same auxin-like herbicide into fully developed leaves where cell division and expansion have ceased, and where normal aging processes have started, may increase the rate at which the leaves age. It is known that leaf spot severity increases on each older leaf of the shoot; i.e., leaf spot is enhanced by the aging processes of each older leaf. Therefore, when the two oldest fully developed leaves of the shoot are exposed to auxin-like herbicides they may age at a faster rate and, if infected, the disease will increase in severity. This concept is less clear relative to disease development on the youngest, expanding leaves. The increase in leaf spot severity on the youngest, visible leaf of Kentucky bluegrass exposed to auxin-like herbicides is less than that on each older leaf; in fact, 2,4-D will not increase the disease on the youngest leaf. The youngest leaf often shows the same or slightly higher disease levels in response to the auxin-like herbicides. The two youngest leaves are in a very youthful condition and as such do not respond to infection with extensive yellowing and blighting. Hence, the youthfulness of these leaves retards extensive disease development; the promotion of disease on these leaves by the herbicides is minimal. The slight elevation in disease is not explainable relative to aging because in young, expanding leaves the auxin-like herbicides would probably be youth promoting. The greater increase in disease on the second oldest leaf still suggests a herbicide-aging interaction that increases disease.

Significance of the Herbicide-Leaf Spot Interaction in the Field

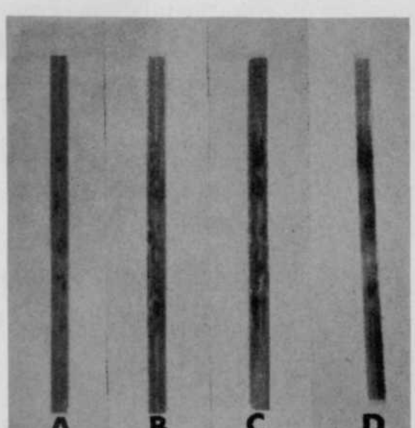
Observations on the stimulation of *H. sorokinianum* leaf spot on Kentucky bluegrass by postemergent, auxin-like herbicides have been made under the controlled conditions of greenhouse and growth chamber studies. To date, experimental evidence from field studies has not been obtained. The leaf spot symptoms produced in response to herbicides in greenhouse studies, however, are not unlike those observed in the field during late spring, summer (with irrigation), and fall to early winter. It is probable, therefore, that herbicide stimulation of leaf spot may occur in the field. Such stimulation probably would be erratic in its occurrence; i.e., the herbicide, pathogen, and proper moisture and temperature must occur simultaneously to increase the severity of leaf spot. Early spring applications of herbicides probably would have little effect on leaf spot development because of the lush, youthful condition of the leaves; with normal senescence, however, in late spring and early summer the herbicides may be a factor in increasing leaf spot severity, especially with irrigation or during a wet season. Preliminary

All factors must occur simultaneously to increase severity

studies suggest that increasing temperature from 72° to 86° will increase the yellowing and blighting caused by leaf spot on plants exposed to herbicides. This suggests that on irrigated Kentucky bluegrass auxin-like herbicides could have a substantial effect on promoting leaf spot damage during periods of warm weather. Auxin-like herbicides might be most promotive of leaf spot in fall and early winter when shorter daylength, and the herbicides may contribute to the rate at which leaves age and subsequently predispose them to more severe leaf spot development.

Acknowledgements

I wish to thank the O.J. Noer Research Foundation for financial support of much of the research from which this abstract is derived. **WTT**



Severity of leaf spot increases on each older leaf of a Kentucky bluegrass shoot in response to 2,4-D, 2,4,5-T, MCPP, and dicamba. A. Youngest leaf shows small brown lesions with minimal yellowing of tissue around lesions. B. The second youngest leaf shows enlarged brown lesions and an increase in yellowing of tissue around lesions. C. Next to the oldest leaf on the shoot showing enlarged brown lesions and yellowing that surrounds and interconnects lesions. D. The oldest leaf of the shoot shows very large lesions and extensive yellowing of the entire leaf. Leaf spot severity normally increases on each older leaf, but the herbicides increase the level of disease beyond what normally occurs.

