gives the soil space to move in reaction to downward pressure.

Research by Dr. Robert Carrow of the University of Georgia and other researchers shows that core aerification provides the best means to soften soil and improve water and air exchange. Core aeration removes plugs of soil and leaves minimal compaction at the sides and base of the holes created.

Soil should be moist during core aeration to achieve proper penetration. Plan for a minimum depth of three to five inches. Soil cores may be removed from the surface or shattered and dragged back into the turf to control thatch. Because plugs of soil are removed, core aeration causes greater disruption to the playing surface than other forms of aeration.

Solid-tine (spike) aeration pokes holes in the soil without removing plugs. Compaction at the sides and base of the holes is a bit greater with this method, since the soil is packed into the hole rather than removed.

Solid-tine aeration can be very effective in reducing hardness and increasing air and water movement. Depths used for standard solid-tine aeration are similar to those of core aeration, but soil should be a bit drier to achieve better shattering and improve the overall effect.

Other aerating techniques are also available to handle particularly tough applications. Deep drilling, water injection, deep-tine, and shatter-core aeration can be used to reach deeper into the soil profile to penetrate deep layering situations.

It's important to keep cores open from the surface downward to promote positive air and water flow. If a hole is clogged for any reason, it may not function properly. In high-profile, high-visibility fields with close-cut turf, holes may be filled by topdressing with sand, sand-peat, a porous calcined product, or another suitable material to stabilize the hole.

Mix no more than five percent peat with the sand topdressing, even if the existing soil profile is 15 or 20 percent peat. By reducing the percentage of peat to about half of what's in the soil profile, you'll still be incorporating sufficient organic matter. You'll have a better infiltration rate, and it will be easier to filter the topdressing material into the holes.

Develop a comprehensive compaction-reduction program that incorporates prevention strategies, targeted compacted area maintenance procedures, and multiple aeration methods. Alternate your methods in accordance with causes of compaction, degree of compaction, field-use schedules, weather factors, and budgetary constraints. Problem areas might need an aeration schedule three times greater than the one used on the rest of the field. ❑

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Budgeting Nitrogen for Cool-Season Turf

by Jim Williams

Heavy applications of nitrogen (N) to cool-season turfgrasses can produce an attractive turf in the spring. Unfortunately, this outward beauty comes at the expense of the roots, and a fragile turf results.

While shoots may flourish under the influence of extra N in the spring, roots remain underdeveloped. Frequent irrigation becomes necessary during summer to keep the turf from deteriorating.

If you want to produce tough, economical turf, go easy on the N in the spring. Save most of the turf's yearly allotment of N for fall, when it will encourage maximum root development. The following chart gives an example of a productive budget allotment:

Timing	% of Annual N
March-April	12.5%
May-June	12.5%
July	-0-
August	25.0%
September	25.0%
October	-0-
November	25.0%

The actual amount of N the turf receives in a year will vary, depending on such factors as:

- *Turf species*: More N is needed for shorter-root species like Kentucky bluegrass, and less is needed for longer-root species like tall fescue.
- *Soil type*: More N is needed for sandy soils, less is needed for heavier soils with higher organic matter.
- *Water resources*: The more water the turf receives, the more N it needs.

Some turf managers may want to vary the percentages a bit. One option is to apply 30 percent of the yearly allotment of N between March and June, 40 percent from August to September, and 30 percent around November. Whatever the schedule, it's important to apply the bulk of the N following summer stress to ensure maximum root development.

Budget agronomics

The suggested budget represents a complete reversal of the practices turf managers used 20 to 30 years ago. N was often applied heavily in the spring and lightly in the fall.

That regimen worked well for a while, but over the years, the turf showed deterioration in late summer. Too much of the turf's carbohydrates were being expended in spring for shoot growth. Reviewing the ways in which turf uses carbohydrates throughout the year will demonstrate why a budget favoring fall fertilization works best.

Turf breaks dormancy in the spring, consuming carbohydrates as it grows. The roots develop first; they are capable of growing at slightly lower temperatures than shoots. When temperatures rise and shoots appear, the turf consumes large amounts of carbohydrates.

Turf produces as much green tissue as possible for photosynthesis. Proper photosynthesis, can replace consumed carbohydrates and store enough to nourish the turf for future months.

