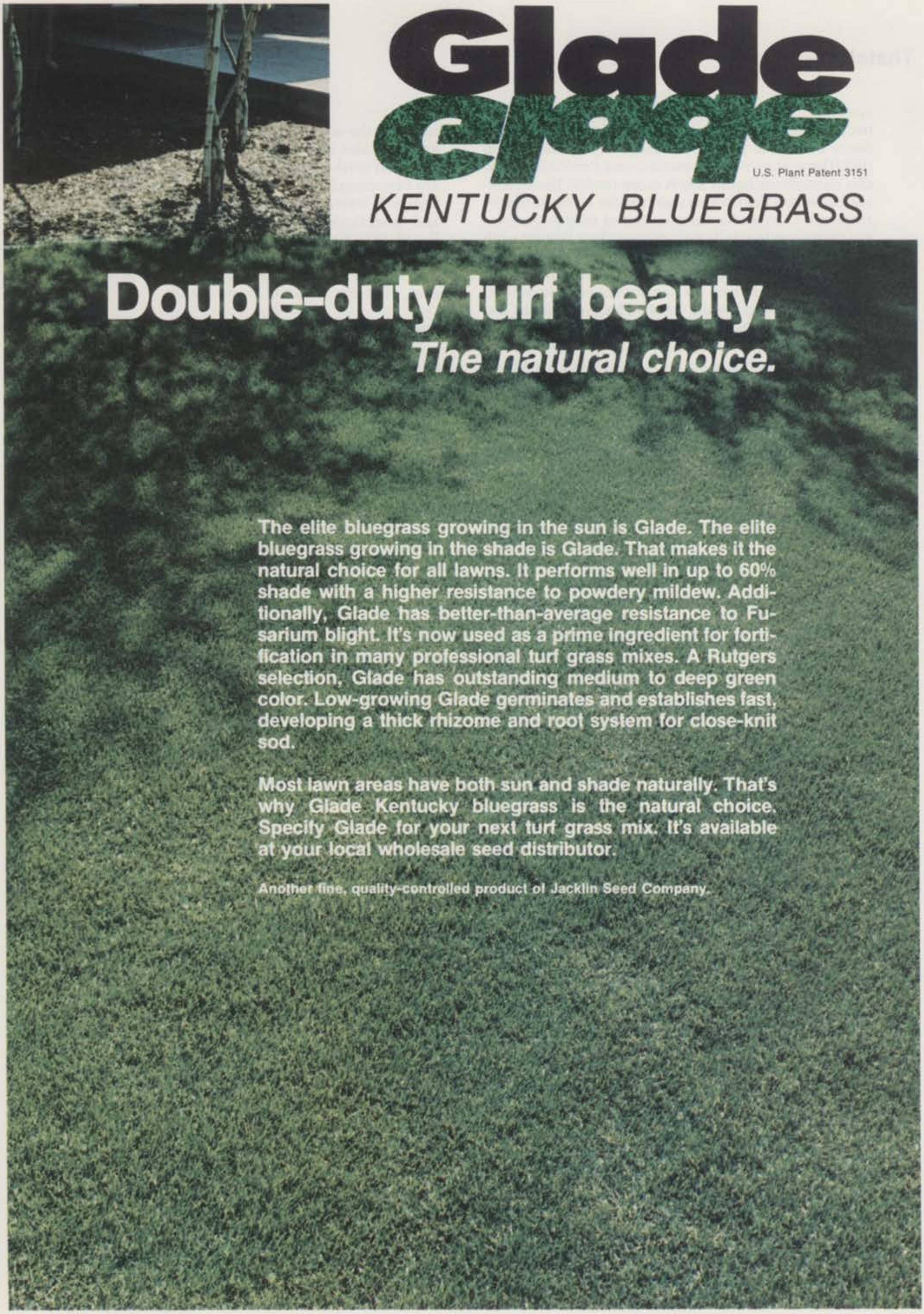


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necessary to decompose more than a few of the components in higher plants. Mukhopadhyay and Nandi (1979) have shown that *Fusarium* and *Penicillium* species decompose lignin much more readily than cellulose, whereas the reverse was true for *Helminthosporium* and *Curvularia*. Successions of microorganisms are necessary to totally decompose plant tissues; each group feeds on the residues remaining from a previous group's activities. Most soil animals, including earthworms, do not produce the enzymes needed to decompose plant tissues (Waid, 1974). The fauna assist decomposition by physically tearing tissue apart to allow microbes access to larger amounts of surface area.

Turfgrass specialists sometimes feel that decomposition of thatch is initiated by faunal activity and concluded by microbial activity. The fauna are thought to digest portions of the thatch and to relocate some of it deeper into the soil. This view appears to be supported only by popular belief and by visual observations of thatch accumulation where earthworms are absent (Lofty, 1974). But this viewpoint is contrary to the results of detailed soil ecology research. Tribe (1960) studied successions of organisms on cellulose in soil and found that fungi initiated the decay. Bacteria became involved later, and then nematodes began feeding on the bacteria and fungi. Later stages of decay involved larger fauna, including mites, collembolans, and enchytraeid worms. Clark and Paul (1970) and Waid (1974) concur with this general sequence for decomposition of grass roots. Curry (1969) used nylon bags of various small meshes to screen out variously sized groups of soil fauna from bentgrass and fescue leaves and stems that were buried or were left on the surface of a grassland. He concluded that the fauna contributed almost nothing to the rate of decay and disappearance of the foliar litter on the soil surface, and did not accelerate its decay in the soil. Malone and Reichle (1973) used chemical toxicants to eradicate different faunal groups in a fescue meadow, and reached the same conclusions as Curry. However, in contrast to the results with foliar litter, these scientists also showed that the fauna slightly accelerated decomposition of buried roots. Thatch accumulation in our long-term fungicide plots (Smiley and Craven, 1978) was considered to be associated with inhibition of the microflora, and not earthworms, by some of the fungicides.

