clay and organic matter content.

Another consistence limit of practical use is the shrinkage limit. The shrinkage limit is a limit within the solid phase at which a soil exhibits a moist friable consistency from the hard consistency of a dry soil. Table 1 shows some examples of values that can be exhibited for various soils that exhibit plasticity.

Strength

Strength is a soil property imparted by cohesive forces between particles and frictional resistance met by particles that are forced to slide over one another to ride out of interlocked positions. Strength characteristics tend to increase with increasing bulk density (compaction) and decreasing water content. For example, in a given soil, strength is greater when the soil is in a dry compacted state than when it is loose and moist. Soils in a liquid consistence state show little or no strength properties.

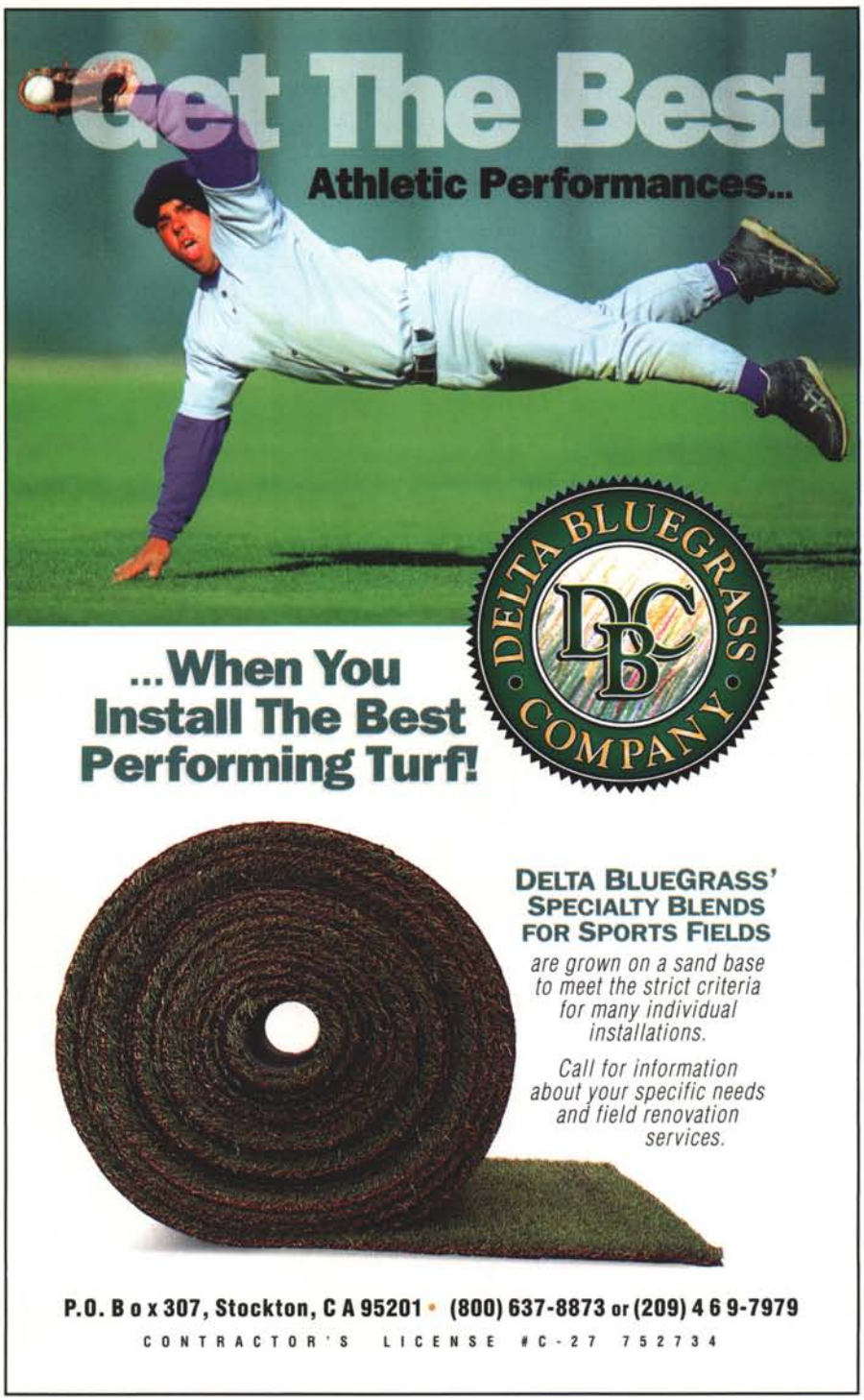
Resiliency (elasticity) is relatively limited in soils and is not generally a strength property of concern. Strength properties of soils concern the stresses that can be applied to a soil that cause permanent deformations until a threshold is reached whereby the soil fails by fracture or by plastic flow.

