DiMascio also battled wind whipping around the fairways, which blew the seed off the soil and desiccated the turf when it started to sprout. On No. 15, he and his crew reseeded the fairway at least four times. When it came time to seed the front nine, DiMascio knew he had to do something to reduce the costs from what he incurred on the back nine. It cost the course $5,000 each time the crews had to reseed a fairway, Mabie says.

"It wasn't cost-efficient," Mabie says. "We tried to do an aggressive syringing program to keep it wet so the seed wouldn't blow away, but it didn't work."

DiMascio's inspiration for a solution came as he watched Tom Nichols, a former Firestone employee and president of Ohio Hydroseeding and Erosion Control, based in Rootstown, Ohio, hydroseed the course's native areas.

"I decided that if you could hydroseed the native grasses, why couldn't you use it to do the fairways?" DiMascio says. "The problem was that we wanted to seed the fairways traditionally to ensure the evenness of the grow-in. We had to figure out whether we could combine the two processes."

The solution

When DiMascio approached Nichols with his problem, the two created a program they thought might work. Instead of putting down a complete hydroseeding mixture, they decided to put down a hydromulch instead. That way, they could seed the fairways traditionally while still getting the ground cover necessary to keep the seed from washing away.

Though Nichols says he'd never done a project like that before, he thought it was a great idea when DiMascio proposed it. He then contacted Fairfield, Ohio-based Finn Corp., which manufactures hydroseeders and the products necessary to make the mix.

A typical hydroseeding mixture includes grass seed, mulch, polypropylene fibers (to hold the mixture together) and tackifiers to bond the mixture to the soil.

"We created a heavy slurry to put over the seed," Nichols says. "The only thing missing from the mix was the seed, which the club didn't need."

Nichols covered the front nine fairways with a one-eight inch slurry. He had a dual tank seeder and used the irrigation system's quick couplers to add the necessary water to the mixture. As he'd run out of water, Nichols would stop the hydroseeder, hook it up to the irrigation system and refill the tanks.

"Whenever you're hydroseeding, there's always a question about whether you're putting down an even layer of seed," Nichols says. "With this operation, you didn't have to worry about that, which made the job much easier."

DiMascio says the process took about six weeks last fall. Nichols covered each hole as the construction company finished it. Once the project was finished, all DiMascio could do was sit back and wait to see if his experiment worked.

Outcome

"I held my breath while I waited for the first fairway to come in, but I shouldn't have worried," DiMascio says. "The grass grew in nicely. It allowed me to get out far earlier with the first cut on the front nine than I'd been able to do on the back nine."

At $1,000 per acre, hydromulching the front nine fairways saved time, money and headaches, DiMascio says.

"Since we didn't have to keep reseeding the fairways after a rainstorm, it cost considerably less to finish the front nine," DiMascio adds. "The crew was able to work on other projects instead of constantly doing repair work. It worked out well."

Nichols says he would recommend the process to architects who want to open courses promptly.

"You can save so much time and lose a lot less seed if you use this system," Nichols says. "It's so smooth." ■

The front nine of the West Course grew in smoothly in eight months thanks to the hydromulching system envisioned by superintendent John DiMascio and Tom Nichols of Ohio Hydroseeding and Erosion Control.

Effective Grub Options Shrink

Preventative or curative plans depend on your locations

BY PAT VITTUM

White grubs (Japanese beetles, European chafers, Oriental beetles, Northern or Southern masked chafers) continue to be among the most challenging turf insects to manage in many parts of the country.

White grubs feed in the root zone, often 1 to 4 inches below the thatch, so it can be difficult to achieve good contact with traditional insecticides. Until about five years ago, there was a long list of insecticides that had been proven to be effective against grubs, but many of those materials have been removed from the turf market (or withdrawn completely).

Remember isazofos, ethoprop and fonofos? All were organophosphates that penetrated the thatch and reached the grubs, but they are no longer available. More recently some insecticides have been removed from the turf market as a result of the Food Quality Protection Act.

Chlorpyrifos and diazinon will be phased out of the homeowner market by the end of this year. Bendiocarb and isofenphos will be eliminated in the commercial turf market at the end of the year.

All of these products had what we call an intermediate speed of efficacy — they killed grubs within three to seven days after application and remained active for three to six weeks in most cases.

By 2003, we will not have any intermediate compounds available for use on grubs. That will leave us with two options — using a quick-acting insecticide like trichlorfon to control grubs curatively or applying a slow-acting material preventively.

There are two slow-acting and relatively long-lasting materials currently on the market, and there are additional products in development that will have similar properties. Imidacloprid is a nerve poison that often takes two or three weeks to start working but remains active for as much as four or five months, at least the first time it's used.

Halofenozide is a molt-accelerating compound (a form of insect growth regulator that only affects white grubs and some caterpillars). It sometimes takes two weeks to start working and remains active for as much as two or three months.

While halofenozide and imidacloprid are most effective when they are applied preventively, they can be justified in an integrated pest management (IPM) program because they are more environmentally friendly than older compounds.

An IPM program normally is based on scouting the property and documenting the presence of an insect problem before applying an insecticide. When turf managers had access to the intermediate products, such an approach was appropriate and relatively easy to accomplish.

Beginning in 2003, however, they'll only have one purely curative product in their arsenal. Trichlorfon kills grubs quickly — often within two or three days after application — but it normally breaks down within 10 days.

Therefore, it's an ideal profile for a clean-up material, and people managing turf with a history of grub activity probably should keep some in stock to spot treat areas as needed.

Although synthetic pyrethroids also work quickly they are relatively immobile once they enter the soil. Therefore, it's virtually impossible to get them through the thatch layer to the root zone. Those limitations mean that class of chemicals are seldom recommended for grub control.

So what is the best approach to take — curative or preventative? There is no simple answer — each turf setting has its own conditions. The timing of the applications for either approach depends on location and the species of grubs present.

In general, either approach can be effective, as long as the application is appropriate for the material, and the product is irrigated in as soon as possible after application with at least .1 inch of water.

Vittum is a turfgrass entomologist at the University of Massachusetts in Amherst, Mass.

A PRACTICAL RESEARCH DIGEST FOR TURF MANAGERS

TURFGRASS TRENDS

Section II • Volume 11, Issue 8 • **August 2002**

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WATER MANAGEMENT

Science of Surfactants Explains Their Usefulness In Managing Water Use

By Kathleen Conard

Turf managers must employ proper watering techniques so that plant roots receive adequate water and nutrients, and so that turf management chemicals are distributed uniformly to derive maximum benefit. The challenge is to ensure this is done in an environmentally responsible way and without wasting water or over-applying chemicals. Unfortunately, the complex characteristics of water and soils make it difficult to meet these challenges.

