TECH CENTER

Too much salt for your grass?

by John Schmitz

■ More and more golf courses and other public recreation sites today are facing a serious health problem: too much salt in their diets, most of it coming from treated wastewater used for irrigation.

One prescription for the dilemma is to use salt-tolerant grasses. Another is over-irrigation, which some say flushes the offending salts away from the turf and root-zones.

A number of grass seed companies are researching salt-tolerant grasses. One of the first to address the dilemma is International Seeds, Tangent, Ore. What prompted the research, says senior seed research scientist Steve Johnson, were complaints from golf course superintendents.

Non-tolerant grass shrivels up and dies when exposed to salty water, says Johnson. Groundsmen and landscape managers can't mistake it for disease because the discoloration doesn't occur in patches, he notes.

In the summer of 1993, ISI began a program to identify grasses that can withstand the devastating effects of inorganic salt-laden effluent from such sources as municipal sewage treatment plants and local factories. To date, ISI has analyzed some 20 cultivars for their capacity to grow in salty environments. So far, the variety showing the most promise is a slender creeping red fescue marketed as Marker by ISI.

Ancestors to the variety actually came from grass growing on and around Dutch dikes, which thrive in salty, ocean air. The variety is also used extensively for roadsides in the Midwest, where a lot of salt is used during the winter.

Dr. Eric Nelson, director of turfgrass research and product development at Medalist America in Albany, Ore., says that the use of effluent on golf courses and other public reaction spots is definitely a trend.

International Seed's Steve Johnson with some of the grasses ISI's looking at for their salt tolerance properties. These particular grass varieties are being considered for grass tolerance analysis, even though they're growing under normal conditions rather than being subjected to salty water.

"You'll see more recycling of water as treatment processes become better."

Nelson says that one benefit of using treated wastewater on turfgrass is that the plants are able to use the nitrogen and phosphorus, whereas the dumping of that same treated water in streams or oceans is harmful to fish and humans, as well as being against the law.

Different species of grass react differently to high salt concentrations, says Nelson. Some simply exclude salt from being taken up by plant roots while others can either exude it after being taken in or store it away from plant cells. Those plants having low tolerances for salt will become stressed and unable to take up water efficiently and eventually die.

Medalist America's Fults, an alkaligrass developed by Colorado State University, is being used successfully in mixtures for roadsides which are subjected to salt during and following snow storms. The variety was also used to seed a golf course in Chicago with a heavy amount of imported sewage sludge in its topsoil.

Nelson says that Fults will actually "fade" and become "non-competitive" without a certain amount of salt pressure. The variety grows best in slightly basic soil with a pH of around 8.0, he says.

Dr. Leah Brilman, research director for Seed Research of Oregon in Corvallis, says that extensive studies done at the University of Arizona show that "the turfgrass commu-

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nity" can actually clean effluent water, "so by the time it goes through the turfgrass and works its way down to the aquifer it's pretty much cleaned up of all the things that people don't like. Turf is a great cleaning mechanism for water."

Although effluent can provide beneficial nutrients to grass plants, you must keep regular tabs on the amount of nitrogen being supplied, says Brilman. "You have to be careful you don't over-fertilize because you're essentially fertilizing with nitrogen and phosphorus every time you water."

Brilman says that salty effluent can become even more of a problem and adds more stress to plants as the water evaporates off and leaves behind a salt crust. The cure for this, especially in well-drained soils, is a healthy irrigation program that tends to keep the rootzone flushed.

In many grass species, the relationship between salt tolerance and drought tolerance is similar, says Brilman. "What you have is the water wanting to leave the plant instead of come into it. So, very often if you can identify a plant or group of plants with good drought tolerance, such as the alkaligrasses and some of the fine and tall fescues, often they will have pretty good salt tolerances.

"We have some things that show good salt tolerance but I won't say that's what we were breeding for," says Brilman. "When we were looking for drought tolerance, we got salt tolerance with it."