Soil strength is commonly evaluated as direct shear, torsional shear, triaxial (confined) compression resistance, unconfined compression resistance, rupture, impact resistance and penetration resistance. Although each of these types of soil strength parameters are measured and evaluated differently, each is basically an evaluation of the soil strength characteristics of cohesion and internal friction. A basic equation for expressing soil strength empirically is given by: $S=C+(N \times \tan F)$, where S is soil strength (shear) at the point of failure, C is cohesion, N is the normal or downward passive pressure, and tanF is the coefficient of internal friction. The terms S, C and N have units of force per unit area while F is called the friction angle. The relationship of each of these terms is shown graphically in Fig. 1.

The points determined can be used to establish a line with the angle formed by the slope of the line being the friction angle. With cohesionless sand, the strength term is defined proportionally with the normal load with the intercept of the graph at the axis.

Typically, C values of soils can vary from 0 in sands up to 30 KPa in clays. Angle F can vary from 0 degrees in saturated clays up to 45 degrees in densely packed angular sands.

Michael DePew is an agronomist with Environmental Turf Solutions, Inc. and is the chairman of the STMA Technical Standards Committee.



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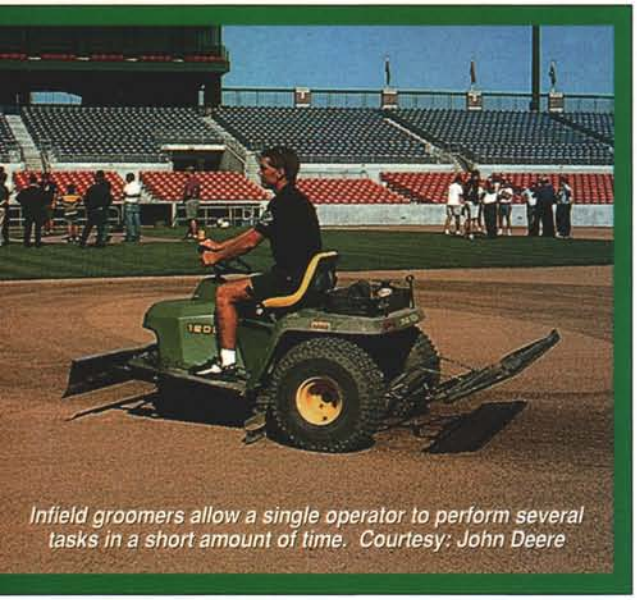
Infield Grooming

by Bob Tracinski

Daily maintenance of the infield skinned area is key to producing top playability on baseball and softball fields. At least 70 percent of the action of the game takes place on the infield basepath, batters box and baseball's pitchers mound or softball's pitching circle. An average of 70 percent of the sports turf manager's baseball and softball maintenance time is concentrated on these areas.



Infield groomers allow a single operator to perform several tasks in a short amount of time. Courtesy: John Deere

Homeplate and mound daily maintenance demand the precise attention that can only be achieved by hand. This makes it even more important to develop quick, effective and efficient methods to maintain the remainder of the skinned area.

Field groomers provide the availability of three infield maintenance attachments mounted on one unit and give the operator the ability to switch quickly and easily from one of these attachments to the other, without leaving the driver's seat. With front-, rear- and mid-mount attachments, the operator can move skinned material to cut down high spots and fill low ones; deep scarify to the desired depth; and wrap up the job with the finishing pass. This boosts efficiency, allowing one person to do more in less time. Since labor costs form the highest percentage of the field maintenance budget, this makes field groomers a cost-cutting factor as well.

While the infield skin material may form a basepath enclosing turf or cover the entire infield area, each field's "dirt" is a combination of clay soil, sand, soil amendments and moisture. Maintaining the desired moisture levels and working the material combine to create an underlying packed layer covered by a shallow topping of looser material.

Skinned area maintenance is a continual balancing act between proper drainage and playability. If the infield material is too soft, add clay/soil; if it's too firm, add sand, calcined clay, calcined diatomaceous earth or other amendments that loosen the surface. Moisture control is essential. Too much water and the skinned material becomes "muddy;" too little water and it can get hard as concrete.

The following scenario fits most high profile field basic baseline daily maintenance practices:

• Practice daily removal of excess clay from all inside and outside edges of the turf with a soft-bristled brush, rake, "leaf blower," or stream of water to avoid lip development—that ridge where infield material builds up in the turf along the infield and outfield edges of the skinned basepaths.

