TURFAX™

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JB COMMENTS:

CONFUSING WORD SELECTION

In discussing the seasonal timing of cultural practices, the terms "fall seeding" or "late-fall fertilization" are frequently used. However, is this really the true intent of such word selection? Fall, or more specifically autumn, is the season between summer and winter extending from approximately the September 23 equinox to the December 22 solstice, in the northern hemisphere. Thus, in discussing the appropriate timing for seeding of cool-season turfgrasses in many cool-climatic regions the appropriate word selection is late summer. Similarly, the term late- fall fertilization specifically would refer to December which is not the intent in most situations. One should keep these specifics in mind when selecting terminology related to seasonal cultural practices and turfgrass pest management.

PHYTOTOXIC IRRIGATION WATER

In the 1960s it was not uncommon to be called out to a golf course where the turfgrass on all putting greens had died essentially overnight. Detailed diagnosis revealed no specific symptoms that suggested a disease, insect or environmental stress as a likely cause. In these cases the irrigation water was obtained from a nearby river. By a process of elimination, the most likely cause of the turf injury symptoms was a toxic chemical in the irrigation water, probably introduced via irregular dumping by an industry upstream from the intake line for the irrigation system. However, since the potential chemical involved was unknown it was very difficult to make specific quantitative analyses in an effort to confirm the phytotoxic chemical. Thus, rarely was a definitive cause or potential source for a phytotoxic chemical specifically determined.

Now times have changed! Rarely do I encounter these types of overnight kill in which the turf dies across a broad area overnight. Most likely this is due to concerted efforts in improving the water quality of rivers, including close monitoring of potential industrial dumping into streams and rivers. This program has been very successful in the United States. However, this has not been the case in a number of countries around the world. Unfortunately, I still encounter overnight turfgrass injury symptoms over a broad area on golf courses in other parts of the world.

JB VISITATIONS:

August - East Lansing, Michigan.

Attended the 1997 Michigan Turfgrass Field Day at Michigan State University held at the Robert W. Hancock Turfgrass Research Center. It was a great honor for my wife, Harriet, and myself to be present at the announcement of the James B and Harriet Beard Endowed Graduate Fellowship.

On two putting greens constructed of native soil and a high-sand root zone, regular rolling treatments for three years showed the incidence of both dollar spot (*Sclerotinia homoeocarpa*) and gray snow mold (*Typhula* spp.) continue to be significantly reduced. The specific cause of this consistently observed response is yet to be proven.

Another interesting study involved the effects of lawn care practices on soil organisms, specifically as related to chemical, organic, and untreated regimes for pest management. The basic treatments involved eight different commercial/chemical and organically treated approaches, plus an untreated control plot and a comparison with nearby cropland. Results for the first set of evaluations in 1996 revealed no significant differences in either carbon or nitrogen mineralization potentials among the eight different turf treatments. Furthermore, the only significant differences found were between the turfgrass treatments and the adjacent cropland assessments, with the turfgrass treatments exhibiting 2 to 3 times the mineralization potential for both carbon and nitrogen compared to that found in the cropland. These assessments are being continued in 1997 with the goal of obtaining a better understanding of how various turfgrass cultural practices influence soil biological activity.

October-Torino, Italy.

Conducted *Agrostis* cultivar assessments at the Italian Golf Federation research plots. The application of flutolinal made in 1996 for the control of extensive fairy ring development on a putting green constructed of a high-sand root zone was sufficiently effective that no fairy rings have redeveloped throughout the 1997 growing season, even though there was no follow-up treatment with flutolinal. Efforts continue to identify the specific causal basidiomycete organism, but to date have not been successful in developing fruiting bodies. Note that over 40 different species of soil basidiomycetes can cause fairy rings and furthermore that it is unlikely for any one fungicide to control all of these species.

October - Garlinda, Italy.

This golf facility has winter resort golf play, as it is located near the Mediterranean coast in western Italy. Permanent surface golf cart paths are extensively used, with several crossing fairways in play areas. These hard surface paths have been removed from the fairways and replaced by turf grown on a self-flexing, interlocking mesh element system in a high-sand root zone. Good turf density has been sustained on these turfed paths of intense golf cart traffic.

