turf quality has remained high except for the goal mouths. Future efforts in improving these areas include schedule changes to provide a rest period for each field that we may renovate the goal mouths with top soil fill and seeding. Increasing potassium levels to improve wear tolerance. Aerifying heavy use portions of fields twice annually.

Each year our fields have shown a marked increase in quality. As we fine tune our maintenance practices to solve our problem areas, I look forward to having the finest soccer fields in Michigan.

New Turf Fungicide Makes 1987 A 'Banner' Year

In the battle with turf diseases, there's new ammunition. Turf professionals are now armed with Banner®, a new systemic fungicide from the Ciba-Geigy Corporation that controls dollar spot, brown patch and other menacing diseases.

The product recently received label approval from the Environmental Protection Agency for use on cool-season grasses, after years of university and independent research.

"Banner will offer a broader spectrum of disease control than comparable products, plus it's been well-tested," says leading researcher Dr. Houston Couch, Virginia Tech professor of plant pathology. "We've been expecting EPA approval on Banner for a couple of years."

Couch says the product has been better tested than many new turf products because of the lengthy wait for registration. "I'm convinced it will perform under most conditions, from coast to coast," he adds.

"Banner really works on dollar spot," Couch stresses, adding that it provides extended control of the widespread disease.

Brown patch is another major disease that Banner controls. At Lebanon (Penn.) Country Club, Jim MacLaren tested Banner for five consecutive years for longevity and phytotoxicity in controlling severe cases of brown patch. "I could easily see the difference where Banner has been applied, even with my untrained eyes," says the former president of the state's turfgrass council.

MacLaren adds that he was particularly impressed with the product's longevity. "Treating large areas like fairways is expensive, considering the costs of the chemcials plus your time and equipment. With Banner, you can reduce labor and equipment expenses."

At Michigan State University, Dr. J.M. Vargas Jr., professor of botany and plant pathology, has tested Banner for the past eight years. "It works on many diseases and on most species," he says. "It's as good as any product on the market, and it provides long-term control—up to 28 days for some diseases."

Vargas finds Banner works particularly well on dollar spot and anthracnose, the two biggest disease problems in his area.

Another researcher, Patricia Sanders, associate professor of plant pathology at Pennsylvania State University, says Banner's time has finally arrived. "we need a product like Banner in the turf industry because of its broad spectrum of activity," she says.

Banner controls other turf diseases such as rust, red thread, powdery mildew and stripe smut.

"An added benefit," Sanders notes, "is that high rates of Banner also control species of *Helminthosporium*." Banner's label states that the product "aids in controlling" these diseases, commonly known as leaf spot or melting out, "when in a regularly scheduled disease control program alone or in combination with other fungicides registered for control of these diseases."

"Our spectrum of control will be broadened now that Banner is available," Sanders adds.

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Selling Athletic Field Maintenance To Your School Board

Jack Coffman, Margaretta Schools, Castalia, OH

Local boards of education and school administrations must become aware of the importance of good groundskeeping. Today, in Ohio, fewer than 30 percent of the voters have children in school. If voters have no vested interest in schools, how do we get them to vote for our levies? We can't wait until the month before election and try to convince them. Good groundskeeping shows you care and that you have pride in the taxpayers' facilities.

Boards of education think in terms of paybacks, and you must also. Look at life cycle cost vs. least initial cost. If you can show a board how you can save money in the long run, you stand a good chance of getting funded. Look for cost savings in your department. Can a new mower reduce the manpower needed? If an $8,000 mower will reduce hours by 25 percent and allow you to hold off hiring additional help for two years at an annual cost of $12,000, that's a savings of $16,000 over two years and the department has a good piece of equipment for years to come. Look into equipment rental for seasonal equipment such as seeders, aerators, etc., to conserve budget dollars.

In past years boards of education could not be sued for an injury on an athletic field; today that is not the case. Today, boards have a vested interest in reducing accidents and injuries. How do you determine the true cost of an injury to a student because of a poorly maintained field? The cost of a lawsuit? The increased cost of liability insurance? That's if you can get insurance.

All school systems are different, so find out who makes the decisions in your district. Usually it's not the board of education; members follow recommendations from the administrators they hire for this purpose. The true decision is with a business manager, superintendent, high school principal or athletic director. Be careful of using board members to change the minds of administrators—don't play politics. If you need to play politics, use the booster clubs, and be careful. Your booster club may be a good place to start to get the funds for a field renovation project, or to start a fertilization program to show administrators what can be done.

Be prepared for budget cuts before they come. Develop an outline of what can be done for three different funding levels: minimum budget, maintenance budget and expansion budget. You need to be ready to identify the results that will go with a funding level. In other words, if your budget is cut 20 percent, you will only mow once a week, with no weed control, no fencerow trimming, etc. Tell the boss what the results of his actions will be before he does it, not after. Explain the long-range effects of budget cuts; for example, if you eliminate overseeding the football field in fall and spring, will you need to renovate in two years? If you have to hold off replacing a tractor or mower, will the major repair it needs exceed the cost to replace?

Above all, don't give up—budget increases come slowly. You have to walk before you can run. Pick a small area like a football field and show what you can do. Before long the board will want other areas on the same maintenance schedule. Do the best you can with what you have.

Are You Properly Dealing with Compaction?

John R. Hall III, Virginia Tech

Once athletic field managers have obtained administrative support for regular mowing, fertilization and weed control of recreational turf, the next obvious need is the commitment to a regular core aerification program. Very few athletic fields in Virginia currently receive what would be classified as "adequate aerification" to alleviate the negative effects of compaction.

Compaction is a phenomenon the athletic field manager must learn to deal with if there is to be any hope of producing quality turf under normal use patterns. Any inability on the part of the athletic field manager to understand how detrimental compaction can be, will severely limit the likelihood of the production of quality turf.

Compaction destroys soil structure, increasing soil bulk density, carbon dioxide concentrations, surface runoff, heat conductivity and small pore space. It decreases large pore space, soil aeration, water infiltration, percolation and nutrient and pesticide movement.

Bulk density is the mass of soil per unit of soil volume, including solids and the pore space. It is expressed in grams per cubic centimeter (g/cc) and ranges from 0.8 on well aggregated soils to above 2.1 on highly compacted soils. Bulk density values greater than 1.5 are generally indicative of soils compacted to the point where turfgrass root growth is seriously impaired. If increases in bulk density occur during periods when roots are actively elongating the damage can lead to poor development of root systems essential for summer survival.

Mechanical impedance or resistance to root or rhizome growth brought about by compaction is most severe on drier soils. The damage brought about by increases in mechanical impedance of soils is likely to be more severe on the clay and silt soils than on sandy soils because of the greater soil strength of heavier soils. This can result in shorter root and rhizome systems.

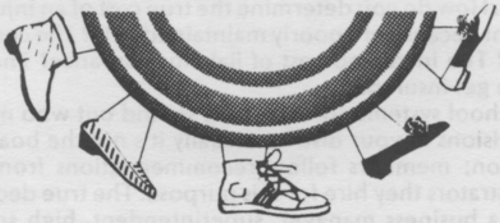
Plant roots need oxygen to survive and as the bulk density of a soil increases, carbon dioxide and other toxic gases evolving from respiration and organic matter decomposition meet increasing resistance to diffusion. Their concentration can build up to the point they become toxic to the root.

Since compaction is very much a surface phenomenon most negatively affecting the top 4 inches of soil, surface runoff is significantly increased. Water use efficiency is decreased leading to greater irrigation demand. Infiltration, the passage of water through the soil surface, is, therefore, severely decreased by compaction. In the presence of poor surface drainage this general leads to pooling of water in low areas and either suffocation of the lturf or increased hydration of crown tissue leading to winder injury. Decreased infiltration rates that persist into summer make it extremely difficult to get water to the root-feeding zone during times of drought stress.

