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MARCH 2002
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1. My primary business at this location is: (fill in ONE only)
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02 ◯ 20 Semi-Private
03 ◯ 30 Private
04 ◯ 40 Resort
05 ◯ 50 City/State/Municipal
06 ◯ 55 Other Golf Courses (please specify)_____
07 ◯ 60 Golf Course Architect
08 ◯ 70 Golf Course Developer
09 ◯ 90 Golf Course Builder
10 ◯ 105 University/College
11 ◯ 115 Distributor/Manufacturer/Consultant
12 ◯ 100 Others Allied to the Field (please specify)_____

2. Which of the following best describes your title? (fill in ONE only)
13 ◯ 10 Golf Course Superintendent
14 ◯ 15 Assistant Superintendent
15 ◯ 25 Owner/Management Company Executive
16 ◯ 30 General Manager
17 ◯ 35 Director of Golf
18 ◯ 70 Green Chairman
19 ◯ 45 Club President
20 ◯ 75 Builder/Developer
21 ◯ 55 Architect/Engineer
22 ◯ 60 Research Professional
23 ◯ 65 Other Titled Personnel (please specify)_____

3. What is your facility's annual maintenance budget?
24 ◯ A More than $2 Million
25 ◯ B $1,000,001-$2 Million
26 ◯ C $750,001-$1 Million
27 ◯ D $500,001-$750,000
28 ◯ E $300,001-$500,000
29 ◯ F $150,001-$300,000
30 ◯ G Less than $150,000

4. If you work for a golf course, how many holes are on your course?
31 ◯ A 9
32 ◯ B 18
33 ◯ C 27
34 ◯ D 36+
35 ◯ E Other (please specify) _____

Please send Golfdom to the following people at my organization:

Name_____
Title _____
Name_____
Title _____
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101	113	125	137	149	161	173	185	197	209	221	233	245	257	269	281	293	305
102	114	126	138	150	162	174	186	198	210	222	234	246	258	270	282	294	306
103	115	127	139	151	163	175	187	199	211	223	235	247	259	271	283	295	307
104	116	128	140	152	164	176	188	200	212	224	236	248	260	272	284	296	308
105	117	129	141	153	165	177	189	201	213	225	237	249	261	273	285	297	309
106	118	130	142	154	166	178	190	202	214	226	238	250	262	274	286	298	310
107	119	131	143	155	167	179	191	203	215	227	239	251	263	275	287	299	311
108	120	132	144	156	168	180	192	204	216	228	240	252	264	276	288	300	312
109	121	133	145	157	169	181	193	205	217	229	241	253	265	277	289	301	313
110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314
111	123	135	147	159	171	183	195	207	219	231	243	255	267	279	291	303	315
112	124	136	148	160	172	184	196	208	220	232	244	256	268	280	292	304	316

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04 ○ 40 Resort
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TURFGRASS TRENDS

Section II • Volume 11, Issue 3 • **March 2002**

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CRABGRASS CONTROL

Postemergent Treatments for Crabgrass Vary in Effectiveness

By Dr. John R. Street and Pam J. Sherratt

Postemergent crabgrass (Digitaria spp.) control has been primarily limited to organic arsenicals (MSMA, DSMA) in the past. The organic arsenicals usually required repeat applications for effective postemergent crabgrass control, were most efficacious on younger seedling crabgrass and caused some discoloration and phytotoxicity to desirable turfgrasses, especially in hot weather.

Acclaim (fenoxyprop ethyl) and Acclaim Extra have shown good-to-excellent efficacy for postemergent crabgrass control, but some discoloration and stunting of Kentucky bluegrass may occur, and efficacy drops off under drought conditions.

Dimension (dithiopyr) also provides early postemergent crabgrass control with the additional benefit of pre-emergent residual activity. A new postemergent herbicide, Drive (quinclorac), was released into the market in 1999.

Over the last several years, The Ohio State University has conducted numerous research trials to assess the performance of Acclaim, Acclaim Extra, Dimension and Drive for pre-emergent and postemergent crabgrass control. This article will briefly highlight results and recommend herbicide use from those studies.

Acclaim/Acclaim Extra in previous Ohio State research has exhibited good efficacy for postemergent crabgrass control. Acclaim efficacy on crabgrass has been good to excellent up to the intermediate stage where soil moisture was adequate and crabgrass was not under stress. Efficacy has been found to drop off dramatically under drought conditions, sometimes causing erratic and variable results in the field. Acclaim efficacy also is significantly reduced when used in combination with phenoxy herbicides like 2 and 4-D. Acclaim is absorbed through the leaves, so adequate foliar coverage is essential for best results (Table 1).

Maximum efficacy from Acclaim requires:

- Mowing prior to treatment to open the canopy for maximum contact of liquid spray with crabgrass foliage; and
- Spraying with sufficient water to assure good foliar coverage.

Irrigation or rainfall shortly after an herbicide application will reduce the efficacy significantly. Some stunting and discoloration of Kentucky bluegrass may occur, especially in the early season when bluegrass is rapidly growing. Our research has observed stunting and discoloration after most applications during the season.

In most cases, the discoloration amounts to a lightening of the blue-green or dark-green color of Kentucky bluegrass. Bentgrass can be severely discolored by Acclaim applications. Light, multiple applications are recommended for bentgrass. Iron and/or nitrogen will help mask the discoloration without any negative effect on the efficacy of the herbicide.

The recommended rate range for Acclaim is .12 to .25 pounds active ingredient/acre (ai/A), with the higher rate targeted for more mature crabgrass. The rate of Acclaim's kill in our research is described as moderate, with crabgrass kill typically

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TABLE 1

Efficacy of Herbicides Applied for Early Postemergence for Crabgrass (Digitaria) Control

Herbicide	Formulation	Rate (lbs. ai/A)	Not Watered In					Watered In			
			7/25	8/3	8/8	8/20	9/5	8/3	8/8	8/20	9/5
Dimension	2 EC	.25	50	40	26.7	18.3	16.7	60	60	40	28.3
Dimension	2EC	.38	50	40	20	6.7	5	63.3	60	28.3	15
Dimension	2EC	.50	50	40	16.7	33.3	3	63.3	60	28.3	6.7
Dimension	0.164 FG	.25	53.3	43.3	33.3	30.3	33.3	63.3	63.3	21.7	18.3
Dimension	0.164 FG	.38	53.3	40	21.7	13.3	13.3	60	50	13.3	10
Dimension	0.164 FG	.50	53.3	40	13.3	5	2.3	56.7	46.7	5	1.3
Acclaim Extra	0.57 EW	.06	53.3	33.3	13.3	10	3	50	40	20	20
Acclaim Extra	0.57 EW	.09	53.3	40	6.7	0	0	50	46.7	8.3	8.3
Drive	75 DF	.25	50	4	0	5	10	41.7	31.7	31.7	36.7
Drive	75 DF	.50	50	0	0	0	10	46.7	40	26.7	28.3
Drive	75 DF	.75	50	0	0	0	10	40	30	26.7	25
Daconate	6 F	2	53.3	36.7	23.3	16.7	20	60	60	50	50
Untreated	—	—	53.3	63.3	66.7	68.3	73.3	60	66.7	68.3	73.3
LSD (0.05)	—	—	5.99	7.34	6.57	4.61	4.63	8.31	10.8	7.16	4.79

occurring in two to three weeks.

Crabgrass initially turns orange or purple in three to five days after an Acclaim application. This coloration response normally lasts for about seven to 10 days. Browning and necrosis occur over two to three weeks.