Water repellency in soils is caused by a range of hydrophobic organic materials that form non-polar "coatings" on soil particles.

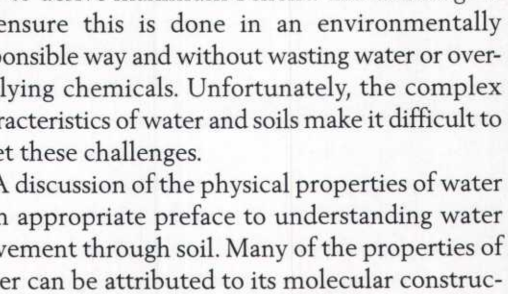
A discussion of the physical properties of water is an appropriate preface to understanding water movement through soil. Many of the properties of water can be attributed to its molecular construction. The two hydrogen atoms and single oxygen atom of water are held together by a strong covalent bond.

Although the water molecule is electrically neutral (i.e. non-ionic), the geometric configuration of the covalent bond of water creates a molecular structure for the entire water molecule, with oxygen having a partial negative charge and each hydrogen having a partial positive charge.

This uneven distribution of charge within a bond is known as a dipole, and the bond and the molecule are said to be polar.

Since opposite charges attract, the hydrogen region (positive charge) of the water molecule is attracted to the oxygen region (negative charge) of other water molecules or negative sites on soil molecules. This attraction is called hydrogen bonding.

FIGURE 1



Understanding the polar nature of water and the attraction of its hydrogen region to negative regions of other molecules (including negative sites on soil surfaces) helps explain what happens to water when it is applied to and moves through the soil.

AN ADVANSTAR ★ PUBLICATION

IN THIS ISSUE

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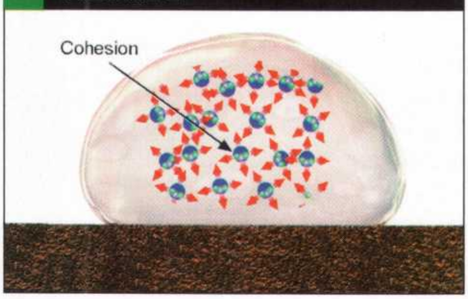
Water normally occurs in nature as a liquid. This fluid state of water exists because individual molecules bond to each other through intermolecular polar attraction and hydrogen bonding

Cohesion

Within a water droplet, water molecules move toward each other constantly. Each water molecule is subject to attractive and repellent forces from nearby molecules that, on the average, are distributed in all directions. This strong attraction between water molecules is defined as cohesion. Cohesive tension determines the amount of water that is attached to surfaces, collects in pore spaces, or moves through the soil.

Any time water molecules located on the boundary of the fluid come in contact with a dissimilar solid, liquid or vapor, their properties can be different. Forces that alter or influence intermolecular attractions on water's boundary are called interfacial tensions.

FIGURE 2



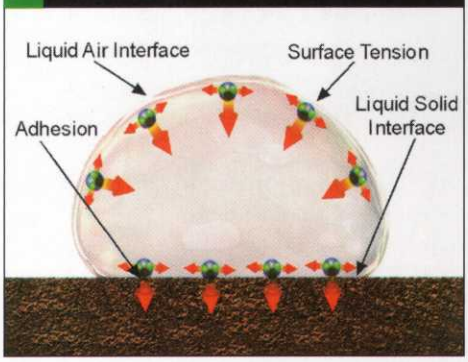
When water comes in contact with the air, only half of the surrounding space is occupied by other water molecules. This requires a new arrangement of the intermolecular forces to hold the surface molecules in place.

Since air contains no polar entity to move toward, water molecules at the surface tend to bond to each other. This inward movement of water molecules at the liquid-air interface is known as surface tension. Surface tension causes water to "bead" on a surface rather than spread out. Surface tension also has a great deal to do with the ability of water to infiltrate pore spaces, either at the soil surface or within the soil.

If the size of the water droplet exceeds pore space size, penetration and infiltration of water into and through the soil may be restricted.

When water comes in contact with a solid surface (liquid-solid interface), the polar attractive forces between the water molecules and the solid surface (adhesion) will dictate the attraction of the water for the solid. Water molecules at the liquid-solid interface will attach to surfaces containing polar sites through hydrogen bonding (hydration).

FIGURE 3



Adhesive tension is associated with the hydration or "wetting" of a soil. When adhesion exceeds the attraction between individual water molecules (cohesion), water will spread out on the solid surface.

When a surfactant is applied to the soil, the hydrophobic (non-polar) end of the surfactant attaches to the non-polar water repellent site on the soil particle.

Water repellency

Researchers generally agree that water repellency in soils is caused by a range of hydrophobic organic materials that form nonpolar "coatings" on soil particles. Decomposing plant materials, microbial deposits, organic acids and fungal hyphae have been identified as possible sources of hydrophobic organic materials.

When a soil particle coated with these

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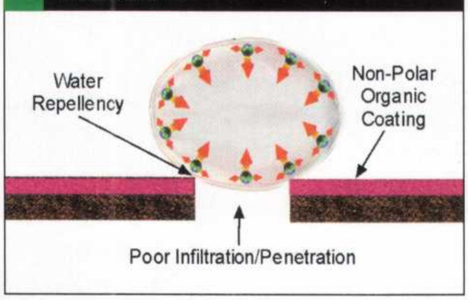
hydrophobic organic materials becomes dry, the normal polar characteristic of the soil is changed to a nonpolar surface.

Water molecules, because of their polar nature, aggregate towards other polar molecules rather than the nonpolar sites of water-repellent surfaces. Therefore, since there is no polar entity to move toward, water molecules at the water boundary tend to move inward toward the bulk of other water molecules. This is the molecular basis of water repellency.

The scientific definition of water repellency is described as a condition where the adhesive polar forces at the water/solid interface are less than the cohesive force of water.

FIGURE 4



Water repellency in soils can result in a number of problems caused by poor water movement patterns. The most obvious effect of water repellency is a reduction of infiltration rates. Additionally, hydration and distribution of applied water and input chemicals can be irregular and incomplete. Turf decline, localized dry spots, poor drainage and nonuniform turf quality have also been linked to water repellency in soils.

Water repellency is often viewed inaccurately as a condition that:

- occurs only in a limited number of soils;
- impacts small areas only (i.e. localized dry spots); and
- occurs at the surface of the soil.