Increases in the heat conductivity of soils brought about by compaction lead to greater soil temperature extremes. The soil particles are packed closer together and the soil becomes a better conductor of heat. This means higher soil temperatures will be reached in the summer and lower temperatures in the winter. This means less rooting of the bentgrasses and bluegrasses at the higher temperatures. The increase in low temperatures, if severe enough, could result in slower root extension in the spring, lower root membrane permeability due to increased protoplasmic viscosity and reduced rates of water movement to roots becuase of increased water viscosity. The lower temperatures would also increase the likelihood of bermudagrass winterkill.

As compaction increases, the total volume of pore space in the soil decreases as does the size of the pores. Small pores are usually filled with water and retain this water with greater force than larger pores. Increased compaction increases the ratio of small to large pores and, therefore, on a volume basis, water begins to replace air in the soil profile. This leads to low oxygen availability to roots. The roots need this oxygen to maintain their normal metabolic functions and to actively absorb nutrients from the soil solution. Pathogenic fungus organisms such as Pythium thrive in high soil temperatures in the presence of a lack of oxygen. The probability of summer disease problems is therefore increased.

The decreased pore space brought on by compaction lowers the oxygen diffusion rate in the soil. Oxygen that was diffusing to the root through relatively large aeration pores before compaction must now diffuse in water at a rate estimated to be 10,000 times slower. Weeds that can persist in low oxygen diffusion rates such as goosegrass and knotweed now gain the competitive edge over Kentucky bluegrass, creeping bentgrass and tall fescue.



Percolation is the movement of water through the soil profile. Water movement through the soil decreases as a result of the decreased infiltration rate and the decrease in pore size. As pore size decreases the resistance to water flow increases. Once a compacted soil is wetted the increased amount of small pores retain more water per unit volume than an uncompacted soil. Therefore, greater amounts of time are required to dry the surface. The small pores in compacted soil hold the water with greater force than large pores and even though the soil retains more moisture than it did prior to compaction, a greater portion of the water is unavailable to the turfgrass plant.

As compaction increases, it comes increasingly difficult to get applied nutrients to the roots. Compaction significantly reduces root growth in the surface 4 inches, and the uptake of relatively immobile elements such as phosphorus, calcium, magnesium and potassium is severely affected. When pesticides require soil mobility for effectiveness; for instance, in the case of grub control or root uptake of some systemic fungicides, compaction can significantly reduce efficacy.

All of these individual negative effects of compaction on the soil work together to impart a very negative total effect on turfgrass growth and quality. Decreased root, shoot, tiller, rhizome and stolon growth results from compacted soil. Nutrient uptake in the turfgrass plant is altered with certain elements being more affected than others. Nutrient uptake of potassium, nitrogen, phosphorus, calcium and magnesium are most negatively affected by compaction. The turfgrass plant growing on compacted soil is less able to produce stored food reserve. Fifty percent reductions in total nonstructural carbohydrates have been noted in research on compacted Kentucky bluegrass when contrasted with uncompacted areas. Research has also shown that while plant succulence increases on compacted turf, total water use tends to decrease as a result of the decreased density and vigor of the turf. Wilting frequency is increased because the moisture in a compacted soil is retained by smaller pores with increased force, and applied water is less efficiently absorbed. The tendency of a turf to wilt more frequently leads most turf managers to increase irrigation frequency at increased labor and water expense. As irrigation frequency increases annual weed competition increases from knotweed, crabgrass, and goosegrass. Excessive plant succulence and anaerobic soil conditions predispose the plant to disease activity. The turf manager quickly finds himself needing more herbicides and fungicides to compensate for what is basically a problem begin caused solely by soil compaction.

Problems such as high and low temperature injury, sun scald, dry wilt and drought, wet wilt, intracellular freezing and winter desiccation can often be traced to compaction.

Managing turf to minimize the negative effects of compaction is important. Management considerations helpful in this regard are aerification, traffic control, water management, soil modification, efforts to improve drainage and irrigation design and turfgrass selection.

Core aerification is extremely beneficial in increasing air exchange, water infiltration rates, water retention, nutrient penetration and thatch decomposition. It also decreases runoff and therefore increases water use efficiency, reducing total irrigation requirements. Heavily trafficked cool-season grasses should be aerified spring and fall during periods of active foliage growth. Mid-summer aerification can be beneficial if irrigation is available and temperatures are favorable. Warm-season grasses can be beneficially aerified from the time they green up till they go dormant in the fall. Once a month aerification on heavily trafficked bermudagrass would not be detrimental. Total number of aerifications per year needs to be linked to fertility levels, amount of traffic and thatch buildup present.

Developing adequate aerification programs is an essential part of any program designed to produce quality turfgrass playing surfaces on athletic fields in Virginia. The frequency of aerification must be geared to the amount of traffic and the type of turfgrass being managed as well as the potential for healing regrowth. Having irrigation, certainly expands the amount of time that aerification can be utilized. Aerification during excessively hot periods when moisture is limiting will only serve to aggravate the limited moisture condition, so it should only be utilized in these situations where irrigation is available. Obviously, the level of growth at which the field is being maintained will affect the frequency with which the field can be aerified. General programs for aerification can be designed around the guidelines in Tables 1 and 2.

Minimizing traffic whenever possible is important. Limiting play of main fields to essential use only is critical. Minimizing traffic when soil is wet is critical. Compaction damage is greater on a wet soil than on a dry soil. At a given soil moisture content light equipment will cause less damage than heavy equipment. Therefore, timing irrigation to allow adequate time for drainage prior to traffic can be a critical factor in reducing compaction damage.

Amending soils with sand is difficult and seldom successfully accomplished with on site incorporation. Off-site blending of sand and soil to achieve maximum compaction resistance and yet retain adequate moisture and nutrient holding capacity is the best approach to soil modification. Laboratory testing to confirm the proper ratio of sand, soil, and peat is essential to success.

Table 1. Recommended times for aerification of cool-season grassses based upon level of traffic.

Traffic Level	Aerification Date (two passes each time)				
Heavy	APR	MAY	JUN	AUG	SEP
Moderate	APR	MAY		AUG	
Light	APR			AUG	

Table 2. Recommended times for aerification of warm-season grasses based upon level of traffic.

Traffic Level	Aerification Date (two passes each time)				
Heavy	APR	MAY	JUN	JUL	AUG
Moderate	APR		JUN		AUG
Light	APR			AUG	

Since wet soils are damaged more by compaction than dry soils, obviously any attempt to maximize drainage efficiency is beneficial. Good surface and internal drainage are essential to minimizing the negative effects of compaction. Inadequately designed irrigation systems will frustrate any attempt to win the battle with compaction. Moisture delivery needs to be easily programmable, uniform in pattern and capable of being matched to the soil infiltration and percolation rate.

Selecting turfgrasses that are traffic tolerant is extremely important. There is mounting evidence that the improved perennial ryegrasses are more traffic tolerant than Kentucky 31 tall fescue. Their intensive root development, quick germination and recuperative potential have made them excellent athletic field grasses in areas where they are adapted. Mixtures of Kentucky bluegrass and perennial ryegrass are performing well under moderately heavy traffic, especially when aerified. Bermudagrass remains an outstanding grass for athletic field surfaces in southern Virginia and most of North Carolina.

It is essential that recreational turf managers develop turf management programs that effectively deal with the negative impact of compaction. Failure to realize that compaction is a subtle but deadly detractor of turf quality will certainly lead to frustration and failure.

Using Herbicides Effectively

Many factors affect herbicide efficacy. Some of the more important factors that should be given consideration prior to use include the following:

1. Identification of the weed and desirable turfgrass. Positive identification of the weed to be controlled is essential to prescribing the most effective herbicide.

In addition, it is important to know which turfgrass the weed is in since different turfgrasses have varying susceptibility to applied herbicides.