The new isomer formulation of Acclaim is Acclaim Extra (fenoxprop p-ethyl). It has provided good-to-excellent control of crabgrass with postemergent rates of .06 to .125 pounds ai/A. There has been essentially no noticeable difference in the efficacy, rate of activity or phytotoxicity between Acclaim and Acclaim Extra.

Dimension (dithiopyr) is unique in that it exhibits both pre-emergent and postemergent herbicide activity on crabgrass. Dimension, therefore, provides a wider window for application of a pre-emergent herbicide in the spring.

Postemergent activity of Dimension is slow, with a total kill typically ranging from three to five weeks. It does, however, stunt crabgrass in 10 to 14 days, making its presence in the turfgrass canopy less noticeable. The stunted crabgrass is initially hidden in the canopy, and then eventually dies over a period of three to five weeks.

During the stunting phase, crabgrass initially turns yellow, then purple, followed finally by necrosis. We call this response the "hidden canopy effect."

Our research supports the claims that Dimension is most efficacious as an early postemergent herbicide. It certainly is not effective on well-tillered crabgrass. The Dimension rate for postemergent crabgrass treatment is .25 to .5 pounds ai/A, with the higher rate necessary for mature crabgrass. A surfactant is recommended for liquid (EC) post applications (Table 1).

Some research has observed a more rapid rate of activity on early tillered crabgrass when combined with MSMA/DSMA (see label for recommendation).

The principal uptake mechanism for pre-emergent activity of Dimension is root absorption. We initiated research to determine if irrigation shortly after a Dimension application to move the herbicide to the

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TABLE 2

Postemergence Herbicide Efficacy Activity Ranking

Herbicide	Activity Mode	Common Name	Relative Activity Rate	Specific Activity Rate
Dimension	Pre/Post	Dithiopyr	Slow	3 to 5 weeks
Acclaim	Post	Fenoxyprop p-ethyl	Moderate	2 to 3 weeks
Acclaim Extra	Post	Fenoxyprop p-ethyl	Moderate	2 to 3 weeks
Drive	Post	Quinclorac	Rapid	7 to 10 days

soil/root zone might improve either the overall efficacy and/or rate of activity of post applications (Table 1).

Irrigation did not appear to have any significantly positive or negative effect on the overall activity or efficacy of Dimension postemergent control. In general, the EC, G, and FG formulations in our research have not shown any significant differences in postemergent herbicide efficacy except for a slightly more rapid rate of initial crabgrass stunting and kill with the liquid Dimension EC formulation.

Beyond the intermediate crabgrass stage, Dimension may cause some discoloration and slight stunting of crabgrass, but acceptable control should not be expected. Dimension, therefore, is certainly a great tool that widens the window for pre-emergent herbicide applications where the target date for crabgrass germination has been missed. Crabgrass control can be reliably handled through early postemergent treatments, with pre-emergent activity the remainder of the season.

Drive (quinclorac) is the most recent addition to the postemergent herbicide arsenal. Drive has been a good-to-excellent post crabgrass herbicide. The recommended label rate of Drive is .75 pounds ai/A. OSU research has shown that young crabgrass can usually be controlled with rates of .25 to .50 pounds ai/A (Table 1).

Most consistent and reliable results will occur at the .75 pounds ai/A rate where Drive is being applied postemergently under a range of environmental and landscape site conditions, and where crabgrass may be in various maturity stages. Drive efficacy does not appear to be as sensitive to soil moisture as Acclaim or Acclaim Extra.

However, the label recommends applying Drive when soils are moist. Drive can be applied in combination with broadleaf herbicides. Drive also exhibits some broadleaf herbicide activity, especially on legumes like black medic and clover.

Drive's rate of kill is rapid, with crabgrass kill usually occurring within one to two weeks after an herbicide application. Young crabgrass may turn brown and die in less than one week. Drive activity is obviously more rapid than Dimension or Acclaim (Table 2). Research showed that Drive provided excellent early postemergent crabgrass control and good-to-excellent late postemergent control.

Drive efficacy was somewhat variable at the intermediate crabgrass maturity stage. There are other research trials and field observations to suggest that Drive efficacy at the intermediate crabgrass maturity stage may be somewhat weaker and/or variable.

The authors suggest avoiding or delaying Drive applications on intermediate crabgrass to a later maturity stage. This approach should work effectively because Drive appears to be more efficacious on more mature crabgrass than on intermediate maturity crabgrass.

Drive is considered in the agricultural literature to have both foliar and root activity and is used in some crops as a pre-emergent herbicide. It has not performed well as a pre-emergent herbicide in turf due to perhaps soil biomass interactions not encountered in agricultural systems. In fact, our research indicates Drive is predominantly a foliar herbicide in turfgrass. Several research results that support its foliar activity include:

- Irrigation applied shortly after Drive applications significantly reduced efficacy.

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• The addition of surfactants has significantly improved efficacy. Some surfactants enhance Drive's efficacy more than others do.

• Watered-in applications of Drive in OSU research have resulted in poorer efficacy than applications that were not watered in.

• A period with no rain of six to12 hours was necessary to ensure acceptable control (Table 1).

Drive efficacy does not appear to be as sensitive to soil moisture as Acclaim or Acclaim Extra. However, the label recommends applying Drive when soils are moist.

Therefore, Drive herbicide should be used as an herbicide that's absorbed through the leaves. Here are application techniques to insure maximum absorption:

• Apply when crabgrass is actively growing.

• Apply when soil moisture is adequate.

• Provide adequate spray contact/spray coverage using an appropriate water volume.

• Mow high grass before application to ensure the herbicide contacts the leaf surface.

• Use a surfactant. Best choices are methylated seed oil or crop oil concentrates.

• Avoid irrigation or rainfall within at least six to 12 hours after application (most labels call for 24 hours).

In tolerance studies, Kentucky bluegrass, tall fescue, and perennial ryegrass exhibited good-to-excellent tolerance to Drive. Finer grasses are less tolerant of Drive. Creeping bentgrass is sensitive to Drive herbicide with discoloration (primarily yellowing) occurring at rates of .5 to .75 pounds ai/A. Higher rates will not only discolor bentgrass but cause thinning.

Lower-cut crabgrass appears more sensitive to Drive, resulting in acceptable control at lower rates. Superintendents using Drive at half-rate or less can reduce discoloration and still get acceptable control. Sprayers must be operated carefully to eliminate overlap rates, and at constant speeds to ensure a proper application.

It is suggested that Drive not exceed one-half the recommended rate on creeping bentgrass.

Table 2 provides a ranking of relative activity and specific activity rate of four postemergent crabgrass herbicides based on six years of OSU research.

Drive and Acclaim Extra have no reliable pre-emergent activity. Where early postemergent applications (i.e. early summer) are made with these latter herbicides, pre-emergent herbicides may also need to be applied to provide a pre-chemical barrier for the remainder of the season.

Drive and Acclaim Extra can be mixed with other pre-emergent herbicides or granular pre-emergent applications can be made separately. Remember, Dimension has both early post- and pre-activity. Drive can be mixed with phenoxy herbicides, but Acclaim Extra cannot.

In seedings, Drive herbicide can be used for postemergent crabgrass control with Kentucky bluegrass, perennial ryegrass, and tall fescue at 30 days after emergence or beyond. Fine fescues are more sensitive to injury than other cool-season grasses.

Drive will effectively control or severely stunt mature crabgrass, favoring the competitive edge of the desirable grass. Drive also provides some control or suppression of a variety of broadleaf weeds. It is more efficacious and safer than other postemergent annual grass options. For example, Acclaim will stunt and can severely injure young seedlings of cool-season grasses. Drive can be an interesting new tool for annual grassy weed control in spring and summer seedings.