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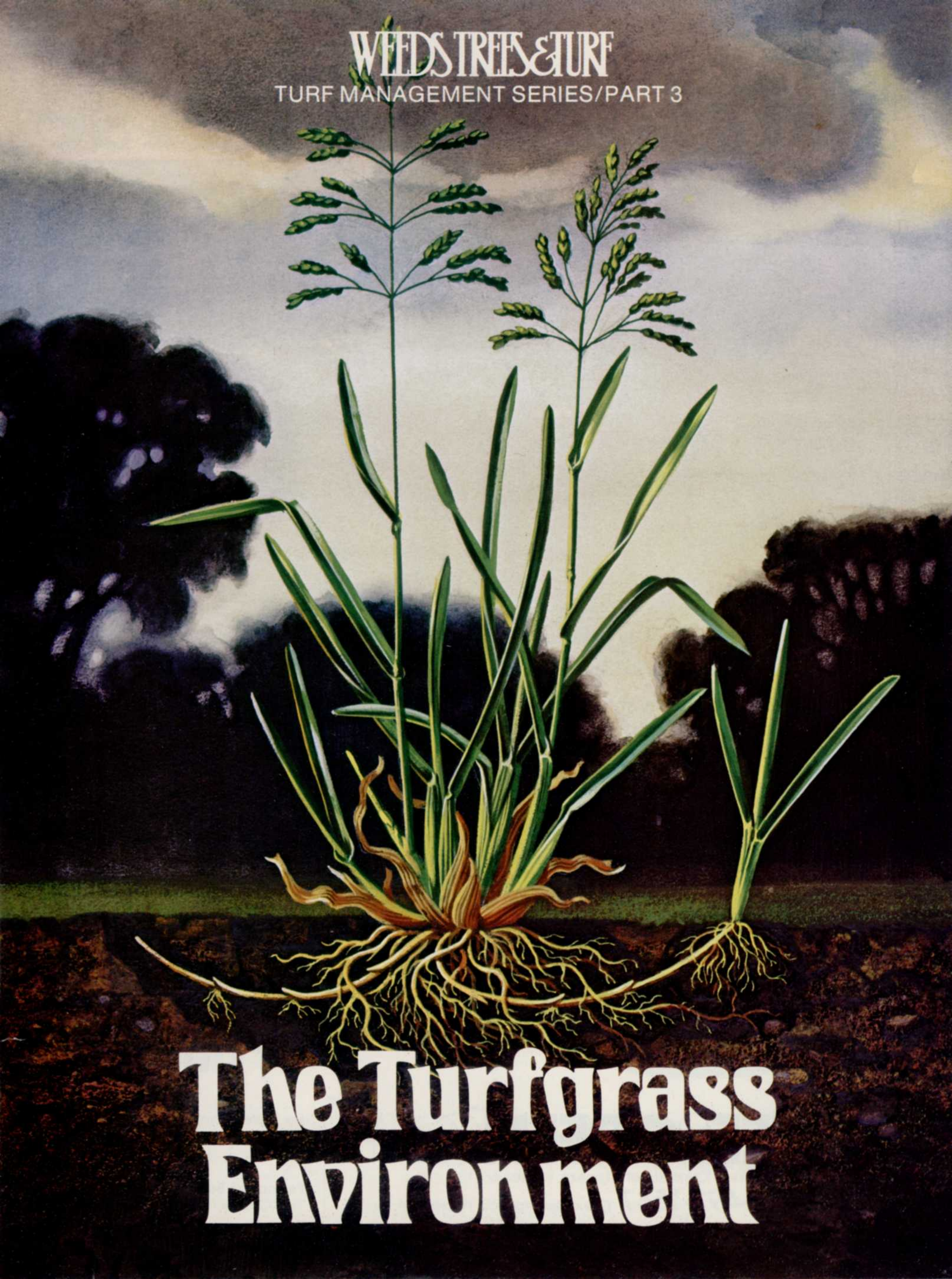
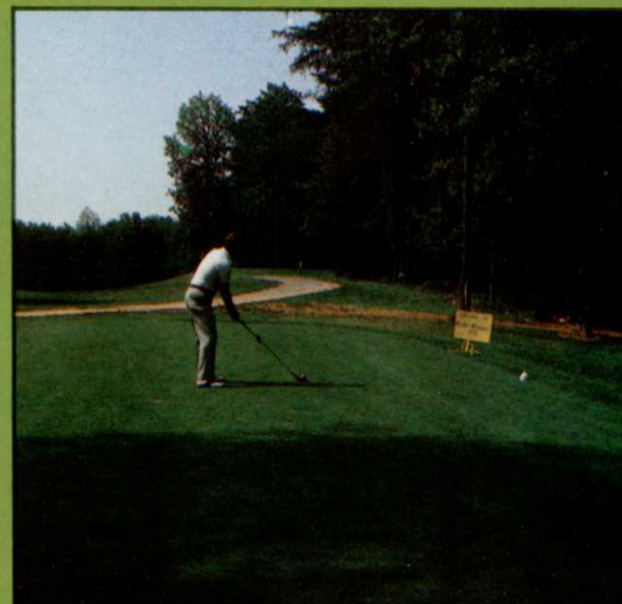