2. Growth stage of the weed. Most effective post-emergence weed control is achieved on young, actively growing weeds. If weeds are nearing the end of their life cycle and not actively growing, they will not be effectively controlled.

Examples of improper timing would include attempts to control winter annuals such as common chickweed, henbit, German moss (Knawel) and sowthistle in June when they have already produced seed for the upcoming fall germination and are near the end of their annual life cycle.

3. Growth rate of the weed. The more metabolically active a weed is, the more effectively it will be controlled by herbicides. Therefore, any factor such as sunlight, moisture or good nutrition that speeds up growth rate will generally increase herbicide efficacy.

If weeds to be controlled are under heat or drought stress they will not be metabolically active and will be less affected by applied herbicides.

On the other hand, if the desirable cool-season turfgrass is somewhat sensitive to the herbicide being applied and is

(continued on page 22)

Using Herbicides Effectively

(continued)

under drought or heat stress, it is likely it will suffer greater damage from the application.

4. Morphology of the weed. If the weed to be controlled has a thick, waxy cuticle or a leaf shape which is not conducive to good herbicide spray contact, decisions about which formulation of the herbicide to utilize can be critical. Weeds like wild onion and wild garlic are better controlled with liquid sprays than granular sprays.

Additionally, waxy cuticles are better penetrated by low-volatile esters than amine formulations. Concern about the increased probability of ester volatilization in the landscape has however reduced ester popularity.

5. Air and soil temperature. Maximum metabolic activity in most weeds occurs between 55 and 80 degrees Fahrenheit and therefore herbicide spraying should be planned for times of the year when temperatures are in this range. Temperatures outside this range will reduce metabolic activity and therefore herbicide effectiveness.

6. Rainfall probability and foliage wetness. Liquid herbicides are most effectively absorbed when applied to dry leaf surfaces. Water dilution rates for herbicides have been recommended assuming the foliage is dry at the time of application.

Wet foliage will reduce liquid herbicide effectiveness at normal water spray rates. Granular herbicides are generally more effectively absorbed when applied to wet foliage.

Herbicide Manufacturers

American Cyanamid
1 Cyanamid Plaza
Wayne, NJ 07470
(201) 831-2000

The Andersons
P.O. Box 119
Maumee, OH 43537
(419) 893-5050

Applied Biochemists
5300 West County Line Road
Mequon, WI 53092
(414) 242-5870

BASF Wyandotte
100 Cherry Hill Road
Parsippany, NJ 07054
(201) 263-3400

Ciba Geigy Corp.
P.O. Box 18300
Greensboro, NC 27419
(919) 292-7100

W.A. Cleary Chemical Corp.
1049 Somerset Street
Somerset, NJ 08873
(201) 247-8000

PBI/Gordon Corp.
1217 West 12th Street
Kansas City, MO 64101
(816) 421-4070

Hoechst-Roussel
Route 202-206 North
Somerville, NJ 08876
(201) 231-2000

Hopkins Agric. Chem. Co.
P.O. Box 7190
Madison, WI 53707
(608) 221-6200

ICI Americas
P.O. Box 751
Wilmington, DE 19899
(302) 575-3000

Lebanon Chemical Corp.
P.O. Box 180
Lebanon, PA 17042
(717) 273-1685

Crystal Chemical InterAmerica Co.
1523 North Post Oak Road
Houston, TX 77055
(713) 682-1221

Dow Chemical USA
P.O. Box 1706
Midland, MI 48640
(517) 636-1105

Drexel Chemical Co.
2487 Pennsylvania Street
Memphis, TN 38109
(901) 774-4370

E.I. Du Pont de Nemours
1007 Market Street
Wilmington, DE 19898
(302) 774-1000

Elanco Products Co.
Lily Corporate Center
Indianapolis, IN 46285
(317) 276-3759

Fermenta Plant Protection
P.O. Box 348
Painesville, OH 44077
(216) 357-3000

Lesco Products
20005 Lake Road
Rocky River, OH 44116
(216) 333-9250

Mallinckrodt Inc.
P.O. Box 5439
St. Louis, MO 63147
(314) 895-2000

Mobay Chemical Group
P.O. Box 4913
Kansas City, MO 64120
(816) 242-2000

Monsanto Co.
800 North Lindbergh Boulevard
St. Louis, MO 63167
(314) 694-1000

Nor-Am Chemical Co.
3509 Silverside Road
P.O. Box 7495
Wilmington, DE 19803
(302) 575-2000

Ortho Div. Chevron
575 Market Street
San Francisco, CA 94105
(415) 894-7700

Pennwalt Corp.
Three Parkway
Philadelphia, PA 19102
(215) 587-7000

Regal Chemical Co.
P.O. Box 900
Alpharetta, GA 30201
(404) 475-4837

Rhone-Poulenc Inc.
Agrichemical Div.
P.O. Box 125
Black Horse Lane
Monmouth Junction, NJ 08852
(201) 297-0100

Rohm & Haas Co.
Independence Mall West
Philadelphia, PA 19105
(215) 592-3000

Sandoz Crop Protection
341 East Ohio
Chicago, IL 60611
(312) 670-4665

OM Scott & Sons
Proturf Div.
Marysville, OH 43041
(513) 644-0011

Stauffer Chemical Co.
Agricultural Chem. Div.
Westport, CT 06881
(203) 222-3294

Union Carbide
Agricultural Products
T.W. Alexander Drive
Research Triangle Park, NC 27709
(919) 549-2000

Uniroyal Chemical
Elm Street
Naugatuck, CT 06770
(203) 723-3000

Vertac Chemical Co., Inc.
5100 Poplar Avenue
Suite 3122
Memphis, TN 38137
(901) 767-6851

Vineland Chemical Co., Inc.
1611 W. Wheat Road
P.O. Box 745
Vineland, NJ 08360
(609) 691-3535

Most foliar absorbed post-emergence herbicides require four to six hours of foliar absorption to be effective. Rainfall prior to this time will significantly reduce herbicide effectiveness.

Anything that reduces metabolic activity of the weed during the foliar absorption period will increase the time required to achieve adequate herbicide absorption. Other factors such as physiological detoxification of applied herbicides, organic matter binding, soil binding, leaching, photo decomposition, water pH, mixture incompatibility and rate of the herbicide applied can all have an effect upon the efficacy of the applied herbicide.

Combinations of commonly used broadleaf post-emergence herbicides are generally more effective in providing broad spectrum weed control than single herbicide mixtures.

Repeat applications of some herbicides will be necessary for 100 percent control. Use of post-emergence arsenicals for annual grass control actually necessitates re-application two or three times at 10- to 14-day intervals.

Repeat applications of the broadleaf herbicides should be spaced at least 30 to 45 days apart to minimize injury to the turfgrass.

In all spraying situations, spot spraying minimizes cost, environmental exposure and general stress on the desirable species while maximizing herbicide efficiency. In all instances, it is of paramount importance that label recommendations be closely followed.

From the President...

One question that has frequently come up from many people interested in become a member of STMA is, "What do I get in freturn for a STMA membership?" Probably the most important part of the answer to that question is that an STMA membership will provide you with a valuable resource of information in the management of your sports field.

Being a STMA member gives the athletic field manager an opportunity to share ideas and experiences with others in the same profession. It also allows him to learn from others encountering the same basic problems which can be an extremely valuable tool in the day-to-day operations of our athletic fields. And it doesn't matter which level of care an area receives. Whether it be a professional stadium or a local park area, the information is just as valuable.

In addition to an informational pool, an STMA membership offers reduced rates at our STMA sponsored educational seminars and trade shows, an informative newsletter, as well as timely information from our commercial members on the latest tools, equipment, materials and services available in our industry.

But perhaps the most important advantage to the membership majority is the availability of each person to be able to pick up the phone and call another member for tips, ideas, and testimonials on the day-to-day problems he encounters.