Seed Research of Oregon is trying to identify good salt tolerators. It's screening germplasm from species that grow in salty environments, such as near seashores. Also being looked at are "new" species of grasses, which Brilman explained as being other species of grasses that potentially could have good salt tolerance but haven't been looked at for their turf potential. "Any new varieties that look promising may be crossed with existing varieties having other characteristics we want," she says.

For the past five years, Cactus Seed Co. in Arizona has been working with a promising salt-tolerant grass for use on the fringes of turfgrass areas. "It's very, very salt tolerant," says vice president and general manager Ernie Milner of a grass he calls "Salt Grass." Samples of the grass were brought to Milner by two Tucson seed breeders who specialize in developing salt-tolerant grain and vegetable seed for use in places like Saudi Arabia. Milner has been able to identify the male and female grass plants and cross them to produce seed.

Salt Grass, which can be irrigated with ocean water, could be released next year, says Milner. It's presently being "bumped" in a small production field about 45 miles east of Yuma.

Milner says the grass, which is a bunch type that grows upright and spreads by sending out rhizomes two or three feet underground, is able to use the beneficial components of salty water while depositing the salt itself on the leaves. "It would make a good reclamation grass or contrast grass and requires very little maintenance. It only grows 18 inches high."

Plant breeder Crystal Rose Fricker of Turf Seed, Inc. in Hubbard, Ore. says that even effluent with low salt concentrations can become a problem over time. "It may seem okay in the beginning," she says, "but as you water, the salinity builds up in the soil over time, so it gets hotter and hotter and hotter, starts burning the grass."

This burning action actually attacks the grass in two places: above ground where the freshly mowed tips of the plant are exposed to the salt, and below ground where the roots can't take in needed water because of the presence of salt.

Managing effluent use should be guided pretty much by both the level of salt in irrigation water and the type of soil, particularly drainage characteristics, says Fricker.

Seabreeze, a slender creeping fescue, and Dawson are the most salt tolerant of all cool-season grasses tested by Turf Seed, says Fricker. This September, Tee-2-Green will be releasing Seaside II, a Penn State-developed creeping bentgrass ideal for fairways, she adds.

Irrigation systems fight sodium build-up

■ Landscape managers make informed purchasing decisions when they understand irrigation options and how they relate to a system's primary role. One of the effects of proper watering is a reduction in sodium build-up in the soil.

Soil composition—"The primary purpose of an irrigation system is to maintain the viability of your plant material," says Bud Knowles, president of Wolf Creek, a Rain Bird distributor in Dayton, Ohio.

For a healthy turf—and satisfied customers—sufficient water must reach the roots of the grass. That is, it must infiltrate the soil well. The irrigation system regulates infiltration by controlling salinity and bicarbonate levels as well as the Sodium Absorption Ratio, or SAR.

"An important factor is being in tune with what the plant and soil requirements are," says Bruce Funnell, specification manager at Wolf Creek.

• **Salinity.** Salts slow infiltration and keep water from plant roots. If water is applied too conservatively, it will aggravate the problem. When this happens, even less water penetrates the salt barrier. With less water flushing out excess salts, salinity will increase. Plants won't get enough water, and turf will die.

"All salts cause an imbalance in the water in the membrane of the plant cells," says Gil Landry, extension turfgrass specialist at the University of Georgia. "Then the plant can't take up sufficient water."

The most common solution is leaching. That is, applying sufficient water each irrigation—being careful not to over water—so that enough nutrients reach all plant roots.

• **Sodium Absorption Ratio.** Sodium causes a problem when more than 160 mg/l is in the water, or if the SAR of the water is greater than six. The common result is plant stress.

"Many people use a non-ionic material like gypsum, which is calcium sulfate," Landry says. "The calcium displaces the sodium on the exchange complex, and the sodium can then be leached out as sodium sulfate."

• **Bicarbonates.** "Bicarbonates can cause calcium and magnesium to precipitate," Landry explains. "That brings about an increase in sodium."