• Use a scarifying drag as needed to penetrate one to three inches into the skinned area to break up the surface and loosen any areas of compaction. The infield material and field use will dictate the frequency of this step but, for most fields, it's at least weekly.

• Prepare new infield material in the same proportions as the existing skinned area material. The new material will need to be moist, but not overly wet. It should be wet enough to "bond" with the existing material, dry enough to keep from sticking to equipment, but not so dry that it continually needs rewetting.

• Add new material as necessary. Base the addition of any commercial infield mix or soil amendments on the texture of the infield material and the desired moisture level. If desired, work a higher percentage of commercial infield mix into the top quarter inch of the skinned area.

• Use a leveling drag to move material from high points to low points, and to create a level surface. Roll or tamp the area to create a solid base. Continue adding new material, "spiking" or scarifying, rolling or tamping, until the desired level is reached.

• Eliminate differences in the level between the turf soil surface and the skinned area, or of the "feel" of the area as the player moves from the turf to the skinned surface and back again. This helps give the ball a "true" bounce, whether it hits turf or the infield "dirt."

• Keep leveling drags 8 to 12 inches from the edge of the turf to avoid throwing infield material onto the turf and creating a lip. Use hand rakes and tamps to level the areas next to the turf. Start and stop each dragging procedure at a different point on the field each time to keep a level surface.

• "Finish" the area with a finishing attachment or mat drag. After the infield turf has been mowed, water the infield clay. Water the clay again after mat dragging it.

• Monitor moisture and apply water as needed until batting practice begins. Following batting practice, touch up the skinned area with a finishing attachment or mat drag.

• Touch up the skinned area again during the fifth inning drag and, if needed, at the second and seventh innings.

Bob Tracinski is the Business Communications Manager for the John Deere Worldwide Commercial & Consumer Equipment Division headquartered in Raleigh, NC. He serves as public relations co-chair for the national Sports Turf Managers Association.

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Micronutrients in Sports Turf

by Dr. Kent Kurtz

Turfgrasses need a total of 16 essential nutrients for healthy growth and development. Three of these essential nutrients—carbon, oxygen and hydrogen—are derived from the air or are found in water and are beyond the control of the sports turf manager.

The 13 remaining elements either come from the soil or are added by the sports turf manager through the addition of fertilizer materials. These 13 elements are further divided into macronutrients, which include the primary elements such as nitrogen, phosphorus and potassium, and the secondary elements calcium, sulfur and magnesium.

The remaining elements are known as micronutrients, which consist of iron (Fe), zinc (Zn), boron (B), manganese (Mn), copper (Cu), calcium (Ca), chlorine (Cl) and molybdenum (Mo). These elements are required by the grass plant in minute or trace amounts, but they are very important to the health and vigor of turfgrasses on sports fields. The key to plant-availability is the soil pH; however, other factors may control the availability of micronutrients, such as the type of soil-sand versus clay or loam, or the source of irrigation, domestic or reclaimed water.

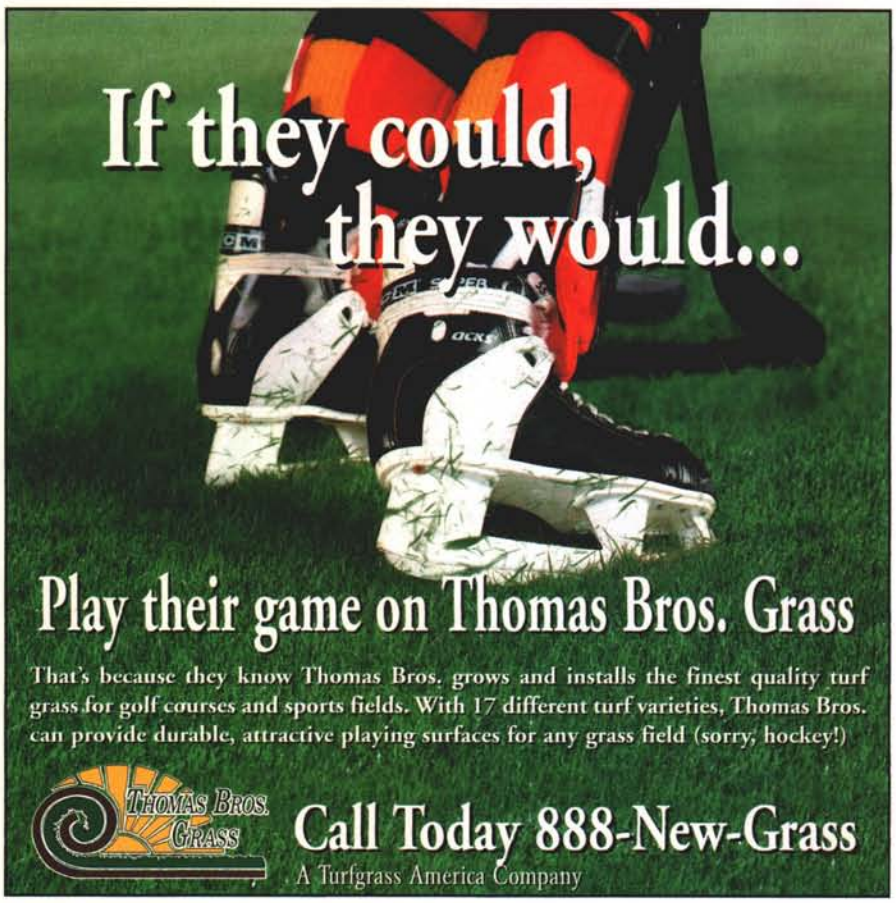
Most micronutrients are available at a neutral pH and decrease as the soil pH becomes more alkaline (over 7.0). However, micronutrient availability increases as the soil pH becomes more acidic and these micronutrients may become extremely toxic to plants below 6.0.