Each STMA member offers his or her knowledge and experiences freely and openly to any other member which can't help but elevate the productivity and image of our profession as a whole.

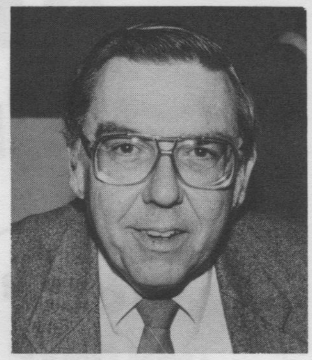
Please keep STMA in mind when searching for information on how to better manage your athletic fields. We're definitely here to help and we are definitely here to stay!

I wish you all a most successful Fall.

Steve Wightman, President

Doc's Dugout

Dr. Kent Kurtz



Another successful Sports Turf Institute was held in June at the College of Dupage in Glen Ellyn, Illinois. George Rokosh, COD's director of buildings and grounds, once again did a superb job of setting up and organizing the commercial exhibits and trade show. Susan Glasglow and Nancy Thomas, as always, organized the registration, planned and had the lunch served, and made sure the conference ran smoothly. Nearly 400 attended the Institute.

At Dupage we experimented with holding special on-site demonstrations to show the audience how to do specific projects or tasks. These demonstrators (Show'N Tell) proved to be the highlight of the conference. In fact, the opening of the exhibits had to be delayed because the speakers were inundated with questions. Based upon the success of this venture and its popularity, all future sports turf institutes which are held in conjunction with outside exhibits, will have on-site demonstrations. Demonstrations included 1) by-pass drain installations (Dave Heiss-Spring Lake, Michigan), 2) baseball infield drainage systems and installations (William Wrobel-Aimcor). 3) Repair of pitching mounds, home plate area and proper preparation of skinned infields (Roger O'Connor-Chicago Cubs), 4) line marking materials and techniques (Frank Smith-Palantine, Illinois) and 5) Turf variety and fertilization plots (Julia Fitzpatick Cooper and James Mello-College of Dupage).

STMA has made many friends and has reshaped the lives of many of its members. Congratulations to Dean Kuykendall (formerly of Lewis University - Joliet, Illinois) who is now caring for the turf at the New Miami Dolphin Stadium in Florida. Dean is the young, "new breed" of grounds person who works very hard, pays his own way to Conferences, asks a lot of sound questions, is always available to help someone and is extremely well liked by his peers. Dean came to the 1st Midwest Sports Turf Institute at Dupage and immediately gained the friendship and respect of older STMA members. These same STMA members highly recommended Dean to the Miami Dolphin organization and the rest is history. STMA is here to serve each and every one of its members - so get involved.

Sports Turf Manager

GET INVOLVED!

ATTEND OUR INSTITUTE!

CONTRIBUTE TO YOUR PUBLICATION!

SIGN UP A NEW MEMBER!

1st Annual Southeastern Sports Turf Institute
Daytona International Speedway
September 16-17, 1987

Sports Turf Institute Program

September 15, 1987

Exhibitor move-in and set-up
Early bird golf at Indigo Lakes Resort

September 16, 1987

7:30 a.m.	Registration
8:10 a.m.	Intro to activities
8:20 a.m.	Welcome—Dick Hahne, Track Superintendent (D.I.S.)
8:30 a.m.	"We grow grass at over 200 MPH" John Riddle, Gen. Manager (D.I.S.)
8:50 a.m. Split Session:	
9:00 a.m.	• Drainage, a new look at an old problem. • Cost Effect-sprigged or sod
10:00 a.m.	• Effectiveness of irrigation. • The ultimate playing surface-P.A.T.
11:00 a.m.	• Liquid fertilizer injections-a buyable alternative. • Using proper equipment.
12:00 Noon	Lunch & Exhibits/Alternative activities
2:30 p.m.	Professional sports grounds superintendents available in Pit area for one-on-one questions & answers
3:30 p.m.	B.B.Q. with Winston Cup Driving Star.
3:30 p.m.	Drawing prize winners—D.I.S. 100+ Club rides.
5:00 p.m.	Adjourn.

September 17, 1987—Split Sessions:

8:00 a.m.	• Southeastern Turf Grasses. • Water Management.
9:00 a.m.	• New Technologies in Sports Turf. • Sports field renovation.
10:00 a.m.	• Fertilizers-Why, How, When. • Effective Pest Management.
11:00 a.m.	• NFL Field Marking Techniques. • Year around color at your sports facility.
12:00 Noon	Lunch & Exhibits/Alternative activities
2:00 p.m.	Professional Sports Grounds Superintendents available in Pit area for one-on-one questions and answers.
3:00 p.m.	Drawing prize winners—D.I.S. 100+ Club rides.
4:00 p.m.	Thanks for Coming— on P.A. by D.I.S. & STMA officials.

Exhibits!!!

Here are the names of some of the companies that will be demonstrating equipment and turf management techniques.

- Aimcor
- Ransomes
- Hunter Irrigation
- John Deere
- Ameriquatic
- Toro Irrigation
- Honda
- Ford
- Lessco
- Goldkist
- Tifton Turf
- Southern Turf

...AND MANY MORE.
The important suppliers in your area will be adding their names to this list as we go to press...

Registration

Pre-registration	On-site	
STMA Member	$40.00	$45.00
Non-member	$45.00	$50.00

For more information, contact:

STMA
c/o Dick A. Hahne Track Superintendent
Daytona International Speedway
P.O. Drawer S 1801, Speedway Boulevard,
Daytona Beach, Florida 32015

Hotel Reservations

The official meeting hotel is The Clarendon Plaza Beachfront at 600 North Atlantic Avenue, Daytona Beach, Florida 32018 800-532-3224/904-255-4471. There are other nearby hotels affording special rates for this meeting. They are:

Howard Johnsons Motor Lodge
I-95 and U.S. 92
Daytona Beach, FL 32020

Holiday Inn - Speedway
1798 Volusia Ave. (U.S. 92)
Daytona Beach, FL 32014

Indigo Lakes Golf and Tennis Resort
2620 Volusia Ave. (U.S. 92)
Daytona Beach, FL 32014

Nitrogen Fertilizers For the Turfgrass Industry

John R. Street, Ohio State University

Turfgrass growth is dependent on maintaining an adequate supply of all essential plant nutrients as well as properly maintaining a multiplicity of other cultural and edaphic factors. There are at least 16 elements considered essential for plant growth and development. Elements used by plants in relatively large quantities (percentage levels in the plant on a dry weight basis) are commonly referred to as macronutrients. Nitrogen, phosphorus and potassium fall into this category. Elements required by the plant in relatively small quantities (ppm levels on a dry weight basis) are referred to as micronutrients. Iron, manganese and zinc are included in this category.

Nitrogen is the essential element that receives the most attention in turfgrass fertilization programs. There are several reasons for its key position. First, the nitrogen content of turfgrass tissue is usually higher than any other element supplied by the soil. Generally, the nitrogen concentration in turfgrass tissue ranges from three to six percent on a dry weight basis. Second, nitrogen often is referred to as the "TNT" of turfgrass fertilization programs. Turfgrass growth usually increases with increasing application rates of nitrogen fertilizer. Overapplication or mismanagement of nitrogen can result in many detrimental effects. Thus, proper fertilizer selection, seasonal timing and application rate all are important in successful long-term programs. Third, nitrogen is a very dynamic element in the soil system. The concentration of soil nitrogen is in a constant state of change. Nitrogen depletion in soils may result from leaching, clipping removal, volatilization, denitrification, immobilization or nitrogen fixation in the lattic structure of certain clays. Thus, nitrogen must be added to turfgrass sites on a routine basis to maintain a sufficient soil level for turfgrass growth.