The Turfgrass Environment

Pair for the Course



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SITE CONSIDERATIONS

Soil samples *should be taken for every site and tested for texture, nutrients, and pH.*

Progress in turfgrass science provides today's lawn installers with high quality turfgrass seed and sod. The biggest risk has therefore become the readiness of the site for the seed or sod.

The site must provide the physiological needs of the desired turfgrass. The purpose of this article is to describe these needs and how to alter a site to supply them.

No professional lawn installation should proceed without a thorough evaluation of the site and a soil test. The results should be discussed with the customer with a simplified explanation of the needs of the desired turfgrass. Geographically impractical turfgrass species should be eliminated and the customer's desired level of maintenance should be established. Share your knowledge of improved turfgrasses. There is a good selection of both seed and sod so the customer can have a custom lawn. Today, a quality lawn is a sales tool in real estate. The residential customer can have an individualized lawn in addition to a sales advantage.

The commercial customer installing a new lawn at its building site is a tougher challenge. If the landscape architect is not up on improved turfgrasses, it takes a strong salesman to get improved varieties in the specifications. Too many industrial sites, multi-family housing developments, and shopping areas are seeded or sodded with outdated or cheap turfgrass varieties. The low bid process encourages this unless the improved turfgrasses are specified during bidding.

The scope of commercial jobs also encourages the use of hydraulic seeding with higher seed rates. Hydraulic seeding has grown in popularity as the least labor intensive way to seed all types of lawns. General contractors often want the lawn installation handled quickly and simply. This, however, is not always the best for the site. The owner must clearly specify his desire for quality turf by the best methods available. To achieve a quality lawn, some hand seeding and sodding is usually required. The hydraulic seeder is a great tool, however, research on the use of hydraulic seeding for fine turf is limited.

The health of a turfgrass plant is entirely dependent upon its environment, both above and below the soil surface. Once the seed has germinated, that plant must adapt to its fixed position or die. Man has the knowledge and ability to amend both above and below surface environments so that the turfgrass plant has optimum growing conditions. The best time to make the changes is before planting or sodding. If the basic needs of the turfgrass are provided, the plant will exercise its own ability to adapt to the stress of heat, drought, or wear. Turfgrass selection and breeding have provided turfgrasses that exhibit greater ability to adapt to stress. That does not reduce the need for site preparation in the case of fine turf.

Site preparation can be more than soil preparation. It could include thinning tree cover, installation of irrigation or drainage, filling low spots, changing slopes, installation of anticompaction or erosion control netting, or even installing a sidewalk to direct foot traffic off the lawn. Any change which improves the turfgrass environment is considered site preparation.