Remember, annual grassy weed competition tends to be a major reason why spring and summer seedings of cool-season grasses fail.

Dr. John Street is associate professor in the agronomy department at The Ohio State University. He received his B.S. from California State University and both his M.S. and Ph.D. from The Ohio State University. Pam Sherratt was recently appointed sports turf extension specialist in the OSU Extension Horticulture and Crop Science Department. This is a new initiative that has been undertaken to support the sports/athletic field managers in Ohio. She can be reached at sherratt.1@osu.edu.

Valves Produce More Accurate Spray Patterns

By H. Erdal Ozkan

Spray equipment often needs more effective pressure and flow control at the nozzle to optimize the application of pest-control products. This is especially true for manually operated equipment such as backpack and compression sprayers. These sprayers have little to no pressure regulation, making accurate and consistent applications of pest-control chemicals difficult.

The constant flow valve (CFV) is an innovative device designed to provide pressure and flow control at the nozzle independent of the pumping action of the applicator or the pressure from the sprayer. The effect of flow control at the nozzle is significant.

Originally developed for use in Third World countries where backpack sprayers are often the only means of applying pesticides, the CFV was part of a Dupont Stewardship program to reduce worker exposure and increase spray consistency with manually operated equipment. It worked so well overseas that U.S. experts in pesticide technology took notice.

The CFV is easy to insert between spray wand and nozzle. It's small (2.5-inches), lightweight (20 grams), and constructed of high-grade Delrina plastic with a stainless-steel throttle pin and spring. The valve maintains a steady flow because the diaphragm and spring inside the valve sense inlet pressure from the pump and continuously work to modulate the size of the inlet orifice.

The flow rate remains constant regardless of changing input pressures at or above the pre-set operating pressure of the valve. Conversely, if pumping stops or pressure drops below the desired level, the valve shuts off with no dripping at the nozzle.

I first encountered it during a technical session of the American Society of Agricultural Engineers. The valve makes sense because it controls flow rate and droplet size — both critical to accurate pesticide applications. The result is more uniform applications at correct rates without waste of material, water or labor.

Droplet sizes and spray patterns are consistent so there is no overapplying or underapplying of spray solutions. There's better on-target deposition of material and significantly less potential for drift and worker exposure. There's also reduced labor because operators don't need to pump sprayers as often with accurate regulation of pressure.

With constant pressure and flow, there is even distribution of chemicals, and equipment can be accurately calibrated to deliver chemical at the labeled rate.

With constant pressure and flow, there is a consistent, even distribution of chemicals throughout the entire application. In addition, the equipment can be accurately calibrated to deliver the chemical at the labeled rate. For manually operated equipment, it provides water conservation and a reduction in the effort required to make an application.

Since it's placed close to the nozzle, the valve can increase the function and effectiveness of motorized equipment as well. Retrofitting a backpack sprayer with a CFV resulted in a reduction in chemical use of more than 20 percent when sprayed in concentrated amounts. Fortunately, the reduction in chemical amounts didn't change its efficacy.

The CFV allowed a more controlled application and a uniform application of chemicals. Also, the amount of fine spray particles was reduced, and off-target movement of the spray solution was minimized.

The valve comes in four pre-set pressures


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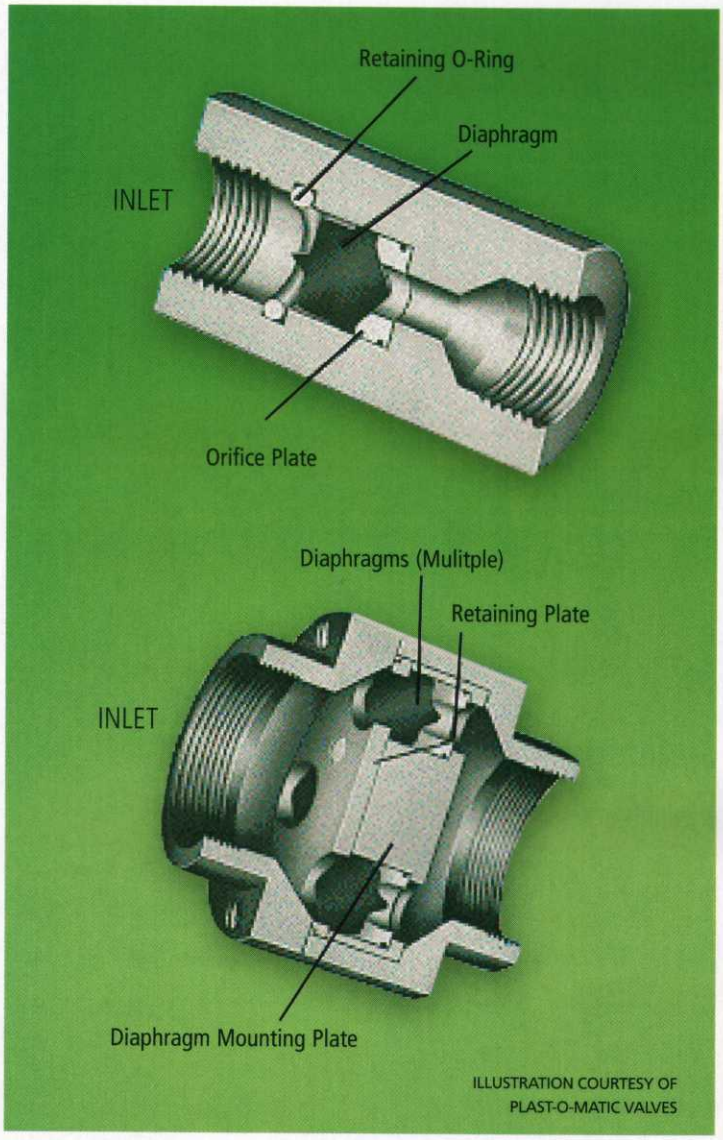


ILLUSTRATION COURTESY OF PLAST-O-MATIC VALVES

The flow rate remains constant regardless of changing input pressures at or above the pre-set operating pressure of the valve.

— 14.5 pounds per square inch (psi), 21 psi, 29 psi and 43.5 psi. It's also built with thread sizes to fit most sprayers. For most applications using manual spray equipment, the 21-psi CFV is recommended.

The valve also works as a check valve. When pressure drops below the operating pressure, the valve closes completely with no dripping from the nozzle. Benefits of using the CFV and the constant flow that results include:

- Accurate, consistent flow of spray solution;
- Constant and predictable spray pattern;
- Predictable droplet spectrum;
- Ability to select a nozzle most appropriate for application;
- Better water management;
- Closes completely (no drips) when pressure too low;
- More on-target deposition of spray solution;
- Even distribution of spray solution over the treated area;
- Precise and cost effectiveness of chemical application;
- Reduced labor investment for manual sprayers;
- Focus on application of chemicals to targeted areas instead of focusing on equipment operation; and
- Limited potential for worker exposure and environmental contamination.

It takes people a while before they learn how to use spray equipment, so superintendents and other industry professionals are showing keen interest in the technology, especially for new employees.

Inexperienced workers often overpressurize, walk too fast, spray too much and finish the tank before they should. Even experienced operators find it difficult sometimes. The increased use of CFVs should help ease the situation in the field.

Dr. Erdal Ozkan is a professor in the food, agricultural and biological engineering department at The Ohio State University. He is the author or co-author of 39 journal articles, four book chapters, 48 Extension publications, 16 software programs and has made over 60 technical presentations at national and international conferences.