Generally, nitrogen additions to the turfgrass system from clipping return, decomposition of organic matter, topdressing, nitrogen fixation and rainfall are not sufficient to supply the needs of high quality turf. The main source of nitrogen is added by the application of nitrogenous fertilizers. Turfgrass managers have many alternatives in choosing a source of nitrogen for turfgrass fertilization. Nitrogen sources can be divided into two general groups: quickly available and slowly available. The choice of a nitrogen source is not simply limited to these categories. Various combinations are available in many mixed fertilizers that may vary widely in the source and amount of quickly and slowly available nitrogen.

Quickly Available Nitrogen Sources

The major characteristics of quickly available nitrogen sources are summarized in Table 1. Quickly available nitrogen sources are also commonly referred to as quick-release, fast-acting, readily available, water-soluble and other terms that denote rapid availability of nitrogen to the turfgrass plant after fertilizer application. A major agronomic advantage to the quickly available sources is a rapid initial plant response (i.e. color and growth) following fertilizer application. Rapid availability does, however, cause an undesirable flush or surge of topgrowth when applied at anything greater than moderate rates and a short residual response. Thus, these sources are applied more often and at lower rates than slowly available sources to minimize overstimulation of growth and in combination with slowly available sources to lengthen the residual response.

These nitrogen sources do have salt-like characteristics. They dissolve readily in water, forming cations (positive ions) and anions (negative ions). For example, ammonium nitrate (NH_4NO_3) dissolves or dissociates readily into the cation ammonium (NH_4^+) and anion nitrate (NO_3^-). The more free cations or anions in soil solution or on the plant surface, the greater the potential for fertilizer burn. The salt index value is used to differentiate the relative burn potential among various fertilizers. The higher the salt index value, the greater the tendency for fertilizer burn (Table 3). Lower soil moisture and higher temperature increase the potential for fertilizer burn. This necessitates a reduction in the nitrogen application rate for quickly available sources during the warmer periods of the growing season.

Slowly Available Nitrogen Sources

The major characteristics of slowly available nitrogen sources are summarized in Table 4. These nitrogen sources are also commonly called controlled-release, slow-release,

Table 1. Several Characteristics of Quickly Available Nitrogen Sources

Advantages	Rapid initial plant response Ease of application in liquid delivery systems Minimum temperature dependence for nitrogen availability to the plant Low cost per unit of nitrogen
Disadvantages	High foliar burn potential Potential for undesirable growth surges at anything above moderate rates Short residual plant response Greater nitrogen loss potential due to leaching, volatility and surface run-off Lower and more frequent applications relative to slowly available sources

Table 2. Commonly Used Quickly Available Nitrogen Sources*

Fertilizer	Analysis
Urea	46-0-0
Ammonium nitrate	33.5-0-0
Ammonium sulfate	21-0-0
Potassium nitrate	13-0-46
Diammonium phosphate	18-46-0
Ammonium polyphosphate (liquid form)	10-34-0

*The quickly available nitrogen sources are readily available under numerous turf and agricultural trade names.

slow-acting, water-insoluble and other terms that denote gradual release or availability of nitrogen to the turfgrass plant after fertilizer application. The gradual release characteristic provides for a more uniform turf growth response and a longer period of nitrogen release as compared to quickly available sources. Safety is another major agronomic advantage due to their low foliar burn potential (Table 3). The potential for producing turf injury from overapplication or overlapping is minimized due to the slow rate of nitrogen release. This is a very desirable characteristic, especially during warm weather. These latter characteristics also enable slow-release sources to be applied at higher nitrogen rates and less often than quickly available sources. Some sources do provide a slow initial plant response, especially at low rates, and some are dependent on warm soil temperatures for maximum nitrogen release. The cool-weather response is minimal from many of these sources.

Many commercial fertilizer formulations will include a certain percentage of quickly available nitrogen to compensate for these disadvantages.

Table 3. Salt Indexes of Various Nitrogen Fertilizer Sources*

Fertilizer	Salt Index Value
Urea	75
Ammonium nitrate	105
Sodium nitrate	100
Potassium nitrate	74
Ammonium sulfate	69
Nitroform	10
IBDU	5
Methylene urea	4

*Concentration of ions in soil solution based on sodium nitrate at 100°.

Table 4. Several Characteristics of Slowly Available Nitrogen Sources

Advantages	Low burn potential due to low salt index values More uniform growth response Longer residual plant response Higher application rates allowing for less frequent applications and reduced labor costs Less potential for nitrogen loss compared to quickly available nitrogen sources
Disadvantages	High cost per unit of nitrogen Slow initial plant response with some sources Nitrogen carryover into the following growing season Some sources not adaptable to liquid application systems

Slowly available nitrogen sources can be classified according to the mechanism controlling the release of nitrogen. The three major groups and fertilizer sources included in each are as follows:

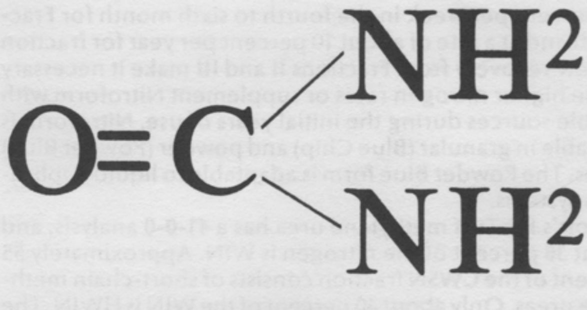
Group I. Organic (carbon) compounds dependent on microbial decomposition for nitrogen release
1. Nitroform
2. Methylene ureas
3. Methylol ureas
4. Natural organics

Group II. Organic compounds of low water solubility that release nitrogen by slow dissolution of the fertilizer particle
1. IBDU

Group III. Soluble sources that are coated forming physical barrier or shell that delays dissolution or release of nitrogen
1. Sulfur-coated urea

Ureaform (UF)-Type Fertilizers

UF-type fertilizers are formed by reacting urea with formaldehyde under specific reaction conditions. In the reaction process, urea initially reacts with formaldehyde to form an organic (carbon) compound called monomethylol urea. Monomethylol urea is the primary organic compound in Formolene (Ashland Chemical Company). This compound further reacts with urea to produce methylene ureas that vary in chain length from short-chain, water-soluble molecules to the long-chain, highly water-insoluble molecules. The longer the methylene urea chain length, the less soluble the nitrogen product. Some free or unreacted urea also remains as a part of the final product. Thus, the UF-type fertilizers do not consist of a single compound, but they are composed of a mixture of various chain length methylene ureas and free urea. The relative percentage of the latter components in the final product will depend on reaction conditions such as temperature, pH, reaction time and the ratio of reaction components (i.e. urea to formaldehyde). Nitroform, Scott's ProTurf methylene urea, Fluf and Nitro 26 and UF-types that fit into this category. The relative percentages of free urea and short- and long-chain methylene ureas give each product its own unique fertilizier characteristics.



UREA

The nitrogen release or availability characteristics of the UF-types are classified by the solubility of the products in water. Two water temperatures are used: room temperature-cold water (22°C) and boiling water-hot water (100°C). Three water soluble fractions are designed from this test:

Fraction I. Cold water-soluble nitrogen (CWSN)
—consists of free urea and short-chain methylene urea polymers
—methylene diurea and dimethylene triurea polymers
—nitrogen release is rapid and similar to quickly available sources

Fraction II. Cold water-insoluble nitrogen (CWIN)
—consists of slowly available nitrogen and intermediate-length methylene urea polymers
—trimethylene tetraurea and tetramethylene urea polymers
—nitrogen release is slow and over a period of several weeks

Fraction III. Hot water-insoluble nitrogen (HWIN)
—consists of slowly available nitrogen and long-chain methylene urea polymers
—pentamethylene hexaurea and longer-chain polymers
—nitrogen release is very slow and over a period of several years

The amount of water-insoluble nitrogen (WIN) that makes up a fertilizer product is designated on the fertilizer label. The WIN value indicates the percentage of Fraction II (CWIN) plus Fraction III (HWIN) in the fertilizer. The WIN value, however, does not define the relative percentage of these two fractions. Thus, two fertilizers with identical WIN values could produce significantly different agronomic responses.