Determining Micronutrient Availability/Deficiency

There are three ways that micronutrients can be assessed for availability in turfgrasses and soils: Chemical soil analysis, plant tissue analysis and through observation of the sports field or turfgrass area. Soil analysis is not always accurate since tests may reveal unavailable forms along with available forms. Tissue analysis will reveal the content in the plant at that particular moment while observation by the sports turf manager may not provide a true picture or pinpoint the exact element because some elements do not exhibit visual signs or may be masked by other factors.

Most Common Micronutrients

Micronutrients are used by plants in very small amounts but are just as essential for plant growth as large amounts of the primary and secondary nutrients. Micronutrients must be maintained in balance for all nutrients and water to be used efficiently in turfgrasses on sports fields. According to most experts, there are three micronutrients that are necessary to maintain green color and plant vigor in turfgrass plants. The most frequently used micronutrient and one that is contained in many fertilizer formulations is iron. The other two micronutrients that are essential are zinc and manganese.



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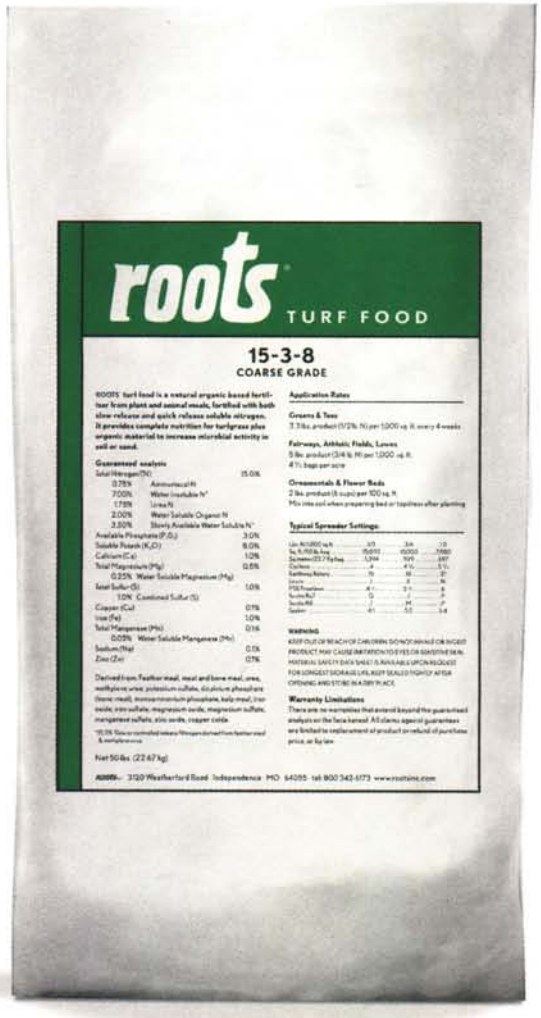