A light application of N in spring stimulates a balanced production of shoots and stored carbohydrates. If too little or too much N is applied, problems arise.

With too little N available, plants become chlorotic and incapable of achieving maximum photosynthesis. On the other hand, too much N exaggerates the plants' spring tendency toward shoot production. Too many carbohydrates are consumed during this growth, and not enough are stored. This produces a fine-looking turf, but it leaves carbohydrate reserves dangerously low.

In summer, cool-season turf growth

slows as the turf diverts its carbohydrate consumption to help it survive the stress of heat. If carbohydrate reserves are low at the beginning of summer, plants can totally deplete them before the heat abates, especially during severe years.

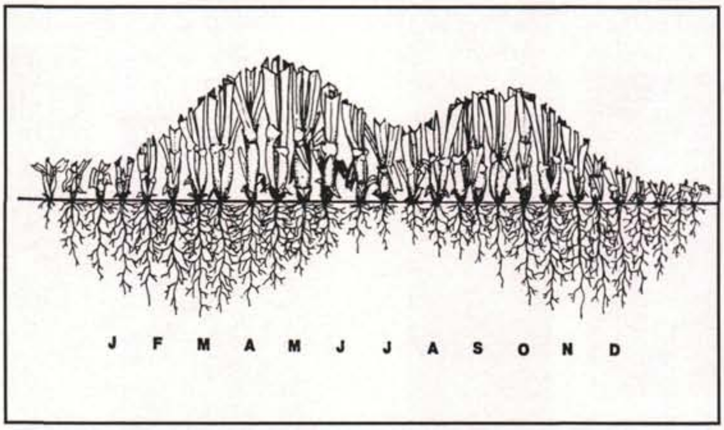
During most summers, frequent irrigation will relieve moisture stress, and quality loss can be averted. But in the long run, the turf is likely to encounter problems due to frail roots.

To help turf survive the stress of July, it's generally best to avoid using N applications, as they force plants to consume carbohydrates for growth. A light application of N in July is usually beneficial only if the turf shows signs of chlorosis.

As temperatures cool in late summer and early fall, turf emerges from its summer swoon. It begins consuming carbohydrates in a surge of growth that is similar to the development that takes place in the spring. However, it doesn't grow quite as high at this time of the year. The emphasis shifts away from expending carbohydrates for shoot growth, and plants begin storing the nutrients for the upcoming dormancy.

Now is the best time to fertilize low-budget sites that receive only one application of N per year. On most other sites, you'll want to continue to maximize storage of carbohydrates into late fall. A growing trend among turf managers calls for moderate applications of N between the last mowing of the season and the time when soil temperatures drop below the level required to sustain roots.

If you fertilize heavily in fall and lightly in spring, you'll help your turf build more massive roots. They'll come in handy throughout the year, and will better equip the turf to survive heat, traffic, drought, and other stresses. ❑



Between January and December, cool-season turf experiences two surges of growth—one in spring, and the other in late summer/fall.

Jim Williams is the former editor of sportsTURF. *He would like to thank Dr. Nick Christians of Iowa State University for inspiring this article.*

Aerate from the bottom up

The Aerragreen turf aerator works from the bottom up. Four narrow, hollow probes on 2-ft. centers are inserted 1 ft. into the ground. The soil is frac-

tured by up to 100 psi of air pressure, followed by a short blast of inert, nonbiodegradable, non-toxic polystyrene beads. The beads help relieve compaction and aid in the percolation of water, oxygen, and fertilizer.

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Improve moisture and nutrient retention

The natural capillary rise of FieldsChoice soil amendment improves moisture and nutrient retention in sports turf. Its naturally porous structure retains up to 63% of its weight in moisture and nutrients, and

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Lesco introduces the LA4800 heavy-duty, pull-type aerator. Designed to be tractor-drawn, it easily converts for use with a 3-point hitch. A heavy-duty weight tray allows opera-

tors to add as much weight as required to penetrate heavily compacted soils. Its 48 hardened-steel tines stretch 42 in. across, and cut holes 3/4 in. in diameter and 4 in. deep.