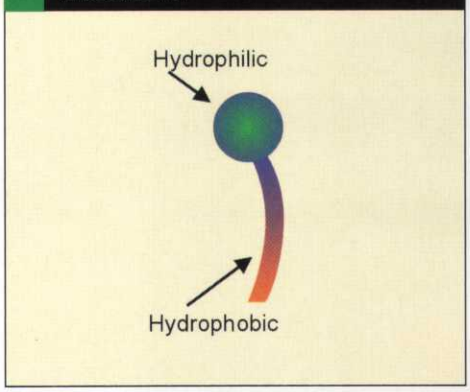
After years of investigation, soil scientists now describe water repellency in much broader terms. Water repellency is characterized as a condition that:

- occurs to some degree in the majority of soils;
- can have an impact on water movement to large areas of the soil, while visible detection is often limited to small areas; and
- occurs from the surface to depths that would include the root zone of most turfgrass varieties.

Role of surfactants

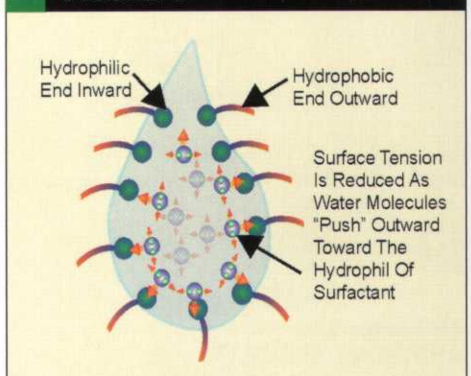
Research confirms that certain surfactants are effective in overcoming water movement problems associated with water repellency. Surfactants are chemical compounds whose molecular structure is well-suited to overcome both the water repellent characteristics of hydrophobic soils and poor infiltration of water due to surface tension.

FIGURE 5



A simplified model of a surfactant molecule is shown above to help explain a surfactant structure and mode of action. It should be noted the construction of a surfactant is quite complex. Although there is

FIGURE 6



similarity in the function of most surfactants, surfactant chemistries and/or their

Snow Mold Control

The long warm days of summer will soon yield to the crisp, cooler days of fall and the first outbreaks of snow mold will again appear as they seem to do every year. For golf course superintendents in northern areas, preparing for snow mold control can be a daunting task, whether they are making multiple fungicide applications under "no snow" conditions or one single application just prior to snowfall. The multitude of control products, fears of potential resistance, environmental constraints, and pressure from the golfing public or club members to have disease-free playing surfaces can make the design of a snow mold protection program a difficult assignment.

The snow mold free strips in the photo at left were treated with the Andersons FFII 14-3-3. Winter 2001 and 2002 Pullman, WA

Since control measures can vary, knowing the type of snow mold species prevalent at a particular site is a critical first step in designing a snow mold defense program. Pink snow mold (Microdochium nivale) occurs under snow but can occur the year around under non-snow conditions in locations where air temperatures are below 65 degrees F with persistent drizzle and fog. A distinguishing characteristic from gray snow mold is the absence of sclerotia. This disease is most severe where a thick thatch layer exists, nitrogen fertility is too high, the soil pH is above 6.5, and shade is prevalent most of the day.

Gray snow mold (Typhula spp.) usually occurs under conditions of prolonged snow cover of sixty days or more, and is most devastating with deep snow on unfrozen ground. Typhula incarnata is more prevalent and is favored by snow cover of two to three months and forms reddish brown sclerotia. Typhula ishikariensis has been seen in severe disease pressure areas. It is favored by snow cover of one hundred days or more and produces small black sclerotia. Typhula ishikariensis typically causes more damage and has proven to be more difficult to control. Gray snow mold is more severe with turf maintained at high nitrogen levels with excessive thatch.

Cultural controls should be a crucial part of a snow mold defense program. Some measures to implement should include: removing excess thatch, improving surface drainage, reducing shade, snow removal, using resistant cultivars, and avoiding lush growth in the fall.

A preventative fungicide program is the centerpiece of an effective snow mold control strategy. Granular products are easy to apply, especially in the fall when cold temperatures make using the sprayer more difficult. The Andersons FFII®14-3-3 (PCNB) was originally developed by The Scotts Company® and has been consistently rated as one of the top snow mold control products in university testing over the years, either by itself or when combined with another active ingredient for enhanced Typhula Ishikariensis control. For locations anticipating heavy gray snow mold pressure or long periods of snow cover, an application of Andersons granular Fungicide IX® (Thiophanate-methyl & Chloroneb) or Fungicide V® (Chloroneb) along with FFII is recommended. Applications are most effective when made just prior to snowfall or when soils have frozen. Repeat applications can be made if snow cover disappears during mid winter.

Under non-snow conditions, FFII or Andersons 10-0-14 with PCNB can be applied at the onset of periods of wet, overcast or foggy weather. A follow up application with Fungicide VIII, (Thiophanate-methy & Iprodione) Fungicide X, (Iprodione) or Systemic Fungicide (Thiophanate-methyl) within thirty days, followed by another application of FFII or Andersons 10-0-14 with PCNB have proven effective.

The Andersons continues to evaluate through an extensive yearly snow mold testing program, new prototypes, and new combinations of active ingredients with different granular carriers, with the goal of producing even more effective products in the future.

formulations may differ widely in their performance. The surfactant molecule is made up of a hydrophilic (water-loving) polar component and a hydrophobic nonpolar component.

Surfactants

When surfactant molecules are applied to soils with water as the carrier (i.e, through irrigation systems), the hydrophilic ends of the surfactant molecules are strongly attracted inward toward the water molecules. As a result, the surfactant molecules align themselves at the surface so their hydrophilic ends are toward the water and their hydrophobic ends are turned away from the water.

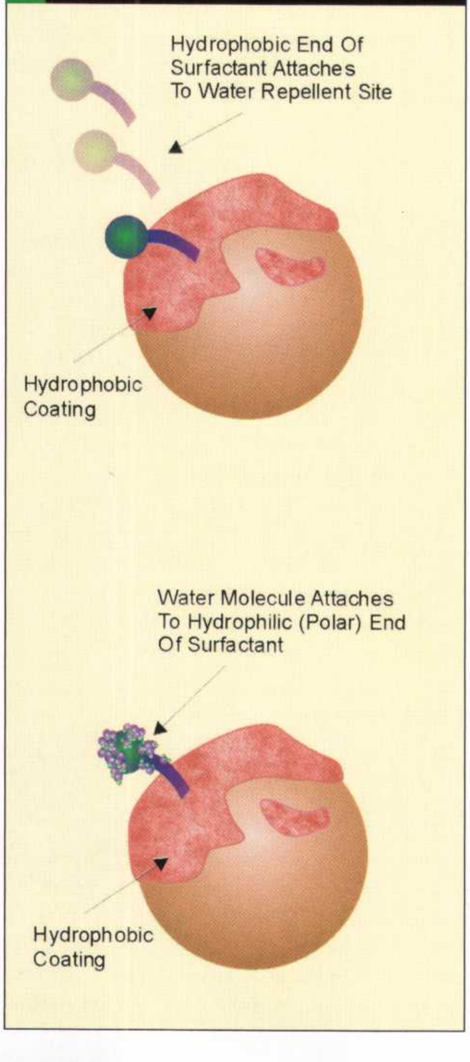
These outward forces at the air-water interface reduce surface tension and ease the infiltration of water from the surface into the soil.