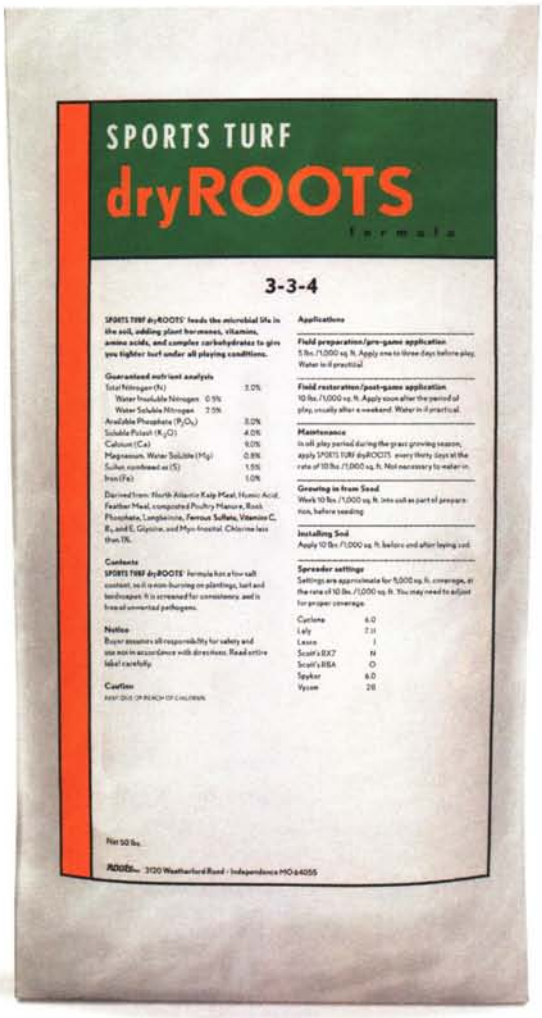

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Iron

Iron is required by the plant cell in the formation of chlorophyll, which provides the plant with a healthy, green color. Iron also serves as a catalyst for biological processes such as respiration, symbiotic fixation of nitrogen and photosynthesis. Applications of iron either through the leaf or applied to the soil may be temporary in soils with high levels of calcium. This condition is known as lime-induced iron chlorosis and can be corrected with applications of elemental sulfur and/or acidifying fertilizers containing ammonium. When ammonium converts to nitrate there is an acidifying effect in the soil and iron and other elements are more available in high pH soils.

Zinc

Zinc is a component of several plant enzymes and is a part of plant auxins which control the synthesis of indoleacetic acid which regulates growth compounds. Zinc also affects the intake and efficient use of water by plants.

Manganese

Manganese is an activator for enzymes in plants. In the absence of manganese, plants cannot use the iron which they have absorbed. Manganese assists the iron in chlorophyll formation which causes yellow turf to green up.

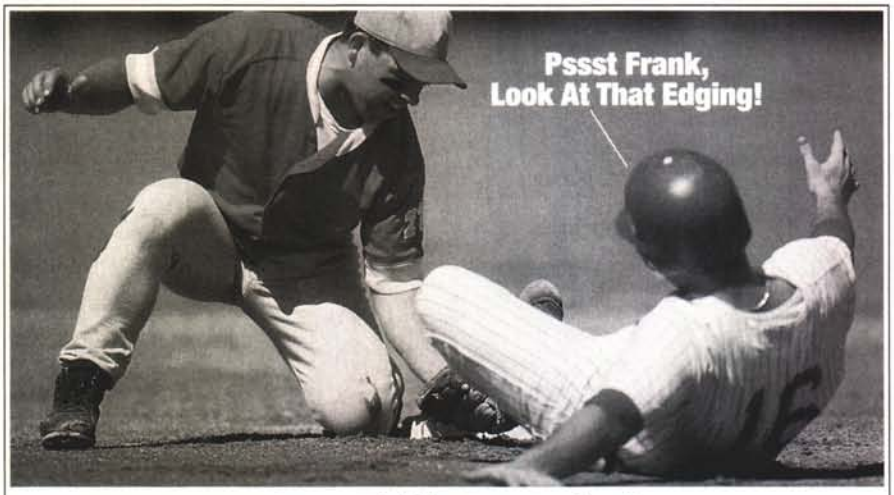
Other Micronutrients

Micronutrients boron, copper, chlorine and nickel are used in very small quantities by plants and are generally available in most soils. Some of these elements can be toxic from excess amounts which may be found in sewage effluent water and sewage sludge used as a granular fertilizer on plants.

Sports Field Application of Micronutrients

Application of micronutrients to sports turf is a common practice in many parts of the United States. Many fertilizer products include the primary micronutrients as a standard practice.

Care should be taken to supply the essential nutrients and micronutrients to sports fields to avoid unhealthy growth and color. Many reputable fertilizer companies have micronutrient packages that will enhance the color and vigor of the turf. Improper construction of athletic fields, fields with poor drainage and poor aeration and soils with high or low pH ranges all have problems with deficiencies or toxicity of micronutrients. Have the soil analyzed, utilize tissue tests and apply high quality fertilizer materials with micronutrients to maintain a quality sports turf.