Recent Research Offers Clues to Boron's Purpose

By Richard J. Hull

As we examine the role of micronutrients in turfgrass nutrition, we enter murky waters when we consider the functions of boron. There is a scarcity of specific research on turfgrasses, so there remain questions about its roles. Since this subject has been reviewed recently (Blevins and Lukaszewski 1998), we interpret the current state of knowledge about boron's importance to turfgrass management.

Boron is required by turf in extremely small amounts and normally is present in dry plant tissues in a range of 6 parts per million (ppm) to 30 ppm (Table 1). Jones (1980) proposed a sufficiency range for boron in turfgrasses of 10 ppm to 60 ppm. Table 1 demonstrates, however, that boron levels of less than 10 ppm are commonly observed in turf with no deficiency symptoms evident.

It's also doubtful whether 60 ppm boron is a critical concentration for any turfgrasses. Plants differ in their boron requirements, with grasses generally having a much lower demand than dicotyledonous plants. Marschner (1995) reports a critical boron concentration range for grasses of 5 ppm to 10 ppm while that for broad-leaved plants ranges between 20 ppm and 70 ppm. Some latex-producing plants have an exceptionally high boron requirement in the 80 ppm to 100 ppm range.

Turfgrasses will respond to small amounts of boron (1.5 pounds/acre to 7.5 pounds/acre) with color, root growth and stand density all improving for five weeks following application (Deal and Engel 1965). Because boron deficiency symptoms can be subtle, slowly affecting meristems of roots and shoots preferentially, an insufficiency may be difficult to spot.

As is the case for most micronutrients, turf grown on sand-based media may suffer mild boron deficiency without the manager ever noticing or recognizing the problem. Thus, it's prudent to know something about boron and how to tell if this essential element might be lacking.

Boron in the soil

Soils generally contain relatively little boron. The earth's crust averages about 10 ppm boron with igneous rocks containing 5 ppm to 15 ppm and sedimentary shales as much as 100 ppm. Most boron containing minerals are weakly soluble, so the release of soluble boron through weathering is slow.

Boron can form complexes with clays and amorphous soil minerals and also become incorporated into organic matter. Hence, the 7ppm to 80 ppm present in most soils, less than 5 percent is in the soil, where it's available to plants.

A well-defined function for boron has yet to be discovered, although it appears we may be getting close.

Boron is one of only two nonmetallic micronutrients and is sometimes referred to as a metalloid element. It does not undergo oxidation or reduction, having a constant redox state of plus-3. It exists in soil minerals as oxy- or hydroxy- complexes with silicon, aluminum, iron and magnesium. The form of boron in the soil is mostly boric acid and, in alkaline soils, some borate anion.

Also in alkaline soils, boric acid can acquire an additional hydroxide through hydration and become a tetrahydroxy anion.

Boron absorption by plant roots

Under the pH of most soils, boron is present primarily as the uncharged boric acid molecule and is absorbed by plant roots in that form. Roots absorb the anionic forms, which exist only in soils with a pH of more than 7, much less readily. This contributes to a marked decline in boron uptake from solutions when their pH exceeds 7.

The mechanism of boron absorption by plant root cells is unclear, but it likely occurs through a hydrogen ion/boric acid co-transport. In this mechanism, a boric acid molecule crosses the plasma membrane of root cells against a concentration gradient accom-

panied by a hydrogen ion (H^+) that enters the cell along an electrochemical gradient. The pH of the cell wall space is normally two pH units more acid than the cytoplasm of root cells. Thus, a hydrogen ion would be energetically favored to enter a cell dragging a boric acid molecule with it.

The inhibition of boric acid uptake by roots in alkaline soils is consistent with this idea. In alkaline soils, the hydrogen ion concentration in the soil solution and cell wall volume would by low, thereby reducing the pH gradient favoring hydrogen ion entry into the cell.

Boron mobility in plants

Once inside root cells, boric acid moves into the xylem vessels with the transpirational flow of water, although specific transporters may be involved in xylem loading. The transpiration stream carries boric acid into the leaves and into any other plant organs that are losing water. In the leaves, much of the boron (about 90 percent) remains within the cell wall where it can bind with cell wall polysaccharides. The boron that enters leaf cells is thought to remain there, with little being transported out of the leaves through the phloem with the photosynthate stream.

This immobility of boron in the phloem is supported by observations that boron accumulates in leaves, especially in older leaves. Boron toxicity symptoms are normally observed first at the tips of the oldest leaves, which is exactly where a nutrient immobile in the phloem would be expected to accumulate. Boron deficiency is observed most often in apical meristems and fleshy fruits or stems that receive most of their water and nutrients through the phloem.

However, there are instances where boron transport in the phloem does appear to occur (Marschner 1995). The ability of some plants to redistribute boron within their cells appeared to be linked with their capacity for synthesizing sugar alcohols, especially sorbitol. In an ingenious experiment, Brown et al. (1999) transformed tobacco plants by inserting the gene that encodes for sorbitol biosynthesis. Tobacco normally does not exhibit boron mobility in its phloem and shows obvious deficiency symptoms soon after boron is withheld.

The transgenic tobacco capable of synthesizing sorbitol exhibited delayed deficiency symptoms when boron was withdrawn. When it was applied to mature leaves, plants failed to show any signs of deficiency. Wild-type tobacco quickly exhibited deficiency symptoms when boron was applied only to mature leaves, indicating that redistribution through the phloem could not occur.

In the transgenic tobacco, boron was found to be transported in the phloem as a B-sorbitol complex. Thus it appears that the lack of boron mobility in plants is the result of the plant's inability to synthesize an appropriate carrier molecule that can produce a phloem mobile complex with boron. This research demonstrates that genetically altering plants for more efficient boron use is a serious possibility.

TABLE 1

Boron content in leaf tissues of several turfgrasses

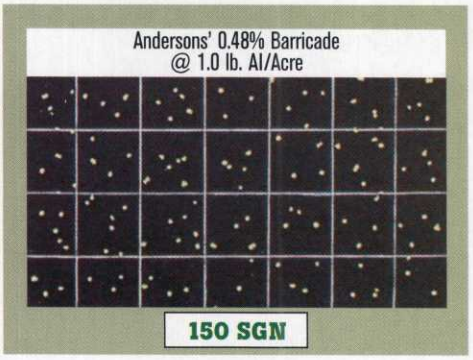
	BORON CONTENT*		
Turfgrass	Waddington & Zimmerman (1972)	Butler & Hodges (1967)	Turner (1980)
			ppm
Annual bluegrass	36	-	-
Kentucky bluegrass	16	7.5	7.9
Colonial bentgrass	26	6	-
Creeping bentgrass	30	-	-
Tall fescue	22	9	-
Creeping red fescue	26	6.5	9.2
Perennial ryegrass	24	14	9.4
Bermudagrass	-	9.5	-
Zoysiagrass	-	6	-

* AS REPORTED IN TURNER & HUMMEL (1992)

Boron's physiological functions

Since boron was first identified as an essential nutrient element in higher plants in 1923 by the British physiologist Katherine Warington, much research has been performed to determine its function in plants. This effort not withstanding, a well-defined function for boron has yet to be discovered, although it appears we may be getting close (Blevins and Lukaszewski 1998). A list of roles proposed for boron is presented in Table 2.

THE IMPORTANCE OF particle sizing & uniformity



The photos above illustrate the difference in particle size between The Andersons' 150 SGN and the competitor's 175 SGN product. Note the influence particle size has on coverage.