When a surfactant is applied to the soil, the hydrophobic (nonpolar) end of the surfactant attaches to the nonpolar water repellent site on the soil particle. As water moves into and through the soil, individual water molecules are attracted to the polar end of the surfactant.

Water management is vital to turf health and growth.

Therefore, the polar end of the surfactant serves as an attachment site for water molecules, allowing a water-repellent soil particle to hydrate ("wet").

FIGURE 6



Surfactant selection

Not all surfactants are the same. The molecular construction of a surfactant can significantly influence the pattern of water distribution once applied to the soil. Surfactants differ widely in their size, shape, structure and molecular weight.

Each of these characteristics can influence how effectively water attaches to a water-repellent soil particle, the uniform distribution of water and chemicals, and the drainage characteristics of a treated soil.

A good surfactant promotes healthy turfgrass since water and water-soluble chemicals penetrate deeper and more uniformly into the rootzone even when water-repellent conditions are present.

Uniform distribution of water and chemicals encourages a deeper root structure, which means healthier, denser and more uniform turf surfaces.

Some surfactants allow superintendents to use less water and chemicals because little is lost to run-off, channeling or surface evaporation. Water and soil-targeted chemicals are available where they are needed — the root zone.

Kathleen Conard is marketing manager with Aquatrols in Cherry Hill, N.J. She has 15 years of experience in the turf and ornamental markets and has authored a number of articles for turf and horticulture trade journals. Contact her at kathy.conard@aquatrols.com.

Scientists Look For Ways To Improve Turf Evaluations

By J.S. Ebdon

Evaluating turfgrass quality is by no means an exact science. As it stands now, the NTEP results, which are based on Grand Mean scores averaged across three replications at different locations, are the most accurate way to predict how turfgrass cultivars will behave on your course.

As with all scientific endeavors, however, we in academia are always looking to refine our evaluation methods to produce even more accuracy than is currently available. That's why several different statistical models are currently being tested to see if we can improve on NTEP's accuracy even further in the next five years.

One such family of models that I, along with my colleague Hugh Gauch Jr. at Cornell University, consider to be more appropriate for NTEP data are Additive Main effect and Multiplicative Interaction (AMMI) models.

Why accuracy is important

Monthly performance data, which is collected by university and industry researchers and breeders, is summarized in NTEP Final Reports. These reports contain turf-quality data for each variety for trials repeated at many locations that are then evaluated over several years.

The data, derived from arithmetical means, are then used by turf-extension specialists in making recommendations on what turf varieties work in which parts of the country. The varieties that ranked near the top based on past performance using NTEP means, are then recommended for planting at specific locations.

It's assumed that using arithmetical means to summarize turfgrass performance provide the most accurate prediction of future performance, but statistical theory and recent research indicate otherwise. Arithmetical means are, in fact, less accurate than other options that will be at the disposal of turfgrass researchers as their methodologies are refined.

Accuracy is an integral part of agricultural science and research. Furthermore, accuracy is also important to the turfgrass manager because greater accuracy ensures more reliable prediction and better turfgrass recommendations.

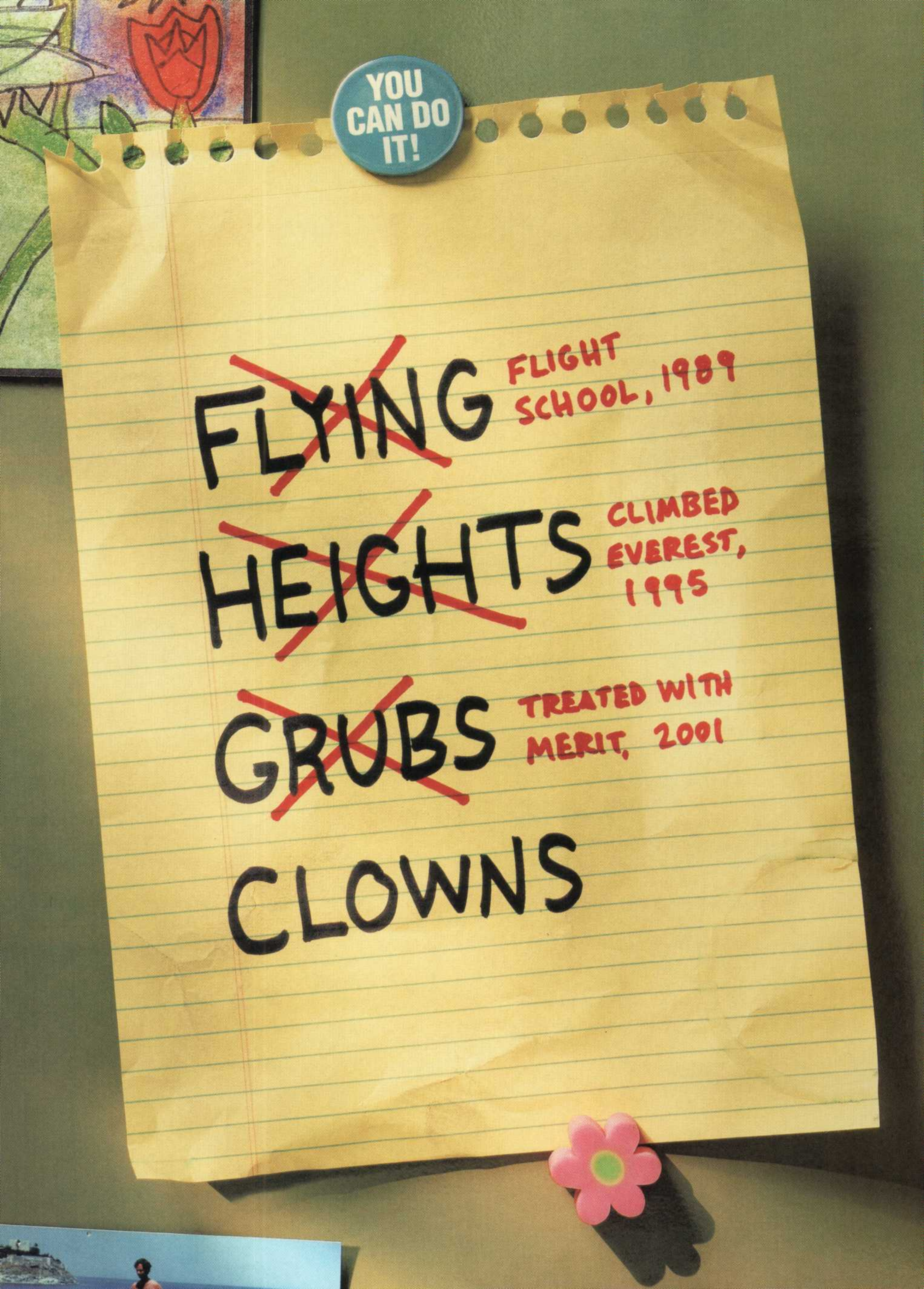
Therefore, predictive accuracy is important to both the science and management of turf. Improved accuracy can be achieved using different strategies, though some are economically more sensible than others.