The activity index (AI) value provides a more specific indication of the relative amount of CWIN and HWIN. AI is represented by the equation:

$$AI = \frac{\% CWIN - \% HWIN}{\% CWIN}$$

The higher the AI value, the lower the amount of HWIN in the product. Nitrogen release will be more rapid from products having a lower HWIN content. UF-type fertilizers should have an AI value of 40 or greater for satisfactory agronomic performance. In other words, 40 percent of the WIN must be soluble in hot water.

Nitroform has a 38-0-0 analysis, and about 70 percent of the nitrogen is WIN. It consists of equal fractions of CWSN, CWIN and HWIN. In soil incubation studies, 4 percent of Fraction I, 25 percent of Fraction II and 84 percent of Fraction III remained int he soil after 26 weeks (Kaempffe and Lunt 1967). The low efficiency or recovery of Nitroform nitrogen during the initial years of use is attributed to the slow mineralization or breakdown of Fractions II and III. It was predicted that mineralization proceeds at about 15 percent per week in the first two weeks and drops to about 1.5 percent per week in the fourth to sixth month for Fraction II and at a rate of about 10 percent per year for fraction III. Low recovery from Fractions II and III make it necessary to use higher nitrogen rates or supplement Nitroform with soluble sources during the initial years of use. Nitroform is available in granular (Blue Chip) and powder (Powder Blue) forms. The Powder Blue form is adaptable to liquid applications systems.

Scott's ProTurf methylene urea has a 41-0-0 analysis, and about 36 percent of the nitrogen is WIN. Approximately 55 percent of the CWSN fraction consists of short-chain methylene ureas. Only about 40 percent of the WIN is HWIN. The high percentage of CWSN provides for a rapid initial plant response yet still good safety characteristics and residual due to the varying degrees of solubility of the methylene urea polymers.

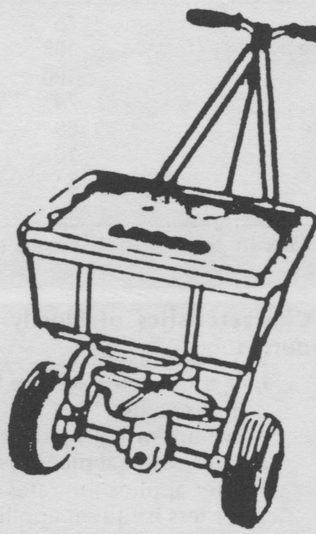
Fluf has a 18-0-0 analysis; about 20 percent of the nitrogen is WIN. It is described as a UF-type liquid suspension. Free urea and methylene ureas constitute the CWSN fraction. In Ohio tests, burn potential has been low and initial response has been slightly slower than quickly available sources.

Formolene has a 30-0-2 analysis and is described as a true solution (clear liquid) with zero WIN. Short-chain methylol ureas constitute the major organic portion of the product. It was ranked low in burn potential in Ohio tests, and the initial plant response has been comparable to quickly available sources. Further research is needed to provide information on the residual response of this material.

The UF-type fertilizers are dependent on microbial activity for release of nitrogen from the organic structure. The breakdown of the organic compound and the subsequent release of nitrogen as ammonium (NH_4+) is termed mineralization. The process is favored by adequate supplies of oxygen and water, soil pH near neutral and warm soil temperatures. Microbial activity occurs slowly at soil temperatures before 50-55°F and increases with soil temperature up to an optimum range at or near 100°F. Thus, the UF-type fertiliziers, like Nitroform, that contain appreciable quantities of WIN will not perform well during the cooler periods of the season when soil temperatures are low. Quickly available sources are usually applied alone or in combination with these UF-types during cool periods.

Natural Organics

The nitrogen in natural organic sources is contained in complex organic (carbon) compounds that are not readily soluble in water. The materials are predominantly byproducts of the plant and animal processing industry or waste products. Dried manures, seed meals, process tankage, bone meal and cocoa shell meal are examples of natural organics, but these materials have received limited use for turf fertilization. The natural organic source used most readily for turf fertilization today is activated sewage sludge. It is sold under the trade name of Milorganite. It is made from sewage freed from grit and coarse solids by aerating in tanks with microorganisms. The resultant organic matter is then filtered, dried, ground and screened. The material is stream sterilized to kill weed seeds and harmful organisms. In addition to nitrogen, Milorganite also contains significant amounts of phosphorus, potassium and many micronutrients. The commercially available product has an approximate 6-2-0 analysis and a WIN value of 5.5. Nitrogen release from natural organics is dependent on microbial activity for breakdown of the complex organic compounds. Initial plant response and residual response is considered intermediate between quickly available nitrogen sources and Nitroform.



IBDU

IBDU (isobutyledene diurea) is formed by reacting isobutyraldehyde and urea in acid solution. The resultant product contains 31 percent nitrogen, and 90 percent is water insoluble (WIN). The WIN portion of IBDU has a uniform composition, whereas UF-type fertilizers consist of various chain-length methylene ureas and free urea. The finished reaction product is screened into two sizes, 0.5-1.0 mm fine and 0.7-2.5 mm coarse.

IBDU has a low solubility in water. The conversion of IBDU to plant-available nitrogen is dependent on dissolution of IBDU molecules from the granule. This is considered the rate-limiting step in breakdown of IBDU. Following dissolution from the particle, the IBDU molecule is hydrolyzed (split) to urea and aldehyde. Urea is then converted to ammonium (NH_4+) by enzymatic hydrolysis.

The nitrogen-release rate is predominantly affected by soil moisture and particle size. Higher soil moisture and smaller particle size result in a more rapid release rate. Nitrogen release from IBDU is somewhat depressed at alkaline pH values, especially those near pH 8. Nitrogen release is independent of microbial activity. Thus, IBDU will release nitrogen much more readily than Nitroform and natural organics during cool weather. Nitrogen release is increased to some degree by higher soil temperatures.

Fall-applied IBDU provides an excellent turf quality response during the late fall and early spring. It has proved to be an excellent nitrogen source for use in late-season fertilization programs. Initial turf response from IBDU applications is usually slow due to low solubility and too high a WIN content. Once a threshold concentration of soil nitrogen is reached, turf response is usually excellent. Commercial formulations are available (e.g. Par Ex 24-4-12) that provide a certain percentage of free urea to enhance early turf green-up. With liquid applications, initial turf response from IBDU is more rapid due to partial breakdown of granules during agitation and pumping. The addition of 1/2 pound of nitrogen per 1,000 square feet as IBDU was found to be a lower limit for extending the residual response of quickly available sources in liquid programs (Street 1978). Two applications (spring and fall) of granular IBDU have given good results on both bentgrass and Kentucky bluegrass during the growing season at nitrogen rates of 2 to 3 pounds per 1,000 square feet (Waddington 1976).

Sulfur-Coated Urea

Sulfur-coated urea (SCU) is formed in a continuous-flow process by spraying preheated urea pellets with molten sulfur. A sealant coat of polyethylene oil or microcrystalline wax is then applied. Finally, a conditioner, consisting of diatomaceous earth or vermiculite, is added to reduce the stickiness of the sealant. Pinholes and cracks do develop in the sulfur coating of certain particles as they cool. The purpose of the sealant is to plug these defects, strengthen the sulfur shell and decrease the initial rate of urea release. Nitrogen content of commercially available products is in the range of 32 to 37 percent. These products usually contain a nitrogen:sulfur ratio of about 2:1.