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Injector offers accuracy

The DI-16 injector from Dosatron International offers accuracy and reliability, while it remains simple to install and operate. With a maximum

flow of 11 gpm, the non-electric injector will dispense many types of fertilizers, nutrients, and chemicals at rates between 0.2% and 1.6%.

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Many tools in one

Toro's Sitework Systems centers around the Dingo, a 1,600-lb., 4-wheel skid steering, 42- or 33-in. compact utility loader. Its 2-pump hydraulic system delivers forces up to 3,000 psi. Sitework features more than 35 attachments,

including: auger bits, buckets, trencher, forks, backhoe, leveler, broom, cement bowl, concrete breaker, tiller, tree forks, and vibratory plow. Attachments fit on a specially designed trailer, and they install easily in less than a minute.

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Spike your turf

John Deere's 40-in. LT133 Spike Aerator penetrates 2 in. into the soil to relieve compaction and bring air, water, and nutrients to the root zone. LT133 features 132 galvanized-steel tine tips with 10-in. diameter tine stars spaced 3.5 in. apart. It has a weight capacity of 100 lbs.

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Humates in SportsTurf Management

by Michael DePew

Applied humates, humus, and humic substances are gaining popularity for use in turfgrass systems. While their use is not restricted to turfed areas, many turf cultural problems may be alleviated through application of this material. Interest in organic humates has been growing, fueled by public concern for the environment, and the desire to reduce the potential polluting effects of chemical fertilizers.

What are humates?

Humus generally refers to decomposed organic material. The term includes different fractions of organic matter, and any number of complexes formed by the reaction of chemical reagents with various organic substances. In natural systems, microorganisms play a vital role in converting organic material into humus.

The academic community defines humus as the fraction of organic material that contains no recognizable plant parts. It can be broken down into three distinct components: a humin fraction, a humic acid fraction, and a fulvic acid fraction. Older characterization schemes have also referred to an ulmic acid fraction.

Using a dilute sodium hydroxide (alkali) solution, it's possible to isolate the alkali-insoluble humin fraction of humus. From this solution of humic substances, the humic acid fraction can be separated by precipitation following an acid treatment. The acid treatment leaves a straw-yellow solution, or supernatant, over the precipitated humic acid fraction. This supernatant contains the fulvic acid fraction.

Humic substances, or humates, are colloidal in nature. In certain respects, they behave like clay minerals. Despite use of the terms humic acid and fulvic acid, humates are not true acids. These materials are acids only when their molecular exchange sites are saturated with hydrogen ions.

The composition of the various organic compounds in humates depends on both the original source of tissue, and the environment in which decomposition occurred.

Figure 1. This SEM image shows organic colloids taken from an undiluted liquid humate aliquot. The dark material in the right center of the micrograph is the organic particulate material that has formed on and around the precipitated salt crystals from the bulk solution.
Courtesy: Michael DePew

The humin fraction is composed of relatively long, cross-linked carbon chains that represent the final decay product. As such, they are relatively inert, and their reactivity in the soil is based primarily on their surface area.

The humic acid fraction has shorter carbon chains, and its high ion-exchange capacity makes it relatively reactive. This fraction is not normally soluble in water unless it is saturated with monovalent (single-charged) ions such as hydrogen, potassium, and sodium.

In sodic (high-sodium) soils, humic acid dissolves and forms a black organic crust (black alkali) on the soil surface. A secondary growth of algae sometimes develops on this black crust.

The fulvic acid fraction has the shortest-chain carbon compounds of the three divisions of humates. They are generally soluble in water.

How do humic substances work?

Humates help convert essential elements into forms available to plants. Many interdependent physical, chemical, and biological (microorganism activity) processes contribute to this function.

With its low molecular weight (short carbon chain), the fulvic acid fraction plays a vital role in plant-membrane permeability, nutrient chelation, and growth stimulation through auxin-like reactions.

Numerous reports have documented the auxin-like effects of humic substances. Auxins are plant hormones that stimulate growth. Humates promote growth as well, by increasing seed germination and aiding seedling establishment.

The humic acid fraction provides a high ion-exchange capacity (both anion exchange and cation exchange). It provides a buffering capacity and increased water retention characteristics. The high adhesive and cohesive characteristics of this material are important to soil structure and aggregate stability.