High bicarbonates initially cause pooling. If this occurs, and soil extracts have high electrical conductivity, further testing should determine if bicarbonates are the problem.

The ultimate effect on the turf is the death of the plant. One solution, Landry says, is to apply enough fresh water to leach the nutrients below the root zone.

—James Holter

'Quality' water for your plants

by W. Lee Berndt, Ph.D.

■ Water quality is vital to turf and landscape plants. Four aspects of water govern its quality:

1) the level of dissolved salts;

2) the level of sodium ion relative to other cations;

3) the level of bicarbonate ion relative to cations; and

4) the level of potentially toxic ions like boron.

Lab testing is needed to judge the quality of a water. A better grasp of the lab terms will give more meaning to the test results.

Salinity and Soluble Salts. Some waters have high levels of dissolved salts. Irrigating with these waters adds salts to the soil. As the salts accumulate, they cause plant stress. For example, salt build-up in soil causes the water in plant cells to flow back into the soil. This is called crenation. It causes the plants to wilt when soil water is adequate. As a result, the plant's energy is diverted away from the normal growth process.

Irrigating with water that is high in sodium may destroy the soil's structure.

Table 1. Classification of irrigation water based on the level of soluble salts (EC), and the ratio of sodium to calcium plus magnesium (SAR). EC is measured in units called micromhos per centimeter (µmhos cm^{-1})*.

Class of Water	Designation	EC (µmhos cm-1)	SAR
C1	Low Salinity	< 250	---
C2	Medium Salinity	251-750	---
C3	High Salinity	751-2,250	---
C4	Very High Salinity	> 2,251	---
S1	Low Sodium	---	< 10
S2	Medium Sodium	---	10.1 - 18
S3	High Sodium	---	18.1 - 26
S4	Very High Sodium	---	> 26

* Many labs give the value of EC in millimhos per centimeter (mmhos cm^{-1}), in desci-siemans per meter (dS m^{-1}), or in siemans per meter (S m^{-1}). 750 µmhos cm^{-1} = 0.750 mmhos cm^{-1} = 0.750 dS m^{-1} = 0.075 S m^{-1}.

The EC (electrical conductivity) of a water is measured to find the level of dissolved salt. The EC of a water varies directly with the salt content. EC is measured in units termed micromhos per centimeter (µmhos cm^{-1}). Water with an EC of less than 750 µmhos cm^{-1} is the most suitable for irrigating turf and landscape plants (see Table 1).

Leaching to Control Salts. Leaching a soil with water will help to prevent the build up of salts. Without leaching, the salts gather in direct proportion to the EC of the water. The LR (leaching requirement) is given by the formula: $LR = EC_{iw} \div EC_{dw}$ where EC_{iw} is the EC of the irrigation water and EC_{dw} is the EC of the drainage water percolating from the bottom of the rootzone. In effect, EC_{dw} is the maximum level of salt the plant of interest can tolerate (see Tables 2 and 3).

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Table 2. Approximate salt tolerance of select grasses and landscape plants.

2,000 µmhos cm^{-1}	3,000 µmhos cm^{-1}	4,000 µmhos cm^{-1}	6,000 µmhos cm^{-1}	8,000 µmhos cm^{-1}	> 8,000 µmhos cm^{-1}
Star Jasmine	Pineapple Guava	Kentucky Bluegrass	Glossy Privet	Tall Fescue	Creeping Bentgrass
Oregon Grape	Chinese Holly	Colonial Bentgrass	Yellow Sage	Perennial Ryegrass	Bermudagrass
Photinia	Rose, cv. Grenoble	Red Fescue	Orchid Tree	Chewings Fescue	Zoysiagrass
Pyrenees Cotoneaster	Glossy Abelia	Annual Bluegrass	Southern Magnolia	Blue Gramma	St. Augustinegrass
	Southern Yew	Centipedegrass	Japanese Boxwood	Orchardgrass	Western Wheatgrass
	TulipTree	Meadow Fescue	Indian Hawthorne	Smoothe Brome	Tall Wheatgrass
		Heavenly Bamboo	Spreading Juniper	Weeping Bottlebrush	Alkaligrass**
		Laurustinus	Thorny Elaeagnus	Oleander	Seashore Paspalum**
		Algerian Ivy	Pyracantha	European Fan Palm	Natal Plum
		Chinese Hibiscus	Cherry Plum	Blue Dracaena	Evergreen Pear
		Strawberry Tree	Japanese Black Pine	Spindle Tree	Bougainvillea
		Crape Myrtle	Oriental Arborvitae	Rosemary	Stone Pine
			Xylosma	Aleppo Pine	Ceniza
				Sweet Gum	Brush Cherry
					White Iceplant*