The effective application of fertilizer and fertilizer pesticide combination products is greatly influenced by the size guide number and particle uniformity. These are industry-recognized standards of measurement. The **size guide number** or SGN is the "average particle diameter" of the product expressed in millimeters multiplied by 100. For example, a product with an average particle size of 1.5mm will have an SGN of 150. Andersons Contec fertilizers may have SGNs as low as eighty. Newer bentgrass varieties often produce over 225 tillers per square inch at putting greens mowing heights of 1/8 inch or below requiring low SGN fertilizers which allow particles to rapidly disperse below the canopy.

The Uniformity Index is the ratio between the size of the average small particle and average large particle multiplied by 100. For example, a product with a UI of fifty means that the average small particle is half the size of the average large particle. The higher the UI means the particles are sized more consistently, resulting in better flowability and even distribution of nutrients across the spreader pattern. Widely varying particle size will result in irregular ballistic behavior, which can lead to speckling or streaking of turf. An acceptable uniformity index is 35 or higher. (Uniformity Index will be discussed in more depth in a future issue.)

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The matrix below illustrates that as SGN decreases, particles per square inch increases.

Particles Per Square Inch Matrix

Pounds Product Per Acre	Size Guide Number (SGN) 80	100	125	150	175	215	240
100	14.1	7.2	3.7	2.1	1.3	0.7	0.6
125	17.6	9.0	4.6	2.7	1.7	0.9	0.7
150	21.1	10.8	5.5	3.2	2.0	1.1	0.8
175	24.6	12.6	6.5	3.7	2.4	1.63	0.9
200	28.1	14.4	7.4	4.3	2.7	1.5	1.0
225	31.6	16.2	8.3	5.0	3.0	1.6	1.2
250	35.1	18.0	9.2	5.3	3.3	1.8	1.3

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This long list of possible functions, each of which has research findings that support it, may be interpreted in one of two ways. Either boron may serve many functions in plants or it performs one master function, with the rest being secondary roles. Current thinking favors the master function hypothesis. Therefore, I would like to concentrate on what now appears to be boron's primary function: the formation of cross links among cell wall polysaccharides, as well as between them and membrane surface groups.

Boron has the ability to form di-ester complexes with sugars that contain a cis-diol configuration. Such configurations with boron form links between carbohydrate subunits of cell wall polysaccharides wherever a pair of C-OH groups occurs that is oriented toward the same side of the molecule.

The ring forms of 5-carbon sugars ribose and apiose are most likely to produce such links, but 6-carbon sugars such as mannose and the pectin chains of galacturonic acid may also participate in these boron links. In this way, boron binds hemicellulose chains to pectin polymers at specific sites giving a somewhat ordered structure to this otherwise disorganized gel.

Because boron links can be easily broken by changes in pH, they likely participate in cell wall loosening during cell expansion, which is promoted by auxin-stimulated acidification of the cell walls. Boron links may also form between cell wall carbohydrates and sugar containing membrane proteins (glycoproteins).

All these links give structure to the cell-wall matrix and provide for a close association with the plasma membrane. This allows for orderly cell expansion, regulated hydrogen ion release into the cell wall, retention of essential calcium and control over lignin formation when cell expansion is completed.

If boron is not available, these processes do not occur or become uncoordinated. Normal cell elongation and wall differentiation are also disrupted. This appears to be the primary function of boron. Most other deficiency symptoms are probably indirect effects of a disrupted cell wall-plasma membrane system.

Grass cell walls have a different structure from those of dicotyledonous plants and even other monocots. The major differences are the amount of pectin present and the types and abundance of sugar polymers produced. Grasses appear to depend less on boron to stabilize primary wall structure, although this role remains essential.

TABLE 2

Postulated roles for boron in plants (MARSCHNER 1995)

1. Sugar transport
2. Cell-wall synthesis
3. Lignification
4. Cell-wall structure
5. Carbohydrate metabolism
6. RNA metabolism
7. Respiration
8. Indol acetic acid metabolism
9. Phenol metabolism
10. Membrane function

Because grasses depend less on extracellular reduction of iron in order to obtain this nutrient from iron-poor soil, they also rely less on boron to regulate the reductant transfer of nutrients across the cell's plasma membrane.

Boron also functions to stabilize cell-wall structure during pollen tube growth. For this, there appears to be no difference between grasses and other plants. However, pollen tube growth is only important during flowering and egg-cell fertilization, which leads to seed development. Thus, grasses experience a substantial decline in seed yield when boron is in short supply, even if no other deficiency symptoms are noted.

Grasses will normally be much less likely to exhibit visible boron deficiency during vegetative growth than most other plants. For this reason, boron is rarely considered to be critical for turf management.

Boron toxicity in turf

A much more likely problem for the turf manager is boron toxicity. It's rarely encountered along the Atlantic seaboard or Great Lakes region where soils are typically low in boron. In the West, on the other

hand, boron toxicity can be a chronic problem, especially where turf maintenance depends on irrigation.

Based on their experiences in California and Colorado, Ali Harivandi and his colleagues at the University of California-Davis (1992) examined the effects of managing turf using boron-contaminated irrigation water. In dry climates, boron from irrigation water can accumulate to concentrations in the soil of 10 ppm or greater. However, their research indicated that, if turf is growing rapidly, it will dilute boron sufficiently that toxic levels in plant tissues will not occur.

Regular mowing will remove the injured tissues if the tips of the leaves burn, which is the most common symptom of boron toxicity. Turf quality will not be compromised as a result.

Boron will leach from fine-textured soils and sand-based greens when water percolation occurs regularly. However, if the turf culture depends on irrigation and there is insufficient winter or spring rain to leach excess boron out of the soil, it will accumulate to potentially toxic concentrations.

Oertli et al. (1961) compared the amount of boron accumulation in leaves of several turfgrasses. Warm-season grasses appear to accumulate less boron than cool-season species, but this could be a function of the greater growth rate of warm-season grasses during the summer, with a consequent dilution of absorbed boron.

Once in the soil, boron may be slow to leach, requiring twice as much water to carry it below the root zone as do soluble salts (Harivandi et al. 1992). A thorough leaching conducted periodically during the season, along with the capacity to remove injured leaf tips through mowing, should make boron toxicity manageable.

Sources of boron in fertilizer

There are a number of boron sources that can be applied as fertilizers (Table 3). The sodium salts are reasonably soluble and are a source of readily available boron. Solubor is a mixture of sodium pentaborate and sodium tetraborate, and contains 20 percent to 21 percent boron. It's the most concentrated source of boron and, being completely soluble, it's suitable for liquid applications and as a foliar feed.

Colemanite is a natural mineral that is less soluble and can be applied to sandy soils with less probability of leaching. Boron frits consist of finely ground borosilicate glass that release boron slowly and are suitable as a controlled-release material for greens and other sites of high leaching potential.

Organic topdressings and composts are also a source of boron and can supply the modest requirements of turfgrasses. However, if these organic materials are homegrown and are used in an area chronically deficient in boron, they may not contain sufficient boron to support normal plant growth. In such cases, a boron source could be incorporated in the topdressing to address any concern over this nutrient.

What appears to be boron's primary function is formation of cross links among cell-wall polysaccharides, as well as between them and membrane surface groups.

Is boron a problem for turf managers?

The answer to this question is generally "no" unless there is boron toxicity. Since grasses require about one-quarter the amount of boron needed by most other plants and its greatest need is during flowering and seed development, boron deficiency is unlikely to be a problem for the turf manager.