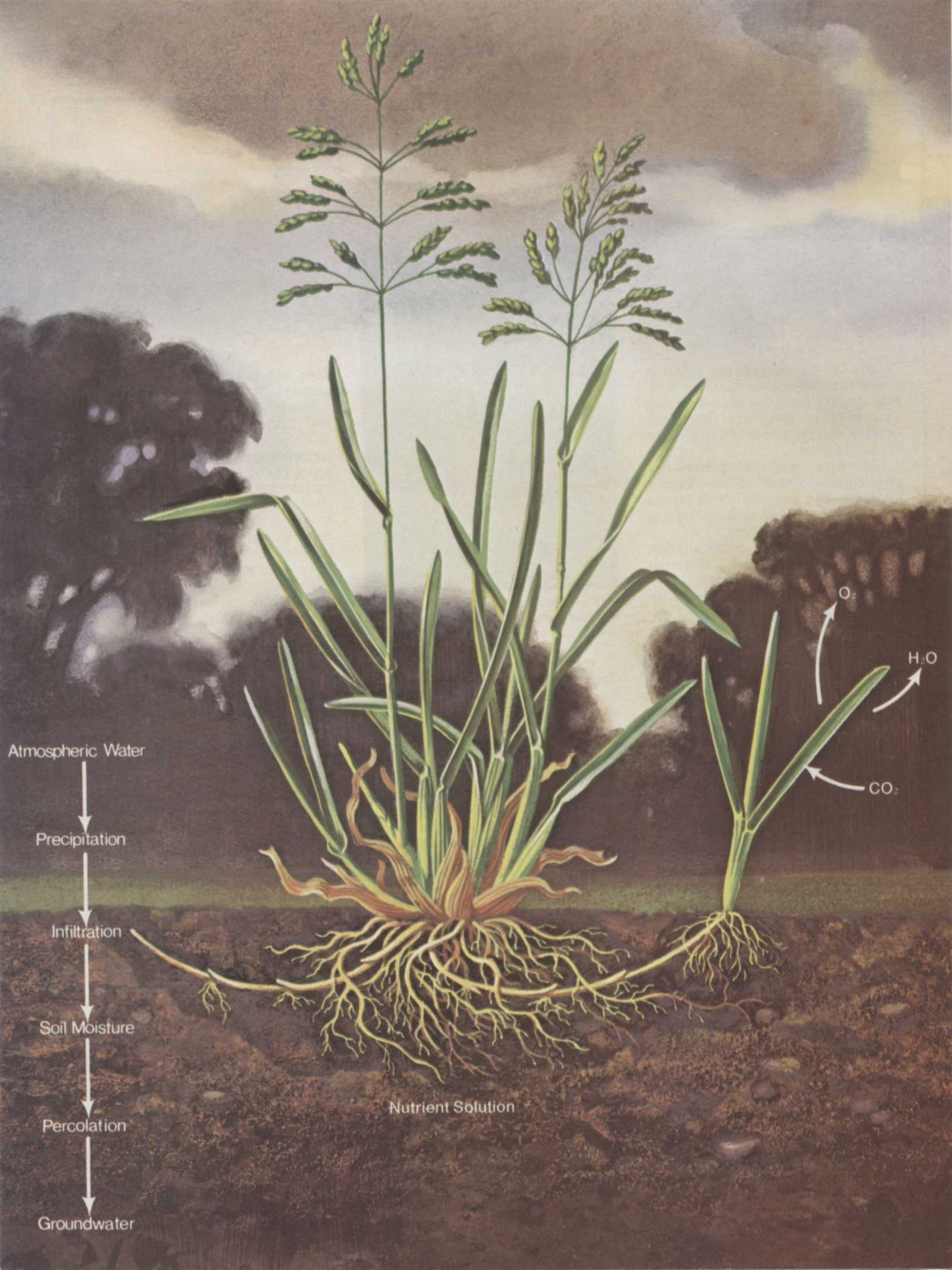
The environment must provide all essential requirements for the life processes of the turfgrass. These include light, water, numerous chemical elements, and air (gases). The environment should also include preventative conditions, such as air circulation, drainage, relatively neutral pH, minimal thatch, and few insects.

All chemical reactions are temperature dependent, require energy, and can be influenced by chemical balances, such as acidity, cation exchange capacity, and the presence of needed elements. Understanding basic chemical reactions of plant growth helps clarify the need for site preparation.

The most important process is photosynthesis. In photosynthesis, carbon dioxide from the air and water are converted to organic carbon compounds which are used in plant growth. Light energy, absorbed by the chlorophyll in the plant, powers this reaction. Lack of carbon dioxide is rarely a problem, but water and light can be lacking very easily. Excessive shade or drought are common problems in turf areas.

The carbohydrates produced by photosynthesis are either utilized to power other growth and maintenance reactions or stored.