* > 10,000 µmhos cm^{-1}

** > 16,000 µmhos cm^{-1}

Table 3. Leaching requirement (LR) as related to the electrical conductivity (EC) of irrigation water and plant salt tolerance.

EC of Irrigation Water (µmhos cm-1)	Maximum Plant Salt Tolerance 4,000 µmhos cm-1	8,000 µmhos cm-1	12,000 µmhos cm-1
	Extra Leaching Fraction Required (%)		
100	2.5	1.2	0.8
250	6.2	3.1	2.1
750	18.8	9.4	6.2
2,250	56.2	28.1	18.8
5,000	---	62.5	41.7

Example: Assume the plant has a maximum salt tolerance of 4,000 µmhos cm^{-1}, and assume that the EC of the water utilized for irrigation is measured at 2,250 µmhos cm^{-1}. An extra 56.2% more water would need to be applied with each irrigation to continiously leach salts from the rootzone. $LR = EC_{iw} \div EC_{dw}$ where EC_{iw} = EC of the irrigation water to be applied, and EC_{dw} is basically the salt tolerance of the plant of interest.

Table 4. Background information on ions with regard to the quality of irrigation water for turfgrasses.

Ion	Name	mg meq^{-1}	meq mg^{-1}	Acceptable Level for Irrigation Water
Na^+	sodium	22.98	0.0435	SAR of 9-10 or less; SAR_{adj} of 3-6 or less; less than 70 ppm or 3 meq L^{-1}
K^+	potassium	39.10	0.0256	
Mg^{2+}	magnesium	12.16	0.0823	
Ca^{2+}	calcium	20.04	0.0499	
Ni^{2+}	nickel	29.35	0.0340	less than 0.5 ppm or 0.02 meq L^{-1}
Cu^{2+}	copper	31.77	0.0318	less than 2 ppm or 0.06 meq L^{-1}
Zn^{2+}	zinc	32.69	0.0306	less than 5 ppm or 0.15 meq L^{-1}
Cd^{2+}	cadmium	56.20	0.0178	less than 0.005 ppm or 9.0 x 10^{-5} meq L^{-1}
B^{3+}	boron	3.60	0.2778	less than 1-2 ppm or 0.2-0.6 meq L^{-1}
Cl^-	chloride	35.45	0.0282	less than 250 ppm or 7 meq L^{-1}
HCO_3^-	bicarbonate	61.02	0.0164	RSC of less than 1.25; less than 120-180 ppm or 2-3 meq L^{-1}
NO_3^-	nitrate	62.00	0.0161	
CO_3^{2-}	carbonate	30.01	0.0333	
SO_4^{2-}	sulfate	48.03	0.0208	less than 250 ppm or 5.2 meq L^{-1}
PO_4^{3-}	phosphate	31.66	0.0316	

ppm = parts per million = milligrams substance per liter of water (mg L^{-1})
meq = number of milliequivalents of a substance
meq L^{-1} = number of milliequivalents of substance per liter of water
meq mg^{-1} = number of milliequivalents of substance per milligram of substance
mg meq^{-1} = number of milligrams substance per milliequivalent of substance
(ppm)(meq mg^{-1}) = meq L^{-1}
(example: 70 ppm sodium x 0.0435 meq mg^{-1} = 3 meq L^{-1})

WATER *from page 21*

Sodium Ion and the Sodium Hazard. Irrigating with water high in sodium (Na^+) may destroy the soil's structure. As the Na^+ is added to the soil, it adsorbs to the exchange sites.