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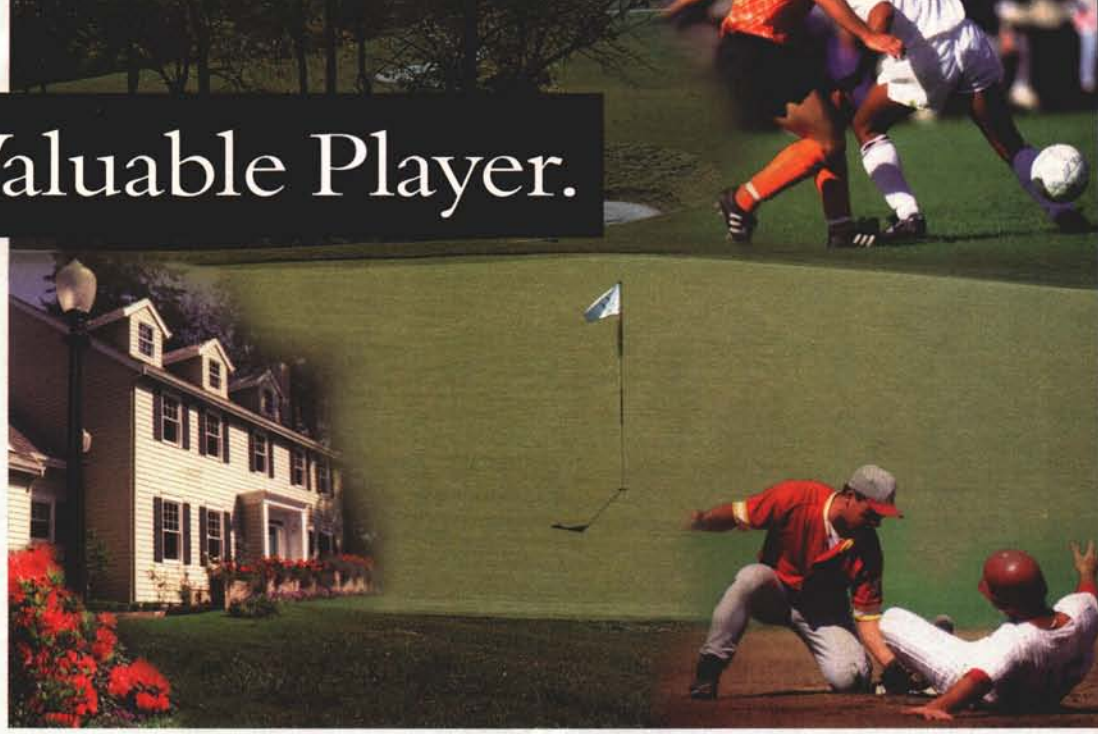

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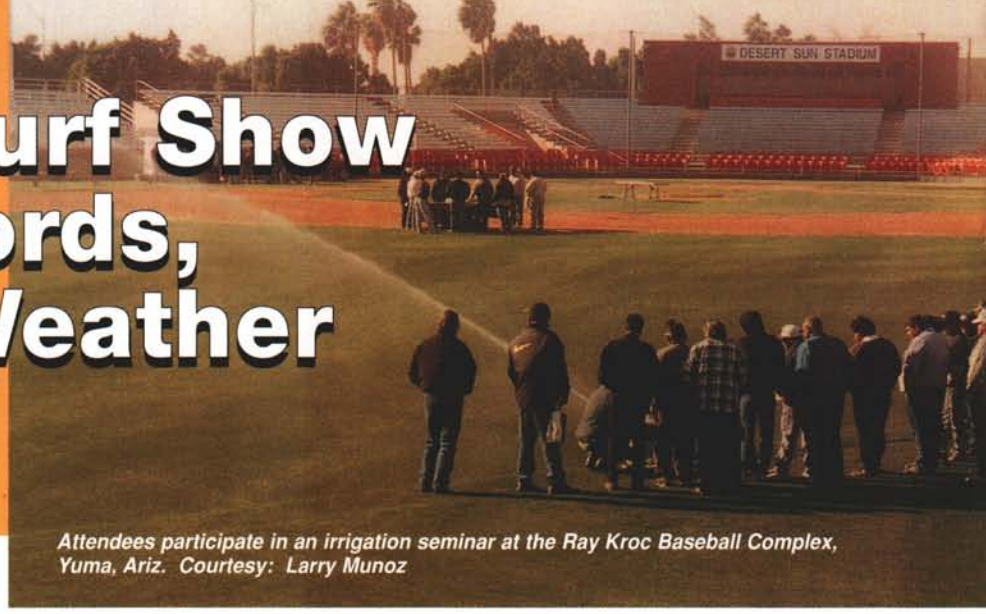
Arizona Turf Show Sets Records, Despite Weather

by Larry Munoz,
City of Yuma Parks Supervisor



Attendees participate in an irrigation seminar at the Ray Kroc Baseball Complex, Yuma, Ariz. Courtesy: Larry Munoz

The Seventh Annual Sports Turf Field Day was the biggest and best ever as 150 participants braved cold, windy conditions to gather at the Ray Kroc Baseball Complex, Yuma, Ariz., on Dec. 3, 1999. Attendees received an information packet and a City of Yuma Sports Turf T-shirt, sponsored by Coca Cola of Yuma.