The golf course also has quite small tees that traditionally have been severely defoliated during the summer playing season. Reconstruction of these tees using the self-flexing, interlocking mesh element system has proven quite successful in reducing divot size and enhancing the rate of divot opening recovery. The result has been more fully turfed tee surfaces throughout critical stress periods. This was achieved without increasing the tee size, as this was not possible in a number of situations on the golf course.

UPCOMING JB VISITATIONS:

Oct. 26 to 31 - Anaheim, California.
Nov. 7 to 15 - Japan.
Dec. 9 to 11 - New York, N.Y.
Jan. 6 to 9 - Toronto, Ontario, Canada.

MINIMIZING DIRECT LOW TEMPERATURE KILL

Both cool- and warm-season turfgrasses can be seriously damaged by direct low temperature kill. The mechanism of injury involves ice crystal formation either within, termed intracellular freezing, or in the immediate exterior space of plant cells when temperatures fall below 32°F (0°C). Eventually these ice crystals can cause, either directly or indirectly, a mechanical rupturing of the vital living protoplasmic portion of plant cells. A higher plant tissue water content typically results in larger and more extensive ice crystal formation. Consequently, any cultural practices or modification of site conditions that result in a reduced plant water content, termed the hydration level, will reduce the potential for direct low temperature kill, although it is not a absolute means of prevention. Note that a turfgrass plant may have damage to the leaves and the roots and still survive, as long as the meristematic regions in the crown and/or nodes of lateral stems are not injured.

Drainage should be the number one priority in minimizing the potential for direct low temperature kill. This includes appropriate surface contours that ensure rapid, timely removal of excess surface water from vital turfgrass areas. Even shallow depressions that result in only a 0.25 to 0.5 inch (6.4 to 13 mm) depth of water on the soil surface can result in a substantial increase in direct low temperature kill.

Drainage enhancement also can be accomplished by subsurface means, such as a drain line system, catch basins, dry wells, and French drains.

Certain turfgrass **cultural techniques** also can be used to reduce the plant water content and especially the meristematic/crown hydration level. They include the following:

- Avoid an excessive autumn **nitrogen** (N) fertilization level that stimulates shoot growth and consequently increases tissue hydration levels.
- Avoid inadequate **potassium** (K) levels. Generally the potassium fertilization level should be maintained at 75 to 100% of the nitrogen fertility level, assuming soil tests reveal adequate existing potassium levels.
- Raise the **cutting height**. This has the dual function of (a) providing an increased surface biomass of vegetation that gives an insulating effect in protecting the vital meristematic tissues under the canopy, and (b) provides increased leaf area for the synthesis of carbohydrates that contribute to the vital cold hardening process for the last 2 to 3 weeks prior to cessation of plant growth. Extraordinarily close mowing heights on hybrid bermudagrass (*Cynodon* spp.) putting greens has been a major contributor to the recent direct low temperature kill problems.
- Avoid **thatch** accumulations that elevate the vital meristematic areas of crowns and nodes higher above the protective soil zone.
- Finally, excluding traffic from turfs can be beneficial, especially during periods of active freezing and/or thawing.

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WATER QUALITY CHEMISTRY: NEEDS AND INTERPRETATION

Too many individuals assume that water quality issues associated with soluble salts are a problem of arid climatic regions. However, this is far from the truth. For example, salt water intrusion in coastal areas resulting from excessive pumping of fresh water is an increasing problem in high rainfall areas, such as Florida and Gulf coast areas and in the Islands of Hawaii. Even in certain humid continental areas the ground water may contain significant levels of soluble salts, which may be associated with underground rock salt deposits. Thus, it is essential that water quality analysis be obtained whenever a new water source is being considered. In addition, periodic monitoring for potential changes in water quality also should be practiced.

Essentially all irrigation water contains some dissolved mineral salts and chemicals. Some of the soluble salts are nutrients and thus beneficial to turfgrass growth, but others may be phytotoxic. The rate at which salts accumulate to undesirable levels in the soil depends on the concentration of soluble salts in the irrigation water, the amount of irrigation water applied annually, and the physical/chemical characteristics of the soil in question. The major salt problems of concern in water quality are the (a) total concentration of soluble salts, (b) sodium (Na), (c) relative proportion of sodium (Na), carbonate (CO_3), and bicarbonate (HCO_3) to calcium (Ca) and magnesium (Mg), and (d) the amount of chloride (Cl) and boron (B).