One major use of carbohydrates is respiration, in which the car-



O_2
H_2O
CO_2
Atmospheric Water
Precipitation
Infiltration
Soil Moisture
Percolation
Groundwater
Nutrient Solution

bohydrates and oxygen react to release energy and to produce carbon dioxide and water. The plant uses the energy released to power other vital life processes. Respiration is increased by higher temperatures or nitrogen fertilization.

It is important that the plant maintain a reserve of carbohydrates for use when plant needs exceed carbohydrate production by photosynthesis. Excessive respiration, caused by overfertilization can deplete these reserves. Storage is greatest on sunny, cool days, especially just prior to onset of winter dormancy. Nitrogen fertilization at this time is discouraged.

One reason nitrogen encourages respiration is its part in protein synthesis. Nitrogen is a key element in amino acids, a major component of protein. Protein is the structural material of cell walls and the plant's genetic code. Abundant nitrogen stimulates growth and the respiration to support it.

Many other elements play a part in the various biological reactions of plant existence. (See table) They supply needed components for physiological processes. Specifically, potassium and phosphorus are critical for a good seedbed because they effect root health. The ability of rhizominous and stoloniferous turfgrasses to spread is also dependent upon adequate levels of potassium. Low potassium levels encourage carbohydrate reserve depletion. Potassium does leach, especially in sandy soils and needs to be replenished. Phosphorus is relatively stable in soil and is not prone to leaching. Consequently, phosphorus should be mixed with the topsoil.

Other important elements are calcium, sulfur, magnesium and a score of other minor elements. Calcium encourages root growth, effects the cation exchange capacity of the soil, and often improves general soil structure. Sulfur is an important part of protein synthesis, it also can be used to acidify alkaline soils. Magnesium is an important part of chlorophyll and effects the green color of turfgrass stands. It is also part of protein synthesis and influences the use of available phosphorus in the plant.

Minor elements include iron, zinc, copper, chlorine, boron, molybdenum, and manganese. Iron assists in the production of chlorophyll and will deepen the color of turf. Most minor elements can be unavailable to plants if soil is too acidic or alkaline. The role of some of the

Element	Chemical symbol	Importance in plant function
Nitrogen	N	The nitrate form is reduced to amino acids which are used to synthesize proteins, such as the structural protein of cell walls. Important in formation of nucleic acids which control genetic code of the plant. Also important in synthesis of coenzymes, vitamins, hormones, and pigments.
Potassium	K	Important in the glycolic pathway, one of four reaction sequences in the respiration process which converts glucose produced by photosynthesis into plant energy. Functions primarily as an enzyme activator.
Phosphorus	P	Also important in formation of nucleic acids. Is a constituent of phospholipids, which with proteins, constitute membranes which maintain structural integrity of plant cells. Important in organic compounds which provide energy for chemical reactions.
Sulfur	S	A constituent of certain amino acids and protein. Also found in coenzymes for lipid (fat) and carbohydrate metabolisms.
Calcium	Ca	Important in developing cell structure and permeability properties of membranes.
Iron	Fe	Essential for chlorophyll synthesis
Magnesium	Mg	An essential constituent of chlorophyll. Seems to function by binding together subunits which make up ribosomes which synthesize proteins.
Boron	B	Unknown. Suggested that borates prevent excess phenolic acid production. Phenolic acids accumulate in boron deficient plants.
Manganese	Mn	Formation of oxygen in photosynthesis. Specifically required for action of some enzymes.
Copper	Cu	Found in enzymes required for respiration and photosynthesis.
Zinc	Zn	Found in several enzymes essential to respiration and nitrogen metabolism.
Molybdenum	Mo	Found in enzyme for N_2 fixation, and enzyme essential for reduction of nitrates (NO_3) to ammonia.
Chlorine	Cl	Activates oxygen production system of photosynthesis.
Sodium	Na	Required by certain halophytic (salt-loving) plants.
Silicon	Si	Required by some grasses and sedges for cell wall formation.

minor elements is not clearly understood. Sandy and alkaline soils may require addition of minor elements.

The purpose is not to give a lesson in chemistry, but to show those things that a turfgrass plant requires from its environment. The next step is to identify site conditions which either permit or restrict the supply of these needs. Since soil is the medium for most of these needs, it is the best place to start.