The humic acid fraction also allows fulvic acid fraction compounds to become liberated as decay products via microbial activity. The liberated compounds are then available for reaction within the plant-soil medium.

Plants have a biochemical mechanism to transport nutrients across cell membranes at the soil-solution root interface. They exude certain ions and protons (hydrogen ions) to set up an electrochemical field that attracts other ions to the plant cell surface.

Once attracted to the surface, nutritional elements may be taken into the plant passively through ion-specific channels in the cell membrane called ionophores. Nutrients may also enter the plant through the active process of binding to an intrinsic protein molecule that is imbedded in the cell membrane.

Once nutritional elements bind to an intrinsic protein molecule, the protein rearranges and releases them into the plant cell. The protein then reverts to its original form so that it's ready to rebind with elements on the cell exterior.

Some researchers have implied that the presence of intrinsic-type proteins in the fulvic acid fraction creates the observed increase in membrane permeability. They speculate that these proteins become embedded in the cell membrane, and function like cell-manufactured protein.

It's also possible that membrane permeability increases due to increased microbial activity caused by the production of intrinsic protein molecules. If humates promote microorganism activity and a large turnover in microbes, then perhaps some of these types of intrinsic proteins found within the cellular membrane of microorganisms are released by the decay of microbes, and are then available for imbedding into plant-cell membranes.

Chelating agents are also known to be found within the fulvic acid fraction of humates. These are organic molecules which preferentially hold certain elements. Chelating agents hold these elements until triggered to release them.

Plants trigger this release of needed elements near the soil-solution root interface by the same exuding of protons and other ionic compounds that sets up a plant's electrochemical field.

How are humates used?

The value of adding organic material to soil has been recognized by growers since prehistoric times. However, scientists remain divided over the subject of organics today. Debate continues to question the chemistry and mode of action of these substances.

Until Liebig (1862), it was thought that plants used humus directly as a nutritional element. Liebig's work showed that plants assimilate carbon from the atmosphere (CO_2), and that growth can be made dependent on inorganic compounds in an inert environment.

Since that time, many soil scientists have only viewed organics as fertilizer that releases plant nutritional elements into inorganic forms upon decomposition. Additional roles of organic matter—in soil aggregation, water-holding capacity, and cation-exchange capacity—have been better understood by soil scientists in this century.

Humate use has long been promoted in agriculture and horticulture, but mostly by uneducated and uninformed investor-promoter types and scam artists. This has helped reduce humates to the level of snake-oil remedies. In the past, poor quality control, poor processing methodologies, and use of untested natural deposits of humic materials contributed to unpredictable and contradictory results of humate use. This helped validate the negative perception.

Humic materials used in the past were often derived from coal, lignite, leonardite, or well decomposed (concentrated) peat. One must realize that the characteristics of these materials may vary greatly over an area and with depths of burial. As such, areas of a deposit may contain varying concentrations of both humus content and trace minerals. In some instances, the humic materials may be saturated with elements that could be released in toxic amounts when placed in the plant-growth environment.

The environment in which organic material decomposes also influences its final characteristics. Humic substances derived from anaerobic digestion processes are generally higher in the inert humin fraction. They are less reactive than those humates derived from aerobic digestion.

How can humates help turf?

In the turfgrass industry, humates are being marketed as aids for reducing thatch and salt effects in the soil. Humates do increase microbial activi-