If Na^+ becomes the dominant cation on the exchange sites, the soil particles tend to repel each other. This is termed dispersion. When a dispersed soil is dried it forms a hard crust. Dispersion hinders the drainage that is vital to plant growth.

Ions in a water can affect plants–even be toxic to them.

The levels of Na^+ and other ions in a water are measured in a variety of ways. The levels are given in units called meq L^{-1} (milliequivalents per liter) or in units called ppm (parts per million) (see Table 4). Once the levels of Na^+, calcium (Ca^{2+}), and magnesium (Mg^{2+}) are known an SAR (sodium adsorption ratio) can be calculated for a water:

$$SAR = \frac{Ma^{2+}}{\sqrt{(Ca^{2+} + Mg^{2+}) \div 2}}$$

The SAR is a term that expresses the relative Na^+ hazard of a water. It is a ratio of the level of Na^+ to the levels of the other major cations. Water that has an SAR value of less than 9-10 is the most suitable for irrigating turf and landscape plants (see Table 1). SAR values greater than 9-10 imply that Na^+ levels are excessive.

Bicarbonate Hazard. Irrigating with a water that has a high level of bicarbonate (HCO_{3-}) may also destroy the structure of the soil. When HCO_{3-} is present in a water it can react with the Ca^{2+} and Mg^{2+} to form carbonate salts. This reaction increases the proportion of Na^+.

The bicarbonate hazard of a water is given by the term RSC (residual sodium carbonate). Once the levels of HCO_{3-} and CO_3^{2-} are known the RSC can be calculated: $RSC=(HCO_{3-}+CO_3^{2+})—(Ca^{2+} + Mg^{2+})$

A water with an RSC of less than 1.25 is safe. A water with an RSC of greater than 2.5 has a high HCO_{3-} hazard. An adjusted value of SAR will also reflect the HCO_{3-} hazard of a water: SAR adj+SAR [1+(8.4—pHc)] where pHc is a calculated value (see Table 5). Water with an SAR_{adj} of less than 6 is safe while water with a value greater than 9 may pose severe problems regarding HCO_3^-.

Toxic Elements. Certain ions that are present in a water can be directly toxic to plants. Ions in a water that may be toxic to plants include Na^+, Cl^- (chloride), and B^{3+} (boron). Boron is needed for normal growth in very small quantities. Injury can occur to plants if that level is exceeded. Boron can injure lemon trees and American elms when levels in soil water are 0.5 ppm (see Table 6).

Summary. Ions that are in a water will affect the health and vigor of landscape plants. High levels of dissolved salts cause plant stress while high levels of Na^+ and HCO_3^- affect soil structure. Other ions like B^{3+} can be directly toxic to plants. Routinely test a water that is used to care for plants. The results of water testing can make a difference in your plant care practices.

Table 5. Data necessary to calculate pHc and SAR_{adj}.

Total meq L^{-1}	$pK_2 - pK_c$	pCa^{2+}	$pHCO_3^-$
0.1	---	4.30	4.00
0.5	2.11	3.60	3.30
1	2.13	3.30	3.00
2	2.16	3.00	2.70
4	2.20	2.70	2.40
6	2.23	2.52	2.22
8	2.25	2.40	2.10
10	2.27	2.30	2.00
15	2.32	2.12	1.82
20	2.35	2.00	1.70
25	2.38	1.90	1.60
30	2.40	1.82	1.52
35	2.42	1.76	1.46
40	2.44	1.70	1.40
50	2.47	1.60	1.30

Sample calculation: assume water contains 2.0 meq Ca^{2+} per liter, 1.0 meq Mg^{2+} per liter, 3.0 meq Na^+ per liter, and 5.0 meq HCO_3^- per liter. The total cation concentration is 6 meq per liter. Therefore, $pK_2 - pK_c = 2.23$. The value of pCa^{2+} at 2 meq per liter equals 3.00 and the value of $pHCO_3^-$ at 5.0 meq per liter equals 2.31. The pHc is the sum of these values, or 7.54. The SAR = 2.45. The $SAR_{adj} = 2.45[1+(8.4 - pHc)] = 4.56$.