TABLE 3

Boron fertilizer materials and their boron content

SOURCE	FORMULA	% BORON
Borax	Na2B4O7o10H2O	11
Boric acid	H3BO3	17
Colemanite	Ca2B6O11o5H2O	10-16
Sodium pentaborate	Na2B10O16o10H2O	18
Sodium tetraborate	Na2B4O7o5H2O	14-15
Ulexite	NaCaB5O9o8H2O	9-10
Boron frits	Complex borosilicates	11-2

Even so, there may be situations where boron deficiency could cause a subtle decline in turf quality that could be easily overlooked or difficult to diagnose. Sand-based greens and turf growing on very sandy, leached soils could experience a boron insufficiency. Since boron sources are inexpensive and are easy to apply, a periodic application once every three to four years might be good insurance.

Applying boron and other micronutrients in topdressing would be relatively easy and should meet turfgrass needs.

Since excess boron can be toxic to grass, tissue levels should be monitored from time to time. If tissue boron exceeds 50 ppm, it would be best not to include boron in fertilizers or topdressing. Monitor your turf for tip burn prior to mowing. This is not a danger level for most plants, but it indicates that your turf is not lacking boron and there may be some accumulation occurring.

If tissue levels exceed 50 ppm boron, it would be best not to include it in fertilizers or topdressing.

The amount of boron in turf leaves is a function of growth rate. When growth slows, the amount of boron could increase to near toxic levels. This is normally not a problem, but it's something worth monitoring.

Richard Hull is a professor of plant sciences at the University of Rhode Island in Kingston, R.I., and specializes in plant nutrition.

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M. Wallace

GCSAA's immediate past president, **Mike Wallace**, was named superintendent at Farview Farm GC in Harwinton, Conn.

Matt Shaffer was named superintendent at Merion GC in Ardmore, Pa.

Brian Zickafoose was named superintendent of Maryland National GC in Frederick, Md.

Fox Hill CC in Longmont, Colo., named **Lori Moser** as its superintendent.

Scott Ellis was named superintendent of South Suburban GC in Littleton, Colo.

Billy Casper Golf Management named **Danny Valera** as its 2001 Employee of the Year. Valera is a Greenkeeper Level 2 (there are three levels of greenkeepers) at the Puakea GC in Lihue, Hawaii.

The GCSAA elected its new officers at its annual meeting last month. The new officers are **Mike Wallace,** president; **Jon Maddern**, vice president; **Mark Woodward**, secretary/treasurer; **Sean Hoolehan**, director; and **David Downing**, director. **Ricky Heine** was appointed to fill Woodward's remaining one-year term as a director.

Rick Oleksyk was named president of Softspikes, replacing **Jon Hyman**, who became CEO of Sport Holdings the parent company of Softspikes. Softspikes also promoted **Dennis Ineman** to vice president of global marketing.


R. Oleksyk


D. Ineman

NOTABLE ACHIEVERS

The GCSAA and *Golf Digest* magazine named its 2001 Environmental Leaders in Golf Award. The national superintendent winners include (the winner's category is in parentheses): (Public Course) **Kevin Hutchins**, Presidio GC, San Fransisco; (Private) **William Davidson Jr.**, Collier's Reserve CC, Naples, Fla.; (National Resort) **Anne Hickman**, Barton Creek CC, Austin, Texas; and (International) **James Sua**, National Service Resort & CC, Singapore.

Retired North Carolina superintendent **George B. Thompson** received the USGA's 2002 Green Section Award.

Dr. David Rickard was named product development specialist for Simplot Partners. The company also named **Tom Carrasco** as western sales manager.

Michael L. Davis joined Heftee Industries as national sales manager.

Mark Cleveland was hired by Aquatrols as territory manager for the southeastern United States.

Continued on page 94

Continued from page 93


R. Mckenzie

The United States Golf Association (USGA) elected **Reed K. Mckenzie** to a one-year term as president.

Growth Products added **Gary Ackerson** as a technical sales representative for Connecticut, Delaware, Maryland, New Jersey, New York, Pennsylvania, Vermont, Virginia and West Virginia.

The Iowa GCSA announced its 2001 award winners. **Chris Coen**, superintendent at Glen Oaks CC in West Des Moines, Iowa, was named Superintendent of the Year; **Jeff Bosworth** and **Jeff Nancarrow**, both of Glen Oaks CC, were named co-Assistant Superintendents of the Year; **Greg Harkin**, certified superintendent at Willow Creek GC in West Des Moines, Iowa, received the Distinguished Service Award; and **Rick Tegtmeier**, certified superintendent of Elmcrest CC in Cedar Rapids, Iowa, won the Charles Calhoun Writing Award.

KemperSports Management named **Bob Wallace** as president of the company's KKL Golf division. The company also appointed **Steve Skinner** as president of Kemper Golf Management.

Mark Mullowney was named national finance manager at Toro. The company also named **Brad Nagel** director of customer care and aftermarket services for Toro's consumer and landscape contractor divisions.

The Board Room magazine named **Michael Hurdzan** as its 2001 Golf Course Architect of the Year.


D. Schwieger


R. Nicotera


J. Thompson

Textron Golf, Turf & Specialty Products named four new vice presidents: **Dennis Schwieger**, executive vice president of sales and marketing – turf and PLC; **Ralph Nicotera**, vice president of marketing and product; **Joe Thompson**, vice president of sales – turf; and **Joe LaFollette**, vice president of customer care – turf and PLC.

The National Golf Foundation elected **Cindy Davis**, of the Golf Channel, as its new chairman of the board. **David Pillsbury** of American Golf Corp. is the new vice chairman.

Peter Innes was named president of Becker Underwood. **Roger Underwood,** co-founder of the company and formerly president, is now CEO.

Rain Bird named **Chris Fay** as director of the company's golf division. The company also announced several other appointments in its golf division: **Rich Forrest**, national business development; **Norma Frotten,** golf controller product manager; and **Susan Spencer**, marketing communication manager.

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CIRCLE NO. 132

HIGH ON VOLTAGE

Electric-powered utility vehicles gain in popularity

BY PETER BLAIS

Superintendents seek utility vehicles that are powerful, quiet and environmentally friendly — a combination that has led manufacturers to provide an ever-growing variety of products.

John Deere, for instance, offers many variations. There's the Pro Gator in gas and diesel with two- and four-wheel drive and a 2,000-pound payload capacity. There's the 6 x 4 diesel with a 1,000-pound capacity. And there's the quiet-running electric Turf Gator with a regenerative feature that puts an estimated 3 percent to 5 percent of the full electrical charge back into the battery during a day's work, says Deere's Chuck Greif, director of worldwide marketing. Greif notes that superintendents desire two components on utility vehicles. First, they want them quieter, which is the reason for the electric versions.

"The electric functions just like the diesel and has the same specs as it," Greif says. "We're also looking at a lower-end gas version that we can make quieter."

Club Car debuted its Turf Transporter 472 at the GCSAA show. It begins shipping later this year.

Second, they want versatility — as in capacity for large payloads and the ability to scoot around the golf course at 13 mph to 15 mph, Greif notes.

Superintendents also want vehicles that can be driven most anywhere while doing minimal damage to turf, says Ralph Nicotera, Jacobsen's vice president of marketing and product management. That's why Jacobsen introduced the Cushman Commander 4800 lightweight turf vehicle.

"It's a lighter unit with a bit more power than our other vehicles," Nicotera explains. "It has a 16-horsepower, V-twin engine vs. the 11-horsepower in our standard Commander. It has larger flotation tires for better ground clearance."

Craig Currier, superintendent in charge of the five courses at Bethpage State Park in Farmingdale, N.Y., uses the Toro Workman as a heavy-work vehicle. "We've gone to the diesel Workman because they're beefier," he says.