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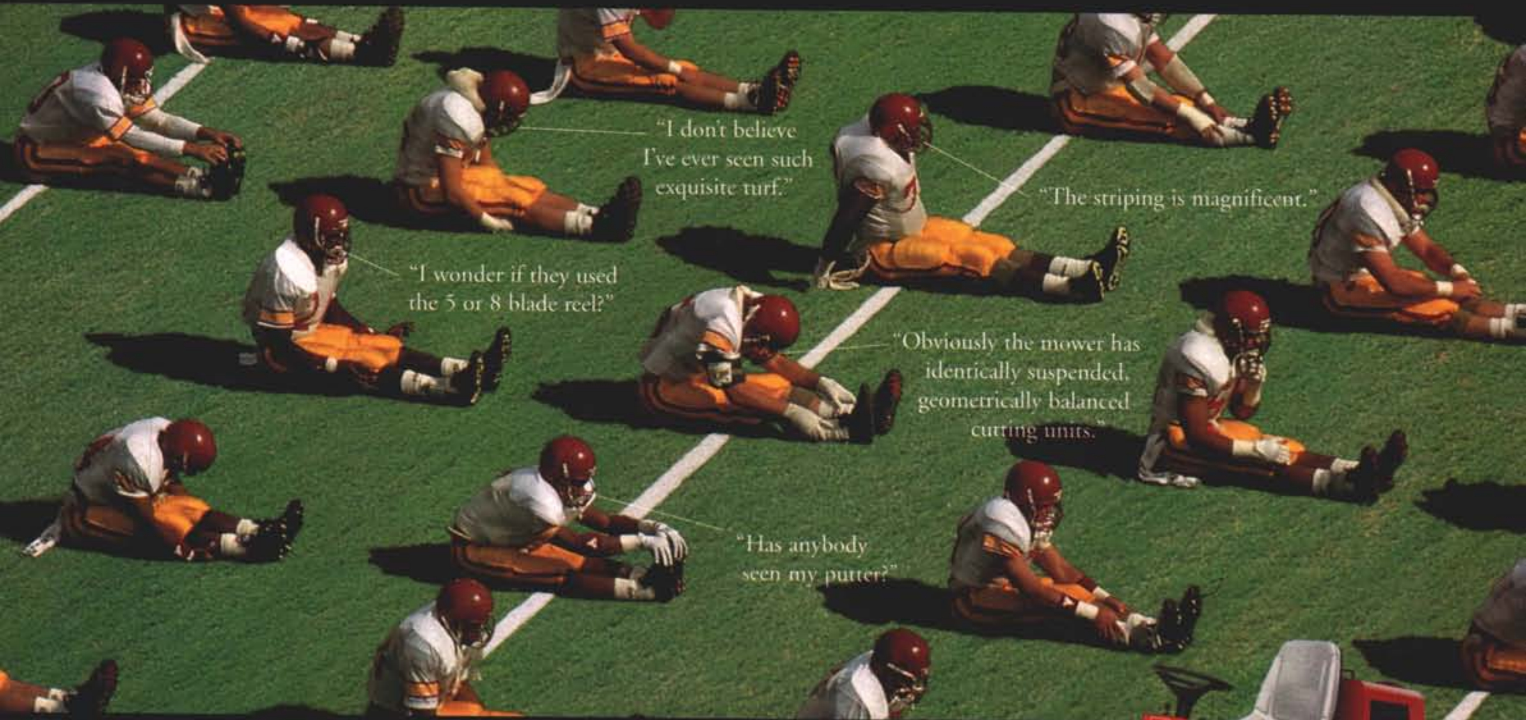

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ty, which hastens the microbial breakdown of thatch constituents. Further, humates increase cation-exchange characteristics and anion-exchange characteristics, which may put excess salt ions onto exchange complexes. This effectively "cleans" the salt from the soil solution.

Humates have also been marketed for relief of soil compaction. However, any impact on soil compaction would have to come from improvement in soil structure. On an already compacted soil, humates will only contribute to significant improvements when combined with an aeration or cultivation operation.

As with all new products, sports turf managers should consider the reliability of the material before purchase and application. The marketing company should be able to provide credible scientific research and not just testimonials. Ask for an explanation of a product's mode of action. Insist on dealing only with knowledgeable and experienced sales representatives that have good reputations. Try applying the product on test areas before committing to blanket applications. ❑

Michael DePew is a consulting agronomist for ProTurf Environmental and Sports Turf Services LC, headquartered in Tekonsha, MI. He is also a principal in Environmental Turf Solutions, Inc. (ETS), and is co-chair of the STMA Technical Standards Committee. ETS specializes in management of turf and landscapes in saline environments. Michael can be reached via e-mail at proturf@itsnet.com.

Manufactured Humate

by Michael DePew

A liquid humate material called Huma Base has been manufactured and promoted as a fertilizer and soil conditioner. It is unique among humate products because it does not rely on secondary processing of natural humic materials for its production. Instead, Huma Base is produced by processing a raw plant-waste product by chemical digestion.

The raw material for Huma Base manufacturing is a byproduct left when sugar is extracted from molasses. This material features a very uniform composition. Applying a controlled regimen of acid digestion followed by alkaline stabilization produces a humic substance that is consistent and uniform in its characteristics and properties.