Salinity. Most water of acceptable quality for turfgrass irrigation contains from 200 to 800 parts per million (ppm) soluble salts. Soluble salt levels above 2,000 ppm are very undesirable and may be directly injurious to turfgrass. If the soil has exceptional permeability and good subsoil drainage characteristics, and depending on the turfgrass species grown (Table 1), irrigation water with salt levels up to 2,000 ppm may be tolerated. Exceptional permeability and good subsoil drainage permit the turf manager to leach excessive soluble salt concentrations from the root zone by periodic, intense irrigations. The USGA Method of high-sand root zone construction fits these criteria very well.

Table 1. The relative tolerances of 18 turfgrass species to soil salinity.

Sensitive (<3 Ds/M)	Moderately Sensitive (3 to 6 dS/m)	Moderately Tolerant (6 to 10 dS/m)	Tolerant (> 10 dS/m)
annual bluegrass colonial bentgrass Kentucky bluegrass rough bluegrass centipedegrass	annual ryegrass creeping bentgrass fine-leaf fescues bahiagrass	perennial ryegrass tall fescue buffalograss, American zoysiagrasses	alkaligrass bermudagrasses

Adapted from M.A. Harivandi, J.D. Butler and L. Wu 1992. Salinity and turfgrass culture. (In *Turfgrass* D.V. Waddington, R.N. Carrow, and R.C. Shearman (eds.) pp. 207-229. Series No. 32, American Society of Agronomy, Madison, Wisconsin, USA.

The total concentration of soluble salts in the soil and the water also is measured as **electrical conductivity** (EC), which is expressed in units as decisiemens per meter (dSm^{-1}) with dSm^{-1} = milli mhos per centimeter (mmhos cm^{-1}). The general equation used to convert electrical conductivity to parts per million is $1 dSm^{-1} = 640$ ppm total salts. This type of soil and water quality information may be obtained by submitting representative samples for analyzes to either a reputable laboratory.

A water EC of 0.70 dSm^{-1} (mmhos cm^{-1}) is the approximate upper limit for growing turfgrasses without potential problems that necessitate costly, specialized adjustments in the cultural program. In contrast, soils having an EC_s analysis below 3 dS m^{-1} are considered satisfactory for growing most turfgrasses. Soils with an EC_s of 3 to 10 dS m^{-1} will restrict the growth of many turfgrass species and cultivars, while readings over 10 dS m^{-1} support only a few salt-tolerant turfgrass species (Table 2).

Table 2. Guidelines for the interpretations of water quality for irrigation.

Potential Irrigation Problem	Units	Degree of Restriction on Use		
		none	slight to moderate	severe
Salinity Ec_w	dS m^{-1}	<0.7	0.7 to 3.0	>3.0
TDS	mg L^{-1}	<450	450 to 2,000	>2,000
Soil Water Infiltration (Evaluate using EC_w (dSm^{-1}) and SAR together):				
if SAR = 0 to 3 and EC_w =		>0.7	0.7 to 0.2	<0.2
if SAR = 3 to 6 and EC_w =		1.2	1.2 to 0.3	<0.3
if SAR = 6 to 12 and EC_w =		1.9	1.9 to 0.5	<0.5
if SAR = 12 to 20 and EC_w =		2.9	2.9 to 1.3	<1.3
if SAR = 20 to 40 and Ec_w =		5.0	5.0 to 2.9	<2.9
Specific Ion Toxicity:				
• Sodium (Na):				
• root absorption	SAR	<3	3 to 9	>9
• foliar absorption	meq L^{-1}	<3	>3	
	mg L^{-1}	<70	>70	
• Chloride (Cl):				
• root absorption	meq L^{-1}	<2	2 to 10	>10
	mg L^{-1}	<70	70 to 355	>355
• foliar absorption	meq L^{-1}	<3	>3	
	mg L^{-1}	<100	>100	
• Boron (B)	mg L^{-1}	<1.0	1.0 to 2.0	>2.0
Miscellaneous Effects:				
• Bicarbonate (HCO_3)	meq L^{-1}	<1.5	1.5 to 8.5	>8.5
(unsightly foliar deposits)	mg L^{-1}	<90	90 to 500	>500
• pH		normal range	6.5 to 8.4	
• Residual chlorine	mg L^{-1}	<1.0	1 to 5	>5