That "beefier" label is due, in part, to the updated Briggs & Stratton Daihatsu engines Toro installed. The Workman 3200 and 4200 feature a 31-horsepower, liquid-cooled gas engine; and the Workman 3300 and 4300 feature a 26.5-horsepower, liquid-cooled diesel engine. The Workman 3100 has a Kohler 23-horsepower air-cooled gas engine. Toro also improved the front suspension springs and added an optional high-flow hydraulics kit to the Workman.

At the GCSAA show in February, ClubCar unveiled the 13-horsepower Turf TransPorter 472, which features a 36-inch bed and 1,200-pound total vehicle payload. The four-passenger vehicle, available in the second half of this year, is billed as a "mobile work station."

ClubCar also recently released a newly designed cab with new features, including a Rollover Protective Structure Certification, which indicates the possibility of injury to a seat-belted operator and passengers has been minimized if the vehicle overturns. The cabs are available for Club Car's entire line of utility vehicles.

The WorkHorse ST 480 is the newest addition to the E-Z-GO WorkHorse line. It has an 800-pound payload capacity and a 48-inch bed. The 16-horsepower, 4-cycle twin cylinder Vanguard V-twin engine is the largest in the WorkHorse ST line and is capable of reaching a maximum speed of 17 miles per hour.

Currier said New York state will soon require that 10 percent of golf course vehicles be powered by something other than fossil fuel. That's an environmental consideration he and superintendents in other states and countries with similar mandates will have to keep in mind when making future utility vehicle purchases.

Greif says environmental issues and noise ordinances are partly responsible for the rise in electric vehicle sales. He predicts hybrid engines that run on both gas and electricity, or perhaps even hydrogen fuel cells, could power future utility vehicles. ■

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

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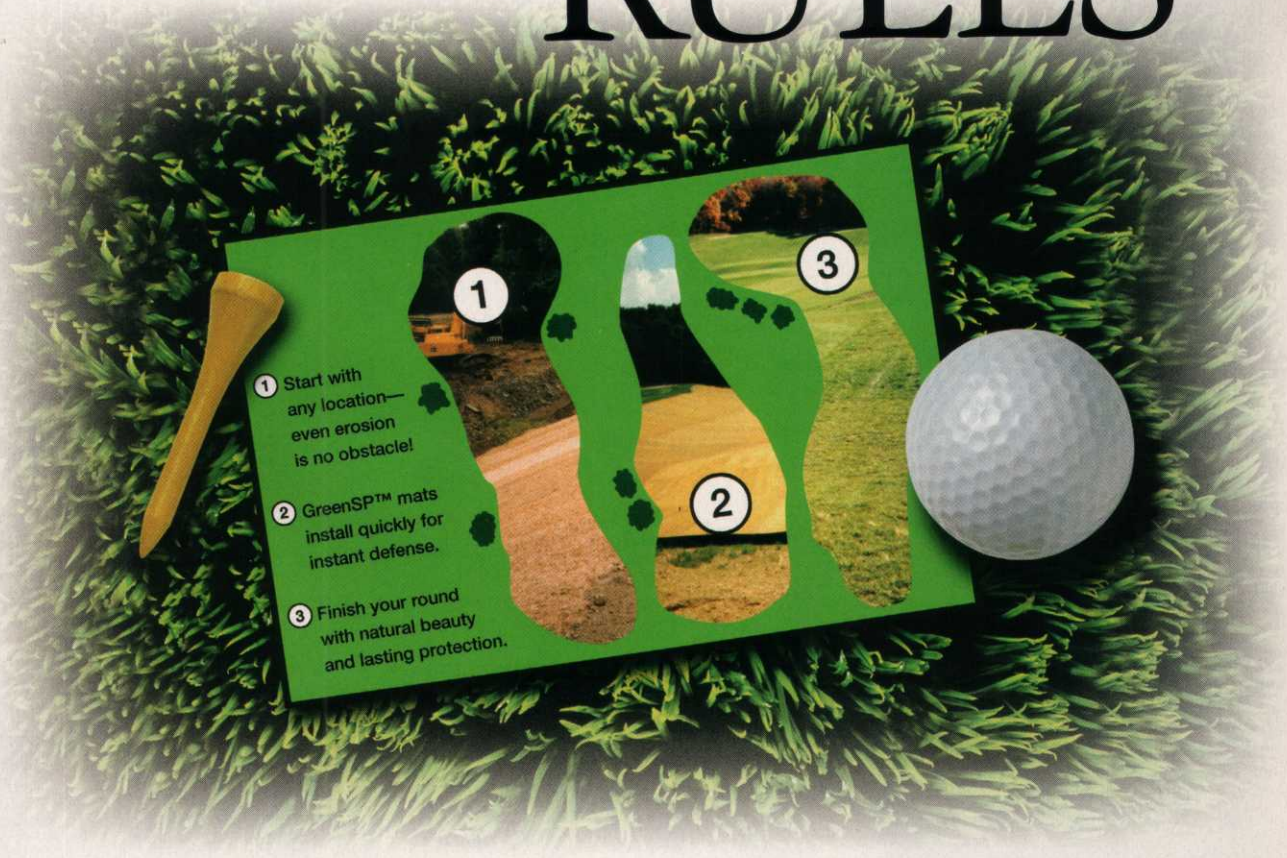

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CIRCLE NO. 133

AD INDEX

Chillin' with Wayne Otto

...*another* Golfdom fan.

What do you do all winter?
"I'd tell you...
but then I'd have to kill you."

Alma Mater: Penn State.

What do you think when you look at your golf course?
"This could be really nice."

How does your lawn look?
"Not as good as my golf course! I bought my wife a $4,000 mower, which she only used once, so now I have to mow the lawn. She says if it had a drink holder, she'd reconsider."