Table 6. Approximate boron tolerance limits of select grasses and landscape plants.

Sensitive < 0.5 ppm	Sensitive 0.5-1.0 ppm	Semi-sensitive 1.0-2.0 ppm	Semi-tolerant 2.0-4.0 ppm
Oregon Grape	Persimmon	Gladiolus	Bottlebrush
Photinia	Grapefruit	Olive	Date Palm
Xylosma	Avacado	Sweetpea	Carnation
Thorny Elaeagnus	Cherry	Blue Dracaena	California Poppy
Laurustinus	English Walnut	Sunflower	Japanese Boxwood
Wax-leaf Privit	Apple	Marigold	Oleander
Pineapple Guava	Zinnia	Poinsettia	Chinese Hibiscus
Spindle Tree	Pansy	China Aster	Sweetpea
Chinese Holly	Violet	Gardenia	Kentucky Bluegrass
Juniper	Larkspur	Southern Yew	
American Elm	Glossy Abelia	Brush Cherry	**Tolerant**
Yellow Sage	Geranium	Ceniza	**4.0-8.0 ppm**
Lemon	Rosemary	Blue Dracaena	Indian Hawthorne
Blackberry	Orange		Natal Plum
			Oxalis
			Purple Vetch

SOIL: the source of turf life

The savvy landscape manager knows soil is a medium to support ornamental plant life, a vital component of the ecosystem.

by John Fech, Ph.D.,
University of Nebraska

■ To some, it's nothing more than "dirt" that sticks to their shoes when wet. Others think of soil as something to be swept away and discarded or covered. An engineer may view soil as something to be moved during a construction project.

Good, healthy soil is a dynamic living system with many biological, chemical and physical properties. In landscape soils, one of the most important properties that affects plant growth and vigor is aeration.

Aeration is a measure of the rate at which oxygen is able to move through the soil to the plant roots.

Oxygen movement depends on the soil water content. A well aerated soil is composed of about 50 percent solids, 25 percent water and 25 percent air spaces or voids (Fig. 1). Soils which have less than 25 percent air spaces are considered compacted and limit root growth to some degree.

Compaction can be caused by foot and vehicle traffic, soil texture and maintenance procedures conducted on the site such as irrigation, fertilization and mowing. Heavily trafficked areas are subject to compaction, and the turfgrass growing in compacted sites usually becomes thin and non-vigorous (Fig. 2).

Soils most likely to be compacted are those with a heavy clay content. The percentage of clay, sand and silt in a given soil combine to form the soil's texture. A soil testing laboratory can make the most accurate assessment of a soil's texture. Once the percentage of each component is calculated, soil texture is determined by using a textural triangle (Fig. 3). The

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three sides of the triangle represent increasing or decreasing percentages of sand, silt and clay. By drawing lines through the known percentages, a soil texture classification can be made. A loam is an ideal combination of the three.

Water retention—Each component (sand, silt and clay) varies in its capacity to retain nutrients and water. Clay has the greatest retention capacity.

Sands tend to drain quite readily, and silty soils range from intermediate to slow draining.

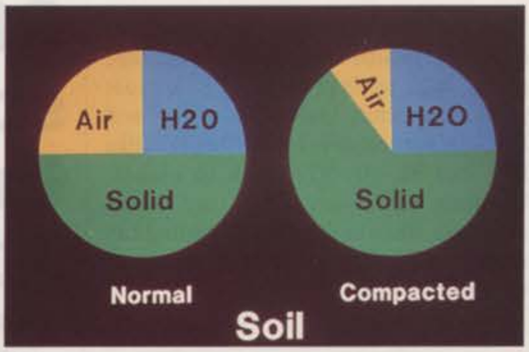

Fig. 1—A well aerated soil is composed of about 50 percent solids, 25 percent water and 25 percent air spaces or voids.