Improving accuracy

The major purpose of NTEP variety trials is to provide accurate estimates of turfgrass quality for each varieties growing in different environments. The growing environment is represented by the various NTEP locations, which usually range between 20 to 30 depending on the test.

Since turfgrasses are perennials, the evaluation period is conducted over several years at each location. NTEP selects locations of diverse soil textures, pHs, cultural practices and climatic conditions to test genotypes in specific environments. By evaluating trials over several years, it's possible to capture information caused by year-to-year variation

> If NTEP wanted to double the accuracy of turf-quality estimates, co-operators would plant 12 replicates instead of the usual three. This strategy is neither economical for seed companies nor practical for investigators.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in the growing season. Consequently, genotypes are evaluated over many location-by-year combinations to account for as much information as is economically feasible to ensure the most reliable recommendations.

NTEP relies on raw means, observations averaged over replications, to estimate and to predict turfgrass performance for genotypes growing in different environments. Replication is used as the basis for quantifying the variety trials' experimental accuracy. Statistical theory tells us that the accuracy of a mean

AMMI predictions are more accurate because they use more data. Secondly, AMMI means are more accurate than the raw means because the analysis is able to partition out variations in the treatments.

to predict issues such as turf quality increases with the number of replications and is related to the square root of the number of replications (Snedecor and Cochran, 1989).

NTEP uses three replications for each variety to estimate turfgrass quality. Therefore, if NTEP wanted to double the accuracy of turf-quality estimates, co-operators would then be encouraged to plant 12 replicates instead of the usual three. This strategy, however, of planting four times the number of replicates is neither economical for seed companies nor practical for investigators.

Turfgrass quality is a visual assessment (1 to 9 scale, with 9 representing the highest quality) used by NTEP evaluators to measure turfgrass performance. Such evaluations are subject to the personal biases and preferences of the evaluator, which introduces variations into the measurements and reduces accuracy.

Additionally, differences can be caused by natural variation in soil texture or may be caused by nonuniform fertilization or irrigation practices. Variations are especially problematic for large NTEP trials. For example, it's not unusual for NTEP to evaluate at least 100 genotypes that are planted in 100 or more environments, resulting in 10,000 treatment combinations and 30,000 observations.

In such large research trials, variations accumulate rapidly and the pattern quickly becomes buried. Without such variations, all replicates would be identical, and turfgrass quality estimates for various treatment combinations would be exact.

Variations cause serious discrepancies between turf-quality estimates and accurate prediction of future performance. Near optimal predictions can be achieved then by minimizing variations to their lowest possible levels. This gain in accuracy by variation reduction is independent of the gains in accuracy that can be achieved by increasing replications as described earlier.

The ability to reduce variations statistically was not possible in agricultural research

TABLE 1

Model accuracy in predicting future turfgrass performance (turfgrass quality): Validation results for the 1990 NTEP Kentucky bluegrass and perennial ryegrass trials.

	KENTUCKY BLUEGRASS TRIAL		PERENNIAL RYEGRASS TRIAL	
Model†	Statistical efficiency‡	Free observations§	Statistical efficiency‡	Free observations§
AMMI	2.05	27,169	5.60	101,844
Cell means	1.00	0	1.00	0

†Most accurate AMMI model compared to the cell means model (means averaged over replicates). NTEP bases predictions of future turfgrass performance using the cell means model.

‡Statistical efficiency is the gain in accuracy (in equivalent replications) afforded by the most accurate AMMI model relative to the standard NTEP model (cell means).

§Free observations are the required number of additional observations needed using the standard NTEP model (cell means) to achieve the same accuracy provide by the most accurate AMMI model.

TABLE 2

Summary of turf quality (TQ) differences between cell means (means averaged over replicates) and AMMI estimates for the 1990 Kentucky bluegrass variety trial.

	MODEL	
Statistic	**Cell means (NTEP model)**	**Adjusted means (AMMI model)**
Environments (no.)	69	
Winners (no.)†	29	18
Avg.. TQ loss (-) or gain (+)	-0.4‡	+0.3§
Maximum TQ gain	–	+1.4¶
Same winners	19 of 69 environments (27.5%)	
Different winners	50 of 69 environments (72.5%)	

†Total number of winners across all environments based on individual winning genotypes (top ranked within each environment) identified by a corresponding model (AMMI vs. cell means).

‡Average loss in turfgrass quality by choosing NTEP winners (based on raw means) over AMMI winners.

§Average gain in turfgrass quality by choosing AMMI winners over NTEP winners (based on raw means).

¶Maximum gain in turfgrass quality by choosing AMMI winners over NTEP winners (based on raw means).

until recently. It is important to understand that these gains in accuracy come at little or no cost to NTEP compared to the alternative strategy of increasing replications.

Assessing predictive data accuracy

The NTEP model considers as relevant data the mean of three observations for predicting the future performance of genotypes growing in specific environments. NTEP variety trials are replicated both in time and space, and therefore genotypes may be growing in 100 or more environments. However, the cell-means model does not consider this data to be relevant in predicting the future performance of genotypes growing in environments. Because the future is uncertain, it would not be good advice to bet on future performance based on only three observations while ignoring all other relevant data.