Twenty-four vendors set up displays of their turf equipment, fertilizers, safety equipment and irrigation supplies, giving everyone a chance to see their products and, in many cases, try them out. This equipment show was sponsored by RDO Equipment Co.

Dual educational sessions were featured for the first time this year. Ron Ramirez, city of Yuma Parks and Recreation crew leader, teamed with Officer Miguel Sanchez for a session on graffiti abatement. Bill Forden of Armadillo Horticultural Services presented a session on "New Ideas in Horticultural Management." Al Herrera, city of Yuma crew leader, was joined by Mandy Cousins and Nick Demetrakas of Continental Leisure Sales for a presentation on playground safety. Dr. David Kopec, University of Arizona, Plant Science Department, addressed "The Principles of Aeration and Topdressing."

This was followed by an irrigation seminar on the main field, sponsored by Agricultural Supply Inc. This year, irrigation vendors didn't just set up their displays of irrigation supplies: they hooked operating systems to the water sources provided and let the sprinklers run for viewing. Attendees split into six groups, rotating to each of the irrigation vendor stations to examine how the sprinklers and controllers operated, to listen to the vendors' explanations of the products' features and benefits and to join in the lively question and answer exchange.

Attendees then had the opportunity to attend either the presentation by Roger Blakeley, parks superintendent, City of Yuma, on "Choosing the Right Tree for the Right Spot," or the presentation by Chris Bartos, supervisor, Kino Sports Complex, on "Maintenance of Facilities." Steve Trusty, executive director of STMA, gave an overview of the STMA program and where the organization is headed.

The day's special guest speaker was Jake Thrower from the Las Vegas Stars AAA baseball team, a minor league affiliate of the San Diego Padres. Thrower grew up in Yuma and played baseball there, progressing from the Little League and Babe Ruth levels through the high school program and then on to the University of Arizona, before signing with the Padres.

Thrower's presentation focused on playing field maintenance as seen through the eyes of a professional player. He noted such details as the impact on play made by the height of cut on the turf and by the dragging methods and degree of moisture in the skinned area. He talked about some of the fields he has played on and some of the techniques field managers have used.

A great lunch was prepared by the Parks and Recreation staff, with staff members doing all the cooking and

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serving. Special thanks go to: Bryan Knight, Forrest Slaughter, Damon Chango, Karen Munoz, John Quintero, Ron Ramirez, David Villalobos and Richard Horcasitas for their contributions to this fantastic finish for an excellent event.

Thanks also go the committee of employees from our Parks and Recreation Department: Joel Hubbard and the Complex Crew, John Quintero and the Athletic Field Crew, Ron Ramirez, Al Herrera, Roger Blakeley and all the other employees who make this the best show we've ever had.

Chapter News

Congratulations to STMA's Newest Affiliated Chapter: ***The Sports Turf Managers Association of Arizona***. For information on upcoming events, contact: Bill Murphy, city of Scottsdale Parks & Recreation Department, at (602) 312-7954, or Kris Kircher, city of Chandler Parks & Recreation Department, at (602) 786-2728.

KAFMO: KAFMO/STMA's 4th annual Pennsylvania Athletic Field Conference will be held at the Holiday Inn in Grantville on Feb. 24, 2000. Along with vendor displays, the conference will feature nationally recognized speakers: Dr. Dave Minner of Iowa State University; Andy McNitt of Penn State University; and Steve Trusty of STMA.

KAFMO also will participate in the Northwest Pennsylvania Athletic Field Turf and Ornamentals Conference on March 21, 2000, at Allegheny College, Meadville, Pa.

KAFMO's Officers for 2000 are: President - Dan Douglas, Reading Phillies; Vice President - Don Fowler, PSU Extension - retired; Secretary - Kevin Yeiser, director of grounds, Lebanon Valley College; and Treasurer - Jim Welshans, county agent, PSU Extension. Board members are: Nancy Bosold, Jeff Fowler, Steve LeGros, Chris Lessig, Neale Magill, Kurt Nilsson, Wayne Schlosser, Tim Spangler, Rich Valentine and Stanley Weaver.