Release of urea from SCU granules occurs through defects in the coating such as pinholes and cracks and through openings as the sealant and sulfur coat deteriorate. A certain percentage of granules contain major defects (i.e. pinholes and cracks) that are not covered by sealant coating. The granules empty rapidly when placed in water. This nitrogen fraction acts as quickly available or water-soluble nitrogen. The seven-day dissolution rate in water is commonly used to characterize the initial release rate (quickly available fraction) of different SCU formulations. Under laboratory conditions, 50 grams of SCU are immersed in 250 ml of water at 38°C and the amount of urea which enters the solution after seven days is measured. This amount, expressed as a percentage of the total urea content, characterizes each SCU product. For example, SCU-30 is a product from which 30 percent of the area is released under the seven-day dissolution test. A seven-day dissolution rate of 20-3 percent has proved acceptable for initial turf response when applied at rates of greater than 1 pound of nitrogen per 1,000 square feet.

Three general solubility classes of SCU are described within a product (Jarrell et al. 1979):

Class I. Granules with holes or cracks through the coating

Class II. Granules with holes or cracks in the coating that are plugged with sealant

Class III. Granules that have no holes through the sulfur coating

Class I granules act like quickly available nitrogen and release urea as soon as they contact moisture. Class II granules begin to release nitrogen as soon as the sealant is broken down or removed. Class III granules begin to release nitrogen as soon as the sulfur coating is penetrated. Temperature, soil moisture and microbial activity are all considered to play a role in the release of nitrogen from Class II and III granules.

The release of nitrogen from individual granules of SCU is described as "catastrophic release." Release of urea from granules is rapid once water gains access into the sulfur shell. Thus, slow availability of nitrogen from SCU results from many granules that release nitrogen at different times. Nitrogen is not released from all granules uniformly.

"Controlled-release soluble urea nitrogen" (CRSUN) is a term used on certain SCU fertilizer labels. The CRSUN value simply refers to the total percentage of nitrogen as SCU in the product. Another term, "controlled-release nitrogen" (CRN), refers to the amount of percentage of Class II and Class III nitrogen in the product. The CRN value excludes the Class I or water-soluble (seven-day dissolution) nitrogen fraction.

Nitrogen fertilizers available for turfgrass fertilization vary considerably in their chemical and physical properties. Fertilizer use should be based on the properties of the nitrogen source and on factors that affect release and availability of nitrogen from the source. Quickly available nitrogen sources release nitrogen rapidly to the plant, and best agronomic responses occur at low to moderate nitrogen application rates. Many of the slowly available nitrogen sources that have a high WIN content, like Nitroform, can be applied at higher rates and less frequently than quickly available sources. In fact, nitrogen sources that have a high WIN content usually provide best overall turf quality at higher rates per application than are traditionally used for quickly available sources. Generally, at least two applications per year are necessary for maintaining an acceptable level of turf quality. Many commercial formulations consist of both quickly available and slowly available sources. These fertilizer products attempt to include the advantages of both types. It is important to understand the differences in nitrogen sources and fertilizer products before making decisions on product, application timing and application rates.

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Does "Thirsty" Turf Make Noise?

Plants have been exposed to music in jest and in research Not too many years ago the University of Illinois exposed corn to sound for 18 hours per day without changing growth. Maybe it is time for man to listen to plants. Dr. E.L. Fiscus, USDA, has listened to noises made by drying plants. These sounds are in the 100 kilohertz range. Since the human ear hears in the 10 hertz to 20 kilohertz range, special equipment is needed to hear the sounds plants make as they become drier. The cells of the vascular system conducting water and nutrients from roots to leaves make minute, high-frequency noise when a deficiency of water causes fracturing in this pathway. Discoveries of this type stimulate many interesting questions for research and theoretical uses. Perhaps this could be used to activate a watering system at a precise time to the advantage of the preferred turfgrass species and to save water. Does this eliminate the need for an on-site agronomist? Scarcely! Things other than a shortage of available soil moisture can cause deficiency of water in the water conducting tissue. An agronomist would seem more important than ever to assume correct interpretation and treatments.

Management of Fungicide Resistance

Patricia L. Sanders, Pennsylvania State University

Fungicides can be divided into two groups according to where they act to protect plants.

I. Contact or Protectant Fungicides are those that stay on plant surfaces and provide a barrier against the fungi that cause disease.

II. Eradicant or Systemic Fungicides are absorbed by plants, and thus can work to protect plants from within, in the same way that antibiotics act to eradicate "germs" inside human bodies. Most systemic fungicides also have protectant properties in that they can provide barriers to fungi on plant surfaces. Systemics have the advantages of long residual action, protection of plant crowns and roots, movement within plants to protect newly-formed tissues, eradication of fungi already inside plants, and protection from washoff and weathering.

Chief disadvantage of systemics: resistance

The chief disadvantage of systemic fungicides has been the problem of resistance to these fungicides in many important turf pathogens. Resistance in fungi to systemic fungicides occurs because these fungicides generally poison fungi at only a single location in their growth and development cycles. It is, therefore, relatively likely that some individuals will be present in populations of disease-causing fungi that are able to circumvent or short-circuit the poisoned site. These individuals will be able to grow and increase in the presence of the fungicide. With repeated, continuous application of the same systemic fungicide, the naturally-resistant individuals in a fungal population will multiply until the population is composed primarily of fungicide-resistant individuals, and disease control fails. This has happened in countries all over the world where systemic fungicides have been used. In the U.S.A., most of the disease control failures from resistance to systemic fungicides have occurred on turfgrass. There are published reports of resistance control failures of Tersan 1991® on dollar spot, Subdue® on Pythium blight, and Chipco 26019® on dollar spot and pink snow mold.

Identification and development of new fungicides is costly and time-consuming. Therefore, we must learn to use systemics in ways that will prolong their useful lives. In order to prevent or delay fungicide resistance in populations of disease-causing fungi, it has been suggested that systemic fungicides should be alternated or used in mixtures. However, there are very few published research studies on which recommendations for preventing or delaying fungicide resistance can be based. Alternations will be effective in cases where the resistant individuals in the population are not as competitive as sensitive individuals. Thus, the population will fluctuate; the resistance component increasing when the resistance-prone fungicide is applied, and the more vigorous sensitive component increasing when the fungicide selection pressure is not present and the alternate fungicide is being used. Unfortunately, many times the resistant individuals in fungal populations are just as competitive and vigorous as the sensitive ones. In such cases, an alternating program will result in a steady increase in proportion of resistant members, until finally the population is predominantly resistant—a condition we are trying to avoid. In populations of equally-fit resistant and sensitive components, mixtures have been found to be effective in keeping resistant proportions stable in experimental populations.

Using fungicide mixtures

Assuming that fungicide mixtures are able to keep resistance levels stable in fungus populations, they must be effective in controlling disease. Obviously, we cannot use full rates of fungicides in mixtures, because to do that would increase financial and environmental costs. We need to be sure that reduced rates of fungicides in mixtures will give satisfactory field control of diseases. Field and greenhouse studies have shown that reduced-rate mixtures can give disease control equal to, and sometimes greater than, the additive control of the individual mixture partners alone at the reduced rate. Although much more research is needed, it appears that reduced-rate mixtures can give acceptable field disease control, as well as delaying problems with resistance.

There are several important things to consider when selecting fungicides for use in alternations or reduced-rate mixtures. First, only fungicides with different ways of controlling the target fungus can be used in alternations or mixtures to delay or prevent control failures resulting from fungicide resistance in fungal populations.

The three systemic fungicides registered for Pythium blight control (Banol®, Aliette®, and Subdue) have different modes of action, and, therefore, can be used in alternations or two-component, half-rate mixtures for resistance management and disease control. Three-component, third rate mixtures of Banol/Aliette/Subdue may also be effective for these purposes, but research to test this is not completed.