NTEP relies on the cell-means model that is simplistic, but is often complicated by noise. This method elevates some genotypes to a higher position and increases the number of winning genotypes unnecessarily, which complicates recommendations. There are, however, alternative statistical models that may be more effective in achieving NTEP goals by providing more reliable recommendations.

The AMMI models have advantages over ordinary cell-means models in that AMMI considers the entire data set to be relevant in predicting future performance by fitting a multivariate model to calculate its turfgrass quality estimate. Where the cell-means model uses a simplistic arithmetic mean that can be calculated with a hand calculator, the AMMI prediction of future performance requires millions of mathematical steps, which requires only a few seconds of microcomputer time. As a result, AMMI predictions are more accurate because they use more data.

Secondly, AMMI means are more accurate than the raw means because the analysis is able to partition out differences in the treatments, thus improving accuracy by variation reduction.

Because of this reduction, AMMI predictions are adjusted appropriately. The statistical principles underlying AMMI theory and gains in accuracy have been available as early as the 1960s. However, it was not until the introduction of high-speed microcomputers did AMMI theory become accessible for turfgrass research. AMMI gains in predictive accuracy have a strong and compelling theoretical basis, but this theory has also been validated by equaling convincing empirical evidence.

TABLE 3

Summary of turf-quality (TQ) differences between cell means (means averaged over replicates) and AMMI estimates for the 1990 perennial ryegrass variety trial.

	MODEL	
Statistic	**Cell means (NTEP model)**	**Adjusted means (AMMI model)**
Environments (no.)	60	
Winners (no.)†	34	18
Avg. TQ loss (-) or gain (+)	-0.4‡	+0.2§
Maximum TQ gain	–	+0.9¶
Same winners	6 of 60 environments (10%)	
Different winners	54 of 60 environments (90%)	

†Total number of winners across all environments based on individual winning genotypes (top ranked within each environment) identified by a corresponding model (AMMI vs. cell means).

‡Average loss in turfgrass quality by choosing NTEP winners (based on raw means) over AMMI winners.

§Average gain in turfgrass quality by choosing AMMI winners over NTEP winners (based on raw means).

¶Maximum gain in turfgrass quality by choosing AMMI winners over NTEP winners (based on raw means).

Predictive accuracy of AMMI vs. NTEP model

Raw data from the 1990 NTEP Kentucky Bluegrass test and the 1990 Perennial Ryegrass test were kindly provided by NTEP to test the predictive accuracy of AMMI vs. competing cell-means model used by NTEP.

In the Kentucky bluegrass data set, 25,875 observations were analyzed [125 genotypes in 69 environments over three replicates]. A similarly large data set was analyzed using the perennial ryegrass trial and included 22,140 GER observations (123 genotypes in 60 environments over three replicates).

The simplest and most effective strategy for assessing accuracy of various models is by data splitting resulting in two parts: modeling data and validation data. The modeling data is used to construct the model (i.e., cell means vs. AMMI) and in turn to estimate turfgrass quality. The validation set is used to assess accuracy. The data splitting into two parts is conducted by randomization for each treatment by selecting two observations for modeling and one observation for validation.

Randomization ensures each observation is given equal chance for selection. The model that comes closest to the validation set is the model that is the most accurate in predicting future performance.

For each data set (bluegrass and ryegrass), this validation procedure was repeated with thousands of different randomizations, so more than 8 million separate validation steps were performed. The results were then averaged. The AMMI gain in accuracy was expressed relative to the predictive accuracy of the standard model used by NTEP.

Estimates of variations in treatment showed that the bluegrass data set had approximately 33 percent differences while the ryegrass data set was 41 percent (Ebdon and Gauch, 2002). Further analysis also showed that AMMI was effective in removing most of these differences. Therefore, it provided more accurate data. To that end, Table 1 summarizes the gains in accuracy with AMMI relative to the competing cell-means model.

To achieve the same accuracy without AMMI, NTEP would have to double the number of replications from three to six for the bluegrass trial (AMMI statistical efficiency of 2, Table 1). Similarly for the ryegrass trial, the number of replicates would have to be increased by a factor of 5.6 (from three to 17 replications).

These gains in accuracy with AMMI come at no additional cost and are equivalent to more than 25,000 free observations for bluegrass and more than 100,000 free observations for ryegrass (Table 1). The cost over the

Scotts

QUICK TIP

One of the most frequently asked questions about Roundup Ready Creeping Bentgrass is, "How do I eliminate Roundup Ready Creeping Bentgrass if it ends up in my roughs?" Fortunately, the answer is simple: Use one of the other nonselective herbicides on the market today.

entire evaluation test to achieve the same accuracy by increasing the number of replications is equivalent to $271,690 (for bluegrass) and $1,018,440 (for ryegrass), assuming $10/observation/year.

As mentioned earlier, increasing accuracy by increasing the number of replicates is not free. Therefore AMMI offers a potential cost-efficient alternative. Furthermore, the AMMI gain in accuracy for the perennial ryegrass trial more than doubles the accuracy possible using the standard NTEP practice.

The cost over the entire evaluation test period to achieve the same accuracy by increasing the number of replications is equivalent to $271,690 for bluegrass and $1,018,440 for ryegrass.

To achieve maximum efficiency and accuracy, these studies suggest that priority then should be given to the more accurate AMMI prediction of turfgrass quality. Greater accuracy with AMMI implies better selection of superior genotypes and more reliable recommendations. Therefore, by giving priority to AMMI winners over raw data winners increases in turfgrass quality would be expected by planting AMMI winning genotypes.

Tables 2 and 3 summarize turf quality differences between the various models for the 1990 Kentucky Bluegrass and Perennial Ryegrass trials. These gains in turf quality by planting AMMI winners over raw data winners shown in Tables 2 and 3 can be as large as .9 to 1.4 on a rating scale of 1 to 9. While these differences focus on winning genotypes identified by competing models, differences can also be found throughout the entire roster. AMMI estimates often lead to different ranking of genotypes within each environment (Figure 1).

For example, in the ryegrass trial (Table 3), the two models picked the same winners in only 10 percent of the 60 environments. Similar inconsistencies were also observed between models for the bluegrass trial (Table 2). Because variations increase the complexity of the data by increasing the number of winning genotypes, it's not surprising that the variation-rich cell-means model identified 1.5 to three times as many winners compared to the AMMI model (Tables 2 and 3).

So, which statistical model predictions are to be more trusted? The answer is AMMI, because:

- AMMI predictions are based on sound statistical theory;
- the theory is validated by compelling experimental evidence; and
- the AMMI results reported here with turf variety trials are consistent with results observed from yield trials (Gauch, 1992).