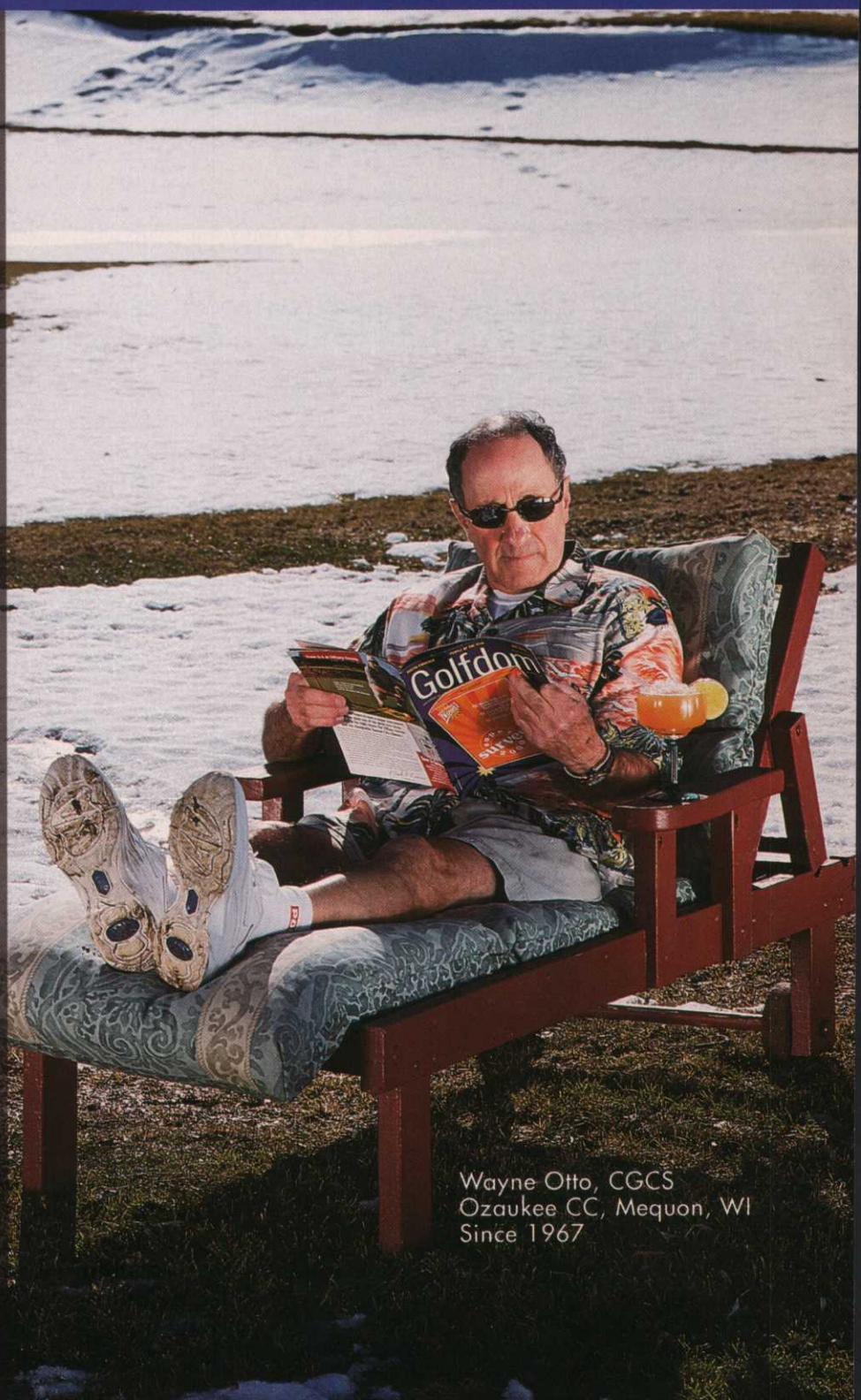
About your course:
"Built in 1921 by Langford and Moreau, it's known for undulating & quick greens. I run a staff of 25 in summer, and five in winter with an annual budget of $700,000. We are the first fully certified Audubon Cooperative Sanctuary in WI."

What course would you most like to play? Pine Valley.

Favorite smell: Charcoal Grill.

Favorite activities:
"Camping, gardening, and football (spelled 'Green Bay Packers'). I like the song they play when the Packers score - 'I don't want to work, just want to bang on the drums all day!'"

Favorite magazine:
"Golfdom. I can really relate to the articles, and I like to read it at home in the evening. I have a lot of respect for the writers. They cover the hottest topics and aren't afraid to address controversial issues."



Wayne Otto, CGCS
Ozaukee CC, Mequon, WI
Since 1967

The Company Line

PRODUCTS & SERVICES

▲ New packaging

Growth Products now offers five of its best-selling products in convenient 1-quart pouches featuring easy-to-follow directions. The products include Companion microbial inoculant, Essential Plus biostimulant and soil conditioner, 18-3-6 fertilizer, Triple Ten (10-10-10) fertilizer and Organic Iron 5%.

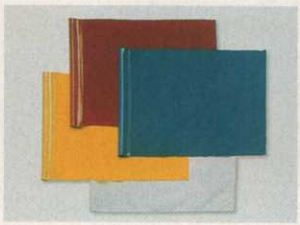
Growth Products also announced that Companion liquid biological fungicide was granted full registration from the EPA for greenhouse use in an enclosed structure.

For more information, contact 800-648-7626, www.growthproducts.com or

CIRCLE NO. 200

▼ Flags, Bunker Rake

Standard Golf Co. introduces the ClearCover Tube Flag, designed to eliminate dirt buildup from golfers' hands and repeated contact with the green. While flags can easily collect dirt, ClearCover



flags feature a clear tube cover that sheds the dirt and lets the color of the flag show through. The flags are available in four stock nylon colors: red, white, blue and yellow.

Standard Golf also offers a new 22-inch Tour Smooth Maintenance Rake, ideal for deep-faced bunkers. The rake features a 22-inch wide, high-impact composite head and a 72-inch Quad-built composite handle that won't splinter, according to the company. A tooth angle and curved head allows the rake to achieve a smooth bunker surface.

For more information, contact 319-266-2638, www.standardgolf.com or

CIRCLE NO. 201

Video

The Superintendent's Video Workshop (SVW) training series, from **Epic of Wisconsin**, can be ordered over the Internet at *www.svwonline.com*. In addition to a training video, each kit also contains a CD-ROM for printing employee handbooks and video workshop assessment worksheets that support the training program. SVW offers 24 titles, many available in English and Spanish. Two new programs introduced at the 2002 GCSAA show include "Sun Safety" and "The Fine Art of Hand Watering, with Paul Latshaw."

For more information, contact 800-938-4330, www.epicwi.com or

CIRCLE NO. 202

▼ Irrigation control

The LEIT X and XR, from **Dig Corp.**, use the most advanced technologies and innovations to provide the latest in ambient light irrigation control systems. All power is provided by an internal, ultrahigh efficiency photovoltaic module and microelectronic energy management system fueled by ambient light.

The X and the XR combine state-of-the-art electronics with an improved menu base and

straightforward programming that allows for a range of irrigation programs with features such as valve grouping and more.

For more information, contact 800-322-9146, www.digcorp.com or

CIRCLE NO. 203

Biofertilizer

Soil Technologies Corp. introduces Micro-Gro Plus liquid biofertilizer. When used as part of a comprehensive greens management program, Micro-Gro Plus reduces the need for fertilizers and fungicides, and optimizes playing conditions, the company says.

Micro-Gro Plus consists of humic materials, beneficial rhizobacteria, seaplant extracts, plant hormones, enzymes and micronutrients. Its shelf life is two years, and Soil Tech has determined that the product is tank-mix compatible with numerous fungicide and fertilizer products for ease of application.

For more information, contact 800-221-7645 (ext.105), www.soiltechcorp.com or

CIRCLE NO. 204

Sprayer

The **Toro Co.** introduces the new Multi Pro® 5600 sprayer, which features a dual diaphragm pump that can be run dry without damage to the seals or pump. The o-ring sealed system components are designed to be leak free. The optional Pro Control computerized controller works in conjunction with a fast-acting hydraulic valve to ensure instant response and precise application rate.

The Multi Pro® 5600 features a hydrostatic drivetrain that provides a high torque traction system that can climb over severely undulating turf without spinning out and scuffing the turf.

For more information, contact 800-803-8676, www.toro.com or

CIRCLE NO. 205

Blowers

John Deere offers the BH25 Handheld Blower and the BP60 Backpack Blower.

The BH25 model has a maximum air velocity of 140 mph, 400-cfm air volume and a powerful 24.5-cc Fuji-Robin engine. The soft-tone muffler reduces noise levels to 68-dBA, and a translucent, 18.9-ounce fuel tank lets you check the fuel level at a glance. The BH25 weighs just 8.4 pounds for easy one-hand operation.

The BP60 model has a maximum air velocity of 201 mph, 517-cfm tube-end air volume and a powerful, 59.2-cc Kawasaki engine. The large 67.6-ounce fuel tank allows for longer run times, and the pistol-type throttle on the tube is easy to use and provides precise, comfortable control of sweeping force during operation. The padded shoulder straps on the BP60 offer comfort and can be easily adjusted while the blower is on the operator's back.

For more information, contact 800.537.8233, www.johndeere.com or

CIRCLE NO. 206