Adapted from D.W. Westcot and R.S. Ayers. 1984. Irrigation water quality criteria. (In G.S. Pettygrove and T. Asand (eds). *Irrigation with reclaimed municipal wastewater - A guidance manual*. Report No 84-1 wr. Calif. State Water Resources Control Board, Sacramento, California, USA). and from D.S. Farnham, et al. 1985. *Water quality: Its effects on ornamental plants*. Univ. of Calif. Coop. Ext. Leaflet 2995. Div. of Agric. Nat. Resources, Oakland, California, USA. by A. Harivandi of the University of California, Hayward, California.

Sodium. The presence of sodium (Na) in irrigation water is of great concern in turfgrass culture (Table 2). The rate at which a soil adsorbs sodium from water is known as the **sodium adsorption ratio** (SAR). This ratio is used for classifying the sodium hazard of water sources. Depending on its soluble salt content, water with an SAR above 6 may produce a sodium buildup in certain soils, unless sulfur (S) or gypsum ($Ca\ SO_4 \bullet 2H_2O$) is applied periodically followed by leaching. The effect of sodium in deflocculation of clay soils is particularly critical on intensively trafficked turfgrass areas because of the decrease in aeration, water infiltration, and soil water percolation.

Bicarbonate. Reduced soil permeability also can occur when a water with high bicarbonate (HCO_3) content is used for irrigation. High levels of bicarbonate facilitate calcium precipitation in the soil, i.e. forming calcium carbonate, which in the presence of sodium may cause a significant reduction in soil permeability. In addition to calcium, magnesium and sodium therefore, water also should be analyzed for its bicarbonate content. A good indicator of a potential negative impact from bicarbonate in irrigation water is the **residual sodium carbonate** (RSC). RSC is calculated in meq/L by the formula : $RSC = (CO_3^{--} + HCO^-_3) - (Ca^{++} + Mg^{++})$.

When the RSC is less than 1.25, the bicarbonate will have minimal impact on soil permeability. At RSC levels above 2.5 there is considerable danger of soil impermeability occurring. At RSC values between 1.25 and 2.5, other factors, such as both the water and the soil sodium and salt contents will determine the magnitude of the problem.

Chlorides. Chloride (Cl) in irrigation water contributes to its total soluble salt concentration. Excessive concentrations of chlorides may cause turfgrass tip burn and even total kill of the shoots. Concentrations of 355 ppm and higher are considered undesirable for irrigation of some salt-sensitive grasses (Table 2). Turfgrasses tend to be more tolerant to chlorides than is the case for many landscape plants. Fortunately, chloride salts are quite soluble and thus may be leached from well-drained soils if there is a functioning subsurface drainage system.

Boron. Boron (B) is an essential micronutrient for plant growth, but is required in very minimal amounts. It is water soluble and is found in many water sources used for irrigation. Turfgrasses generally are tolerant of boron, but it may become toxic to non-turfgrass plants if the concentration in the irrigation water exceeds 1 to 2 ppm. An additional problem is soil accumulation, since boron may form chemical complexes that are not readily leached from the soil. Most turfgrasses will grow in soils with boron levels as high as 10 ppm.

Interpreting Water Quality Hazards. The best approach is to arrange for a qualified, independent soil and water quality chemist to analyze and properly interpret the water and soil analysis reports.

Water quality problems should be analyzed and solved on an individual basis after an assessment of all related factors. The concentrations of individual constituents must be known before water quality can be properly evaluated. In the case of sodium as well as of several other salts, the indirect effects on the soil and the direct effects on turfgrass growth must be considered. There also is a question of the combined effects from several salts. For example, high concentrations of both sodium and bicarbonates are especially undesirable. Similarly, it is difficult to set precise limits on the maximum acceptable sodium level because its reaction is influenced by the quantity of calcium and magnesium in the soil, and the salt content of the irrigation water.

In most cases marginal irrigation water can be used for golf course irrigation if practices such as (a) acid or gypsum injection or (b) gypsum, sulfur or other chemical amendments are added to the soil.