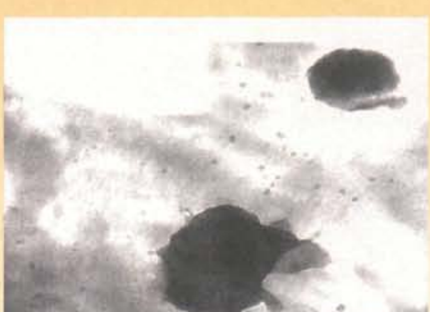

Figure 2. This TEM image shows the small colloidal nature of humates (less than two microns). The image depicts 45,000X magnification; the scale bar represents 0.1 microns. *Courtesy: Michael DePew*

We conducted developmental studies to determine the colloidal nature of Huma Base and to study its surface characteristics. We used both Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM) in this study.

First we verified the colloidal nature (less than two microns in size) by TEM, as shown in **Figure 2**. We then characterized the surface morphology of the humate particulates with SEM imaging. The SEM imaging showed the high surface area characteristic of humic particulates, as they form "clusters" of organic colloids.

Centrifugation at high speeds (10,000 rpm) for more than 40 minutes allowed us to collect enough suspended solids for TEM mounting and examination. The difficulty in centrifuging attests to humates' very fine colloidal size. We brought the solids back into solution in deionized water by sonic dispersion, and then diluted and mounted them on a metallic TEM sample grid.

We produced SEM images by drying undiluted aliquots of the liquid Huma Base onto SEM mounts. To examine Huma Base's interaction with soil, we treated clean granitic sands in a leaching column with Huma Base dilutions at a rate of 150 gallons per acre. We applied an equivalent four-percent Urea solution to sand columns at 150 gallons per acre as a control.

The Huma Base treated sand columns showed humates coating the sand grains. The urea-treated sand columns showed no grain coatings of any kind.

Joy Christian Athletic Complex

1997 STMA Softball Field of the Year

by Bob Tracinski

Reach out with worship, songs of praise—and softball? That's the belief of Bellevue Baptist Church, a congregation of 23,000 in Cordova, TN. Why not serve your people and your community through sports? If God wants the best for his people, why shouldn't this include top-notch athletic facilities? The Church's Joy Christian Athletic Complex, STMA's 1997 Softball Field of the Year, was created to fulfill this philosophy.

Bellevue Baptist Church makes effective use of its 375-acre property. Its first sports-related facility, Grace Family Life Center, was completed in 1994. It houses four basketball courts and a running track.

The Joy Christian Complex lies just across a parking lot shared by the two sports facilities. Work began on its three softball/baseball fields in late spring 1995, and the fields were ready for play at the start of the 1997 season.

Five lakes, four retreat areas, a pavilion, a gazebo, an amphitheater, and 10 additional lower-maintenance athletic fields complete the impressive layout of Bellevue's grounds.

Director Robert Bodi oversees the entire property. He says, "Over 119 teams use these fields, split between 13 leagues ranging from Lassie through Senior girls, Midget through Major boys, and men's and women's separate and coed softball leagues. We play on Monday, Tuesday, Thursday, Friday, and some Saturdays, with eight fields going each session. The outer fields each average 150 games a season; the fields in the complex between 200 and 225—and that doesn't count the practices."

A collective effort helped Bellevue Baptist Church's Joy Christian Athletic Complex earn the 1997 STMA Softball Field of the Year Award. Director Robert Bodi designed the master irrigation system himself. *Courtesy: Robert Bodi*

Six full-time and 12 part-time employees handle maintenance. The ballfields and retreat areas are maintained by one full-time supervisor, Clifford Smith, and two part-time grounds personnel.

Smith joined the grounds staff part-time while attending college in Memphis. He began incorporating some field maintenance practices he'd observed as a baseball player. After graduation, he moved to full-time status and became involved in development of the new complex.

Bodi says, "Coordinating all this is like eating an elephant. You take one bite at a time. We look at one area, assess the needs, and when we accomplish that objective, move on to the next project."

Bodi has 20 years experience in the landscape/irrigation business. He joined his father in business immediately following high school. He has taken courses for design and