Fig. 2—For a very small fee, soil labs will test your soil and tell you its components so you can make fertility determinations.

Soil drainage and water/nutrient retention is a function of particle size and surface area. Clays and loams have much greater surface area than sands. In fact, the surface area increases 1000 times per unit weight as the particles decrease in size from very coarse sand to clay.

The effect of decreasing particle size can be related to a deck of playing cards, which has a small amount of surface area exposed. However, when the deck is subdivided into each card, surface area increases greatly. Chemical and physical reactions in the soil relating to nutrient and water holding capacity and availability occur at the particle surface. Therefore, the greater the surface area, the greater the nutrient and water-holding capacity.

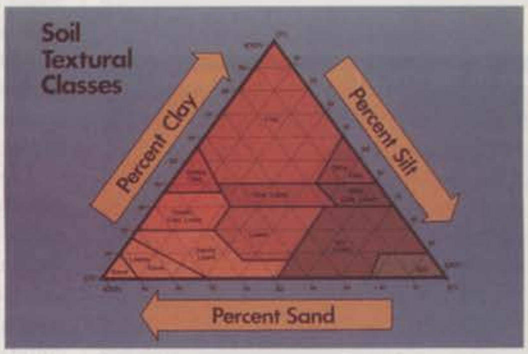

Fig. 3—Once the percentage of each component is calculated, soil texture is determined by using a textural triangle.

An ideal soil profile is depicted in Fig. 4. In general, the "A" horizon is rich in organic matter and water/nutrient holding capacity. At least 12 inches of "A" horizon is desirable to support turf and tree growth. In many recently disturbed soils (as in new housing developments, shopping malls), little or no "A" horizon exists.

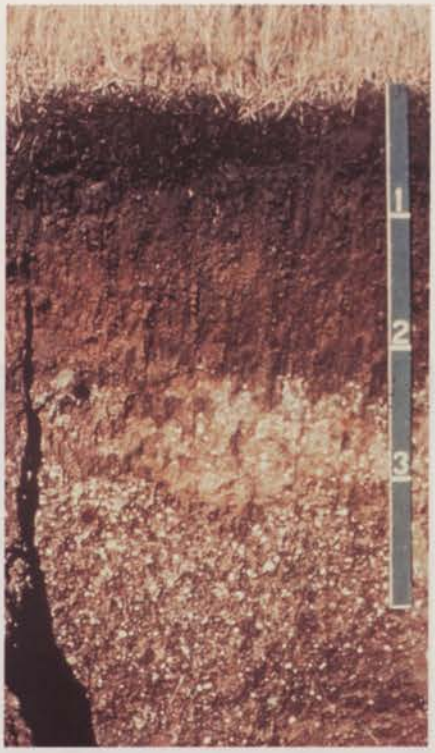

Fig. 4—At least 12 inches of rich organic matter ('A' horizon) is desirable to support turf and tree growth.

Instead, a thin layer of "A"' covers extensive depths of "B" and "C" horizons, which have poorer rooting properties.

pH a factor—Relative soil acidity—or pH— is another major property. Soils with a pH of 7 are neutral, with a balance of positive and negative ions. Most ornamental plants and turfgrasses grow well in slightly acid soils that have a pH between 6 and 7. The pH of a soil has a major effect on nutrient availability. Alkaline soils above 8, and acid soils below 5.5 tend to "tie up" certain nutrients and make them unavailable. The classic example of this is pin oak chlorosis.

When diagnosing plant disorders, remember to consider the soil as a potential cause of the decline. The old adage, "out of sight, out of mind" applies to soils. Half of the plant is growing in the soil below, and can't be seen. Examination of the physical and chemical properties of soil through soil testing and root system observations can go a long way toward diagnosing a suspected plant problem.

—The author is an extension educator for the University of Nebraska Cooperative Extension.