The broad-spectrum systemic fungicides that control other turf diseases fall into three groups according to their mode of action: the benzimidazoles (Tersan 1991, Fungo 50®, CL 3336®), the dicarboximides (Chipco 26019, Vorlan®), and the sterol inhibitors (Banner®, Bayleton®, Rubigan®). Any fungus that is resistant to one of the benzimidazole fungicides will be resistant to them all. The same is true within the dicarboximide and sterol-inhibitor groups of fungicides. Therefore, for resistance management, broad-spectrum systemic fungicides must be mixed or alternated *between* and not *within* groups. Systemic fungicides may also be mixed or alternated with any contact fungicide that will give the disease control desired.

In addition to mode of action differences, the length of disease control provided by mixture components must be matched to avoid resistance selection. If a short-residual fungicide is included in a mixture of delaying resistance, an interspray of the short-residual chemical probably will be necessary.

If they are available, it is probably much better to use systemic fungicides in mixtures for resistance management. The reason is that the turfgrass plant itself can "unmix" mixtures of contact and systemic fungicides. If you apply a

Calendar of STMA Events

September: Southeastern Sports Turf Institute; Daytona Beach, Florida. Contact Sam Newpher, Atlanta Braves (404) 522-7630. See information on page 25.

November: (November 18-20) Pro-show November 19, 1987, STMA Annual Meeting, Dallas Convention Center, Dallas, Texas. See information on page 31.

December: (December 9-11) North Central Turfgrass Expo. Sponsored by the Illinois Turf Foundation. STMA Seminar, December 10, 1987. Pheasant Run Resort, St. Charles, Illinois.

February: (February 6-8, 1988) Golf Course Superintendents Conference and Show, February 6, 1988. STMA Regional Seminar and Sports Turf Tour Institute Houston, Texas.

contact-systemic mixture, the mixture will be present on plant surfaces, but the systemic fungicide will be present alone inside the plant. As an example, in the case of a Subdue/Fore® mixture, Subdue alone will be acting against any Pythium that already has invaded the plant. For this reason, mixtures of systemics are safer for resistance delay than contact/systemic mixtures.

The management of fungicide resistance in populations of disease-causing fungi is an area where much more research is needed. Additive, synergistic, or antagonistic effects may be possible with particular fungicide mixtures. It is, therefore, important that alterations and mixtures of various fungicides be tested, both for disease control and for resistance delay, in as many use setting and turfgrass/-pathogen systems as possible.

There is much more we need to know about how we can best use systemic fungicides to avoid disease control failures from fungicide resistance in fungal populations. One thing is clear: we cannot safely use any systemic fungicide repeatedly and exclusively for disease control. Sensible and prudent use of systemic fungicides dictates diversity in chemicals used. Turf managers should be very skeptical of recommendations suggesting that any systemic fungicide can be used alone and continually without risk of resistance problems.

Getting Back to Backs

(continued from page 11)

go to a more frequent, light application schedule. The grower should experiment with different irrigation frequencies with the goal of irrigating as infrequently and as deeply (i.e. with a higher water quantity) as possible.

This necessitates knowledge of the plant's rooting depth which changes on a seasonal basis and depth of water penetration after irrigation. On most sites, there are indicator spots that first exhibit wilting - as evidenced by a bluish-green color; footprinting; or rolling, folding, drooping of leaves.

By observing these, a grower can obtain some guidance as to when to irrigate his site.

Rate of Application

It should be obvious by this point that the turf manager must know his soil texture, depth of plant root development, and how much water his system applies per unit of time.

For example, if the soil is a loam (Table 1), which the grower believes has an available water-holding capacity of 2.0 inches per foot of soil, and a turf with a 12-inch root system, he should apply 2.0 inches of irrigation when his plant starts to show wilt symptoms.

If by observing the soil a few hours after irrigation, he finds that water penetrated to 16 inches, then the rate of water should be adjusted to a lower one; perhaps 1.50 inches the next time.

By a little experience based on observation, the irrigator can determine the actual quantity needed for his specific soil. After a turf manager determines the quantity of water needed to replenish that lost by ET, he must know how long to run his irrigation system to apply this quantity. In the above example, let us assume that 1.5 inches of water is enough and that the irrigation system applies 0.5 inches of water per hour. Thus, the system must run three hours (1.5/.05) to obtain the total amount needed.

This quantity of water can be applied in different ways. If the soil has a good infiltration rate, above 0.50 inches per hour in this case, the water could be applied in a single three-hour setting. If the soil has a lower infiltration rate, the grower may wish to improve infiltration by cultivation or removal of excessive thatch.

On low infiltration soils, an automatic system can be programmed to apply water onto a site in two or three sequences separated by a few hours or even one day if necessary.

The first application in the sequence can be longer since soil takes water faster when it is dry; especially, if it cracks upon drying.

Of all the management practices that a turfgrass grower must do to develop a good turfgrass, irrigation is the most important. Yet, it is the most complex since the knowledge of each component of the soil-plant-atmospheric system is required.

The turf manager must truly think in terms of managing the whole "system" in order to achieve efficient water use.

STMA to Meet at Pro-Show STMA Annual Meeting

The Pro-Show is sponsored by the Outdoor Power Equipment Institute and will include between 80,000 - 100,000 square feet of exhibit space in The Dallas Convention Center. Outside demonstrations will be conducted on 20 acres of turf surrounding the conventions Center. In its first year, the Pro-Show will become one of the largest trade shows in the United States featuring a wide variety of power equipment for the commercial user - mowers, aerifiers, trenchers, de-thatchers, topdressers, edgers, chain saws, trimmers, etc. Also, chemical, seed companies and fertilizer manufacturers will be represented. STMA is one of the affiliated associations sponsoring seminars during the Pro-Show. The STMA seminar scheduled for Thursday, November 19, 1987 features a line-up of some of the biggest names in sports turf in the United States which address topics both current and relative to the Sports Turf Manager.

A sports Turf Tour is tentatively being planned either for November 18th or 20th. Possible areas to be visited include: Texas Ranger's Stadium, Dallas Cowboy Stadium and practice facility, the National Paralysis Foundation, Texas A&M Turfgrass Research Station, and a high school or municipal sports facility. More information will be forthcoming.

Seminar Schedule Pro-Show 1987

8:00 - 9:00	Sports Turf and Athletic Field Problems Dr. Eliot Roberts ...... The Lawn Institute Dr. Kent W. Kurtz .... Sports Turf Manager's Association
9:00 - 10:00	Selection of Turfgrasses for Sports Turf Warm Season Grasses ... Dr. Milton Englke Texas A&M University Cool Season Grasses ... Dr. Victor Gibeault University of California, Riverside
10:00 - 11:00	Soil Problems and Drainage Alleviating Soil Problems Dr. Paul Rieke .. Michigan State University Specialized Drainage David Heiss Turf Services Inc.
11:00 - 12:00	Ways and Means of Constructing Sports Turf and the Economic Implications Dr. Henry Indyk .... Rutgers University
1:00 - 2:00	Management of Sports Turf Around the World .... Dr. James Beard Texas A&M University
2:00 - 3:00	The Specifics of Managing Sports Turf in the United States ... Dr. James Watson, V.P. The Toro Company

To book special airline rates, call American Express Travel Agency, toll free, 1/800/626/2248, and identify yourself as a Pro-Show 87 participant.

To make room reservations in Dallas, call the Pro - Show 87 management office, toll-free, 1/800/654/0349, to request a pre-registration form. Special room rates, ranging from $55 to $85 for a single, have been arranged. Free shuttle service will link the show site at the Dallas Convention Center with the following hotels: The Ambassador Plaza, Bradford Plaza, Dallas Hilton, Dallas Plaza Suite, The Greenleaf Holiday Inn Downtown. and Sheraton-Dallas.

Photo Memories from the Midwest Sports Turf Institute

Left to right: Bill Wrobel, STMA 2nd Vice President; Dr. Kent Kurtz, STMA Executive Director; Randy Hundley, Keynote Speaker.

Trade Show

Left to right: Mark Hodnick, STMA Treasurer; Dr. Henry Indyk, Speaker; Steve Wightman, STMA President.

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