Soil

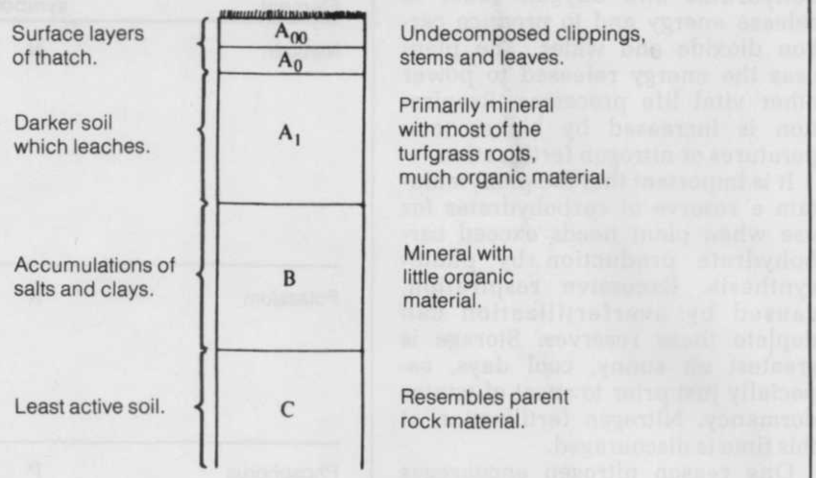
The goal in site preparation is to provide a six to eight inch layer of soil that has desirable texture, structure, and chemical balance. The components of the soil determine these characteristics. Soil amendment may be needed to establish a suitable rootzone for the turfgrass.

Soil is layered. The primary concern is the few inches of topsoil, but lower layers effect drainage, upward movement of water, and chemical activity. Special care to all layers of soil is given during construction of golf greens and other athletic fields. On large areas where lower layers may pose problems but the scale makes changes impractical, special attention should be given to maintenance needs, such as topdressing, aerification, fertilization, and installation of drainage and irrigation systems. The purpose is to counterbalance the effects of an inferior soil.

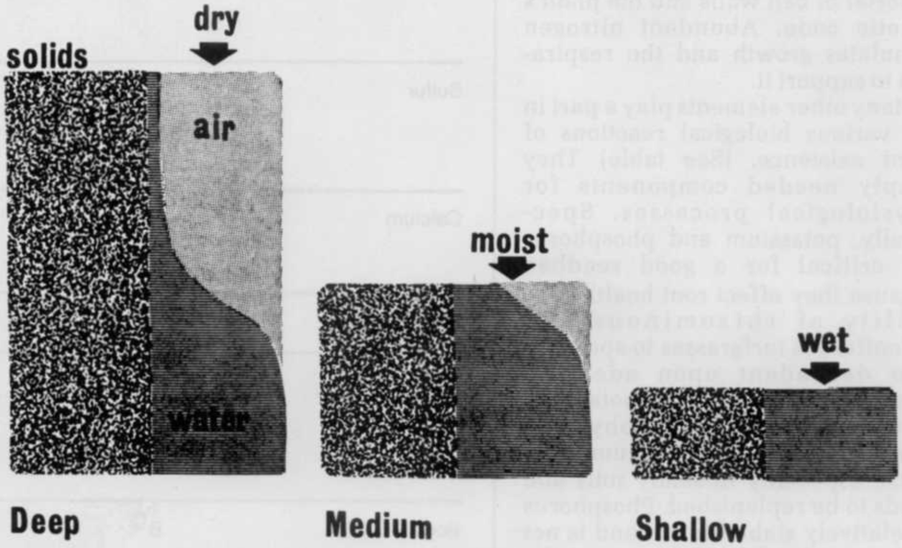
The typical soil of an area is derived from the parent material which may have been the bottom of a lake, a glacier, a volcano, or other mineral or organic material. Other factors influencing soil content are the climate of the area, the period of time during which the soil developed, the vegetation that had grown there previously, and the topography of the area. All these factors combined resulted in the soil characterisitics of any area.

Soils are classified by type or combination of types, including sand, silt, and clay. (See diagram). These identify textural characteristics of the soil. Soils are also classified by structure based upon the shapes of individual groups of particles, or aggregates, in the soil. The size of the aggregates is also a factor in seedbed preparation. Pea-sized aggregates are preferred.