For information on the KAFMO chapter or upcoming events, contact: Dan Douglas, Reading Phillies Baseball Club, at (610) 375-8469, extension 212, or via the chapter e-mail address: kafmo@aol.com.

Colorado: The Colorado Chapter elected officers and board members for 2000

Bob Schottke, a representative from Hunter Irrigation, describes his company's products at the equipment show. Twenty-four vendors displayed their products at the event. Courtesy: Larry Munoz

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Roger Blakeley, parks superintendent of Yuma, leads a hands-on presentation titled, "Choosing the Right Tree for the Right Spot." Courtesy: Larry Munoz

at their annual meeting held Dec. 8, 1999, in conjunction with the Rocky Mountain Regional Turfgrass Conference. The officers are: President - Jim Mueller, Grass-Roots 2000; Past President - Troy Smith, Denver Broncos Football Club; and Commercial Officer - Cita Berthelsen, Hunter Industries. Directors are: Kalin Stovall, Dan Rockne, ton Moody, Phil McQuade and Riley Caldwell. The chapter's executive secretary is Bobbi Smith.

The Board is in the process of planning the Seminars for 2000.

For information on the Colorado Chapter or upcoming activities, log on to the chapter's website: www.cstma.org or call the CSTMA Chapter Hotline: (303) 346-8954.

Great Lakes: GLSTMA's officers are fulfilling the second year of their two-year terms in 2000. The officers are: President - Boyd "Rob" Montgomery, Sylvania Recreation; President-Elect - Duane Smith, Baldwin Wallace College; Vice President Commercial - Dave Conover, The Andersons; Treasurer - Bob Nepper, city of Fremont; and Secretary - Karen Zelinko, AFS.

For information on the GLSTMA Chapter or upcoming events, contact: Joe Zelinko at (800) 897-9714 or Boyd Montgomery at (419) 885-1982, or click on your computer to www.glstma.org to visit the chapter's website.

Midwest Chapter: The Midwest Chapter elected its Officers for 2000 at their annual meeting held on Dec. 1, 1999. The Officers are: President - Dave McCormick, Ridgewood High School; Past-President - Scott Pippen, village of Lincolnshire; Vice President - Scott Gaunky, College of Lake County; Treasurer - Mike Schiller, Rolling Meadows Park District; and Secretary - Eric Adkins, Northwestern University. Committee Chairs for 2000 are: Newsletter - Jeff Green; Workshop - Ted Baker; and Awards/Scholarships - Bob Glascott.

For information on the Midwest Chapter or pending activities, call the chapter hotline: (847) 622-3517.

Minnesota: The Minnesota Chapter has elected its officers and directors for 2000. They are: President - Ron Werner, Kasson Manterville Schools; Past President - Connie Rudolph, Midway Stadium; President-Elect - Ron Unger, Kasson Park and Recreation; Secretary - Dale Wysocki, Minnesota Vikings; Treasurer - Georgianna Smith, University of St. Thomas; Director at Large - Aaron McWhorter, Sports Turf Company; and Minnesota Turf and Grounds Foundation Representative - Paul Griffin, city of Woodbury.

For information on the Minnesota Chapter or upcoming events, contact Connie Rudolph at (651) 646-1679.

Tennessee Valley: TVSTMA has elected its officers for 2000. The officers are: President - Bill Marbet, Southern Athletic Fields, Inc.; President-Elect - Bill Randles, Vanderbilt University; Commercial Vice President - Stan Thomas, Mid Tenn Turf, Inc.; and Secretary-Treasurer - Bob Hogan, Hogan Seed Company. Committee chairs for 2000 are: Program - Mike Moss; Membership - Bill Brunner; Publicity - Deb Robinson; and Nominations - Greg Fear. Chapter corresponding secretary is Bo Henley, Southern Athletic Fields, Inc. The Chapter's Advisory Board members are: Dr. Tom Samples and Bob Campbell, both of the University of Tennessee; Terry Porch, Tennessee Titans; and Brad Myers, Battle Ground Academy.

For information on the TVSTMA Chapter or upcoming events, contact Bill Marbet, Southern Athletic Fields, Inc. at (913) 380-0023, or Bob Hogan at (888) 224-6426.

Wisconsin: The Wisconsin Chapter is currently in the process of planning events for 2000. Details will be announced soon.

For more information on the Wisconsin Chapter or pending events, contact Rich Riggs, R. H. Rettler & Associates, Inc. at (715) 341-2633.

Northern California: For information on the Nor-Cal STMA Chapter or pending activities, contact: Janet Gift at (530) 758-4200.

Southern California: For information on the Southern

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