The next stage in this research is to conduct comparative studies in the field in order to validate these findings. Based on field validation studies from yield trials (Annicchairico, 1992), research indicates that AMMI winners should provide superior turf quality in comparison to those winners suggested by NTEP means.

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World-Class Soccer Fields Provide Own Challenges

By Tony Leach

In the wake of the World Cup, superintendents may wonder how world-class soccer fields are maintained and what they could learn from them. In truth, maintaining soccer fields isn't that different from maintaining any other high-impact turf in the public spotlight. That's certainly the case in England.

Professional soccer has been played in England since 1862 and is the national sport with a huge number of supporters. The popularity of the sport has grown over the past few years with the major soccer stars changing clubs for huge transfer fees and becoming national celebrities. English football is now dominated by European players with different, faster playing styles. Such expensive commodities have to be looked after carefully — injuries from a poor field are not acceptable.

Therefore, soccer requires a surface where the ball can run evenly across the surface without deviation or bounce and where players can run at pace without fear of leg joint, ligament or ankle injuries from an uneven or unstable surface.

The pitch also needs to have a healthy, vigorous grass able to withstand heavy wear-and-tear and be able to recover quickly from the effects of cleats.

In the United Kingdom, the soccer season begins in August and ends in May. Therefore, preparation starts in the late summer and will often involve the application of an iron-based fertilizer to toughen the grass and give it increased resistance to disease.

Irrigation will be required to assist the absorption of the fertilizer into the soil and to prevent scorching. Timing is important to ensure that the flush of growth coincides with the beginning of the playing season to establish the required turfgrass height of 1 to 2 inches. Once achieved, this length is maintained by topping the grasses with the available mowing equipment. The erection of goal posts is left as late as possible to make mowing easier.

As the season progresses into the winter months and the soil becomes colder, wetter and more compacted, the surface must be kept open and free draining. Although the grass plants never stop growing, growth will slow considerably during the winter, resulting in the reduction of nutrient and moisture uptake and reducing the ability to resist stress factors such as wear and tear, frost damage and disease infestation. To keep the grass as healthy as possible, dethatching and aeration is carried out regularly.

Thatch removal carried out at the end of the summer will remove debris such as decaying grass clippings, stolons and rhizomes. Where large amounts of thatch are removed, the surface has to be cleaned with a sweeper if the de-thatcher does not have a collector.

There is a wide range of equipment available to carry out the important task of aeration to get air, water and nutrients down to the roots. On heavy soils it's unwise to use deep slitters after Christmas as the slits may open up as the drier, warmer weather approaches. Where there is severe compaction, it may be necessary to consider deep vertical-action aerators or the use of sub-soiling equipment.

Spring is the time to prepare for end-of-season renovation. It's important to be on the lookout for pest and disease infestations. Herbicide applications must not be left until too late into the summer and weeds must be caught before they have the chance to seed.

It's essential that there should be plenty of moisture in the soil and sufficient time for overseeding and the re-establishment of a dense field.

If a good aeration program has been carried out throughout the playing season, there should be no need for extensive spiking. However, if this is not the case, the field must be spiked thoroughly to relieve surface and deep compaction problems. This is also the time to correct surface levels.

The field can be renovated in a number of ways, depending on the degree of wear. Lightly worn areas can be raked to form a seed bed, and a lime-free sand topdressing can be applied to the surface and worked-in after overseeding. Where extensive remedial work is necessary, then a loam topdressing will be required. Seeders are available which renovate the surface and apply the seed simultaneously.

To ensure successful establishment of the new seed an application of spring/summer fertilizer may be considered following soil analysis to determine any nutrient deficiencies. Mowing and aeration continue to keep the surface open and control any weed infestations even during the summer, when most soccer fields are closed.

Over recent years, climatic changes have led to wetter, warmer winters in the United Kingdom, bringing the groundskeepers further challenges and a greater need for improved surface and soil water drainage.

There has also been a steady increase in pest and disease infestations. In addition, there are ever more incidents of previously unknown virus and nematode infestations in the United Kingdom.

Ever-increasing demands are put on groundskeepers to provide first-class facilities for extended periods beyond the usual end of season and prior to a new season to accommodate preseason training and fitness regimes. This has resulted in seed companies researching new grass cultivars, and, in some cases, new species, to provide increased wear tolerance, disease resistance and earlier establishment at lower temperatures especially useful for late autumn renovations and repairs.

The United Kingdom has probably the longest soccer season and the greatest number of matches of any soccer-playing country. U.K. groundskeepers relish any challenge put before them.

Tony Leach is an independent turf consultant. He's a former lecturer in turfculture at Hadlow College in Kent, England.

In a Word — Resourceful

Superintendents put spreaders to many uses

BY PETER BLAIS

Versatility is the name of the game as superintendents seek chemical spreaders that will both apply a variety of materials and are easy to use, according to manufacturers.

Groundscontrol Products manufactures spreaders for fertilizer, seed, lime, chemical, salt and sand applications, says company President Larry Middleton.

"Superintendents are looking for something that will do a light topdressing, but also an all-around machine that can do other things," Middleton explains. "They use it to spread fertilizer and seed in the summer. But then in the winter, they can use the same machine to spread a sand/salt mixture as a de-icer for their parking lots and driveways."

Groundscontrol Products manufactures the TB750, a 750- to 1,000-pound capacity machine. It also makes a 300-pound capacity machine, and Middleton says the company can manufacture machines with other weight capacities.

Middleton says superintendents have asked about using the TB750 for applying compost.

"This machine will spread anything that is dry-flowable," he says. "We offer vibrators to go with it if the material is damp. We also offer screens to break up the material and give it some air-dry time." The units range from $525 to $1,700.

Monroe Tufline makes two pull-behind spreaders, the SB150 and SB300, with 300-pound and 600-pound capacities, respectively. Larger-capacity models can be special-ordered. Both ground-driven units can broadcast materials up to 35 feet to the right and to the left, or 17.5 feet in both directions at the same time, says Nick Tarlton, Monroe Tufline's marketing research and development manager. The units come standard with a 1 7/8-inch ball hitch, although different-sized hitches are available.

Originally designed for seeding and fertilizing, the SB series can also apply gypsum or lime during the growing season as well as salt and sand on roadways during the winter. It works best with granulized and pelletized materials and less well with powders.