The texture and structure of a soil has a great effect on drainage, movement of chemicals in the soil, upward movement of water (capillary action), rooting ability, and presence



Layers or horizons of soil *The A horizon should be six to eight inches deep and of appropriate texture, pH, nutrient content, and drainage.*



Depth of topsoil affects retention of water *following irrigation or drainage.*

of needed gases in the soil. Loam soil is actually a combination of sand, silt and clay.

Another way to classify soils is as mineral or organic. The organic matter content of mineral soils is less than ten percent, whereas organic soils contain more than 20 percent organic matter. Organic soils are preferred where possible. Michigan sod growers switched from mineral soils to organic soils as part of their growth in the 60's. If the organic matter is only slightly decomposed the soil is termed peat. If the organic matter is well decomposed the soil is termed muck.

Soils with large amounts of undecomposed organic matter need the assistance of bacteria, protozoa, nematodes, algae and fungi for breakdown. Poorly drained soils discourage these organisms from doing their job. These organisms also are essential for thatch decomposition and breakdown. Decomposition is also related to the pH of the thatch and soil. Alkaline or acidic soils can prevent the breakdown of thatch and cause problems associated with thatch buildup.

The composition of the soil effects water accumulation and drainage. Sand soils do a poor job of holding water. However, they have the advantage of aiding drainage when added to other soils. Clay soils hold water but this water may not be available to the plant roots. Silt soils retain water well but also tend to compact easily. The pore space between soil particles determines the ability of the soil to hold and pass water. The organic matter content of the soil also aids in water retention. The ability of the soil to let water in

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is called infiltration. If soils are compacted, pore space is limited and water will not flow into the soil easily. Water can be treated with wetting agents to reduce its surface tension and allow for easier entry.

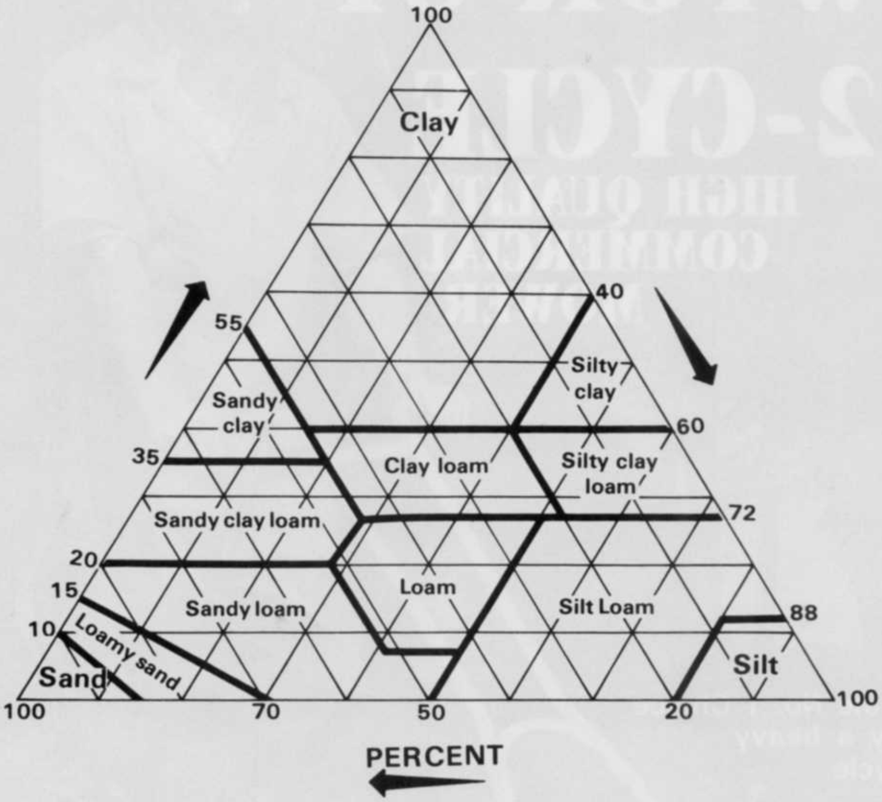
The ability of the soil to allow water to pass through is called percolation. If soil layers are significantly different in texture, water movement downward can be hindered. If surface water is applied faster than the soil can take it in or let it flow through, puddling or runoff will occur.

The ability of the soil to hold water is closely related to its ability to hold needed gases. Many of the things that prevent water retention hinder soil aeration, such as compaction and lack of organic matter.

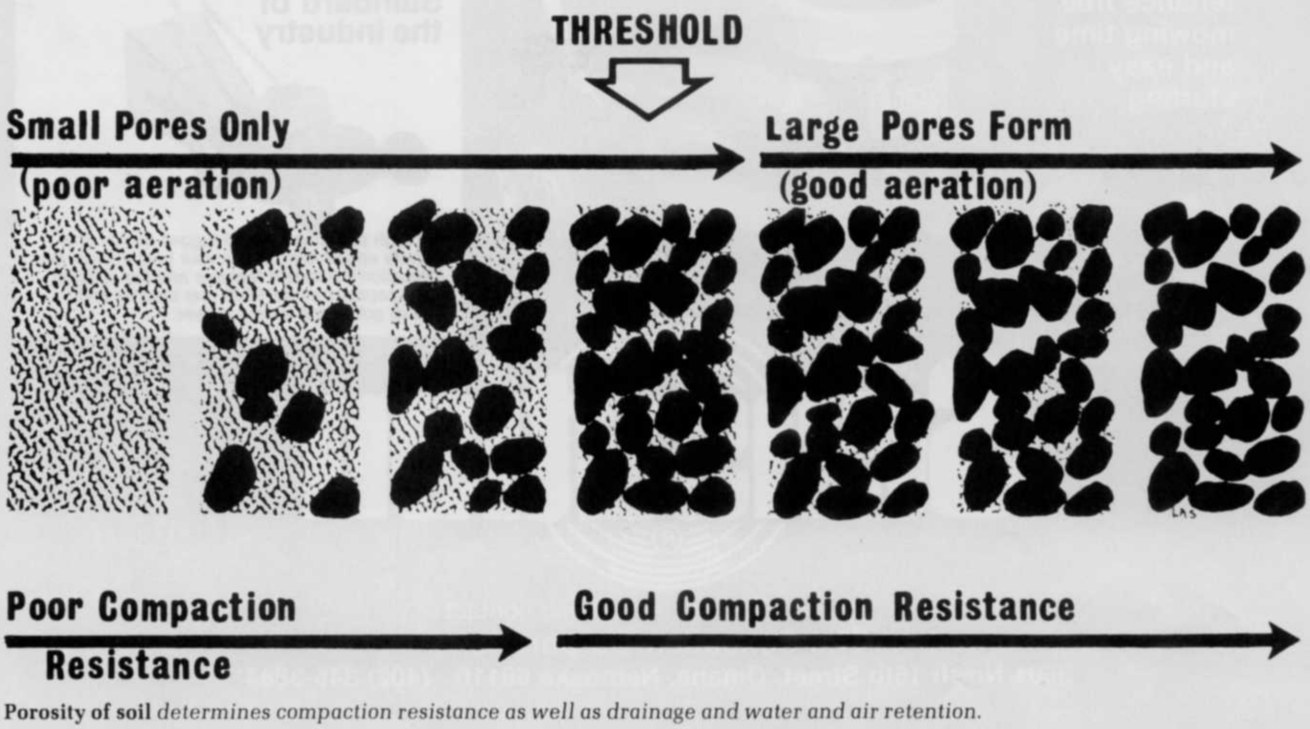
Water and air compete for the same space at times. Poor drainage inhibits soil aeration if water occupies all pore space. Turfgrass roots need oxygen to carry out respiration. Without the oxygen, the ability of the plant to power essential processes is severely restricted.

One final area of consideration for soils is the chemical balance. This is a more complicated subject concerning pH, cation exchange, and salinity. An imbalance of any of these can hinder the plant's health.

pH is a measure of the hydrogen ions in a solution. The more acid the soil is, the lower the pH will be. The



Texture is measured *by the percentages of the three basic mineral components, clay, silt, and sand.*



Porosity of soil *determines compaction resistance as well as drainage and water and air retention.*