"It has a system so you can disengage the gear box and the only thing that turns are the wheels," Tarlton explains. "That's helpful if you need to travel a good distance around the course. The disengagement mechanism is activated by a pull pin and results in less wear and tear on the unit. The agitator, agitator plate and gear box lie still. Only the tires move. If you have fertilizer in there, you don't want something turning the whole time you are transporting that material."

The disengagement unit was the result of Tarlton's surveys of superintendents. Those investigations also revealed superintendents' desires for a mechanism to open and close the hopper from the driver's seat, something Tarlton expects to be available on Monroe Tufline products in 2003.

Efforts to minimize chemical use by increasing organic materials has led many superintendents to begin using Turfco spreaders to apply everything from composts to organic fertilizers, says Turfco Vice President Scott Kinkead.

"In some countries, they've banned the use of chemicals [on courses] entirely," he says. "Superintendents we've talked to [there] are trying to get the same results using organic materials. Our Mete-R-Matic models, with the patented chevron belt, are being used for a variety of compost applications. Superintendents also use them for lime, gypsum, crumb rubber and compost sludges."

Turfco unveiled its chevron design in 1993.

"Traditionally, spreading a solid, wet material or one with organic qualities has been difficult," Kinkead says. "The chevron design allows superintendents to apply wet materials."

Peter Thompson, Lesco's senior product manager for equipment, says the company has traditionally sold three types of spreaders: push/rotary, push/drop and Vicon pendulum spreaders. Lesco's rotary spreaders have 80-pound-capacity hoppers and are overall general-purpose spreaders. Drop spreaders work best for fertilizing or overseeding applications on greens and tees. The pendulum spreaders come with 600- to 950-pound capacities and work best on larger turf areas, like fairways.

Lesco introduced a new rotary drop spreader this spring, Thompson says. The Lesco Roto/Drop Spreader is a combination rotary spreader with a drop panel in the rear. It is particularly suited to trim work and keeps materials falling on their intended targets.

Lesco also markets the Perma Green Supreme, a hybrid spreader/sprayer with a hopper for dry materials and a small tank for spraying liquid agents. ■

Blais is a free-lance writer from North Yarmouth, Maine.

CIRCLE NO. 116

Tips

Preparing for Sodding

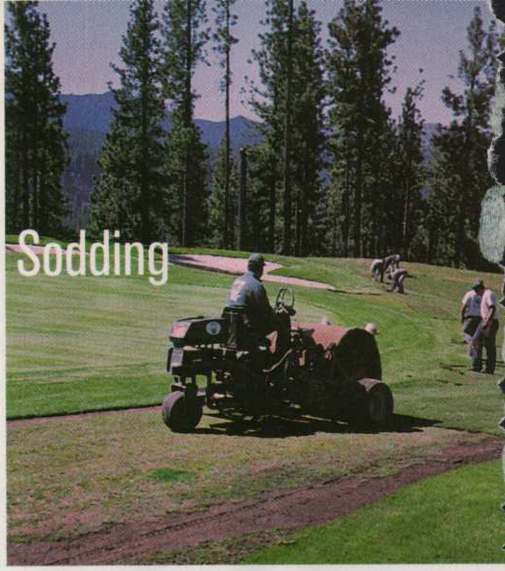

PHOTO COURTESY OF WEST COAST TURF

Experts offer basic but often overlooked pointers

BY LARRY AYLWARD, EDITOR

If you're planning to regrass those worn and torn sections on your fairways with sod, here are some pointers on how to prepare for the process from three experts — David Doguet, owner of Bladerunner Farms in Poteet, Texas; John Marman, Nevada operations manager for Palm Desert, Calif.-based West Coast Turf; and Dale Habenicht, president of H&E Sod in Momence, Ill.

Doguet, Marman and Habenicht admit some of their tips are basic. However, they agree their suggestions are often overlooked by superintendents and crews.

Irrigation plays a vital role in sodding — and from different standpoints. Before laying sod, Doguet says superintendents need to ensure irrigation systems are functioning properly.

"It sounds basic, but [a poor functioning irrigation system] can be a problem," he says. "You need to make sure your heads and pumps are working."

Sprinkler patterns also need to be checked and adjusted if they are out of sync, Doguet adds.

Superintendents should also irrigate the sections to be sodded beforehand to locate puddling areas and correct them with new or improved drainage.

Marman says soil should be irrigated about five minutes before laying sod so it's moist but firm. "That helps create suction to pull down the sod," he notes. "Then the soil underneath is not going to suck the water out of the sod."

Soil preparation is also an obvious but vital element that is sometimes overlooked. "In general, when we go to sites, we notice the soil hasn't been prepared properly," Doguet says.

Superintendents need to do a soil analysis, Doguet stresses. Then the soil

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pH needs to be corrected if it's too high or low.

Marman stresses how important it is for superintendents to attain the proper acidity or alkaline pH levels in soil.

"If you have an acidic soil, which a course would have in a high rainfall area, you incorporate lime into the soil to bring the pH up to an acceptable level, which is about six," Marman says. Lime contains calcium or magnesium, which neutralizes acidity, he notes.

Marman says soil in arid and low rainfall areas is more apt to be alkaline. He adds that superintendents can use sulfur to control pH. "When you're getting ready to resod a fairway or do any sod work where you've stripped out a large area, it's best to apply lime or sulfur and rototill it into the soil," Marman says.

The soil may also require a preplant fertilizer, Doguet notes.

Marman says superintendents should also use a steel drag mat to remove any imperfections in the soil. Rocks and stones should also be removed.

Weeds and invasive grass should be eradicated. If contaminated areas aren't sprayed before the sod is planted, weeds and invasive grass will grow rapidly because of heavy watering after the sod is laid, Doguet says. "If you do it beforehand, you don't have to worry about it after the grass is planted," he notes.

The bottom line: Don't rush preparations. "You want to take as much time as you can to prepare the soil and obtain the surface you want," Marman says.

Once the surface is prepared, don't wait too long to lay the sod or the prepared area could become recontaminated, Habenicht says.

Habenicht also notes that superintendents should lay sod soon after it's delivered because the sod could die.

"Sometimes they get a load of sod and think it's going to keep for several days," Habenicht says. "The sod needs to be installed within 24 hours after it's received. It doesn't have a long shelf life."

There are also important things to do immediately after sod is laid, the experts say. Doguet says new sod should be watered soon after it's planted. Too often, crews wait until an entire acre of sod is planted before watering.

"You can lose a lot of grass that way," Doguet says. "You need to have someone with a hose to stay behind the planting. Watering manually until you can turn on your irrigation system is important."

Sod should be rolled as soon as it's laid. "That way you increase your sod to soil contact and take out any little pockets of air," Marman says. ■