In my view, microorganisms have been demonstrated to be the most important organisms for decomposition of plant litter, and inhibition of the fauna in grassland ecosystems has been of only minor consequence. It is also my view that earthworms can be considered as indicators of overall soil faunal activity, and that their absence is an expression of imbalance in the ecosystem. Tissue decomposition rates may be reduced under these conditions, without the necessity for a cause and effect relationship with earthworms *per se*. More detailed research is needed on this topic.

#### Pesticides

Some pesticides can alter the rates of production for turfgrass tissues, and some can alter the rates of decomposition. Pesticides that reduce the activity of soil microorganisms are most inhibitory to litter decomposition. Many insecticides, herbicides and fungicides can alter the activity of microorganisms such as fungi, and may also inhibit the activity of fauna such as insects and earthworms. The overall effects of pesticides are very complex. Thatch accumulation on turf that is regularly treated with certain fungicides, herbicides, and insecticides is well documented (Beard, 1973; Beard, 1976; Smiley and Craven, 1978). Effects of these chemicals on the soil microflora and fauna are not as well known (Beard, 1973; King and Dale, 1977; Meyer et al., 1971; Smiley and Craven, 1979).

#### Fertility

Nitrogen is essential for decomposition of organic litter. Microorganisms require a carbon-to-nitrogen ratio of at least 25:1 for effective decomposition (Beard, 1973). Organic litter is rich in carbon and lean in nitrogen. Furthermore, nitrogen is quickly and easily leached out of the thatch (Hunt, 1978), and the C:N ratio of thatch can therefore become rather high. Litter decomposition is independent of the nitrogen in soil below the thatch because this nitrogen is out of reach for the microbes in thatch (Hunt, 1978). Thatch decomposition is accelerated when soil is incorporated into the thatch layer (by coring and matting or by soil faunal activity) and when frequent, light applications of fertilizer are applied (Beard, 1973). The biological bases for such observations are provided in detail by Hunt (1978) and Smith (1979). Beard (1976) explained that the nitrogen application frequency and the type of carrier must be manipulated to keep nitrogen up in the thatch. Smith used eloquent mathematical models to predict that decomposition will be most efficient when split applications of water-soluble nitrogen are made, or when a single annual application of water-insoluble (slow release) nitrogen is made. Hunt (1978) illustrated how decomposition can be slowed whenever nitrogen concentrations in the thatch are reduced. Topsoil (but not sand) incorporated into thatch will help to elevate or prolong the available nitrogen supply (Beard, 1973). Care must also be taken to avoid excessive fertility levels which greatly increase tissue production rates, but not decomposition rates.

#### Acidity

Litter decomposition proceeds most rapidly at pH 6.0 (see Beard, 1976), and the rate decreases rapidly as either the acidity or the alkalinity is increased (Fig. 2B). If lime or neutral to alkaline soil are not added to turf, the alkaline components of litter may be leached downward, and the thatch will become acidic. Frequent, light applications of lime are necessary in many regions to maintain a proper pH balance in thatch (Beard, 1973). Infrequent heavy applications of lime appear to be capable of reducing the rate of thatch decomposition.

#### Temperature

All biological activities are temperature dependent. Production of tissues may be reduced or stopped during cold winters and hot summers. Shoot and leaf production are retarded earlier and more positively than root production (Beard, 1973). Tissue decomposition occurs at its maximum rate at 38°C (100°F) and is completely stopped at 0°C (32°F) and 45°C (113°F) (Hunt, 1978). The thatch temperature is quite responsive to air

*Continues on page 60*

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# DRAINAGE DESIGN TO HANDLE INTENSIVE FOOTBALL FIELD USE

**By John Moreland, CGCS,** President, Cambridge Soil Services of America, Glencoe, Alabama

The intensive use of football fields today makes proper construction and drainage critical. Many options are there to correct drainage mistakes depending upon the budget of the owner.

If your field gets very intensive use, you have a million dollars to spend and you are willing to accept the increased injury rate, then synthetic turf may be your best solution.

If you have close to half a million to spend and want the finest natural turf money can buy, then the answer for you may be "Prescription Athletic Turf." Under this system of growing grass, you place a network of perforated pipes on an impervious base and cover this with almost pure sand. The moisture level of the turf is carefully controlled with pumps. The system is expensive and requires sophisticated maintenance, but it can result in "the finest turf money can buy."

If your budget is in excess of a quarter of a million, but still not enough to cover the cost of a PAT system, you might install a drained gravel blanket and cover this with a highly permeable, carefully engineered soil mix such as is used with a PAT system.

As you can see, with a million dollars you have lots of options, but let's suppose that you don't have a million dollars, or a half a million, or a quarter of a million. In fact your budget for field renovation is on the short side of $50,000; so what can you do? You have two options: You can improve the drainage of the field you have, or you can continue to play in the mud.

There is no cause for despair. Most athletic fields in the United States could grow good mud-free turf if they were properly drained, properly maintained and not over used. Fifty thousand dollars is usually sufficient to install an outstanding drainage system on an existing field. I say "usually" because there are exceptions, such as bed rock within a foot of the surface, a water table within a couple of inches of the surface, or a field in a bowl with no outlet. Barring such freak situations, you should look forward to excellent drainage.

The first step is planning. You have to decide whether to do the job yourself or whether to seek outside help. If you plan to tackle the job yourself, just be sure you understand how the various components of a complete drainage system are interrelated. Reading this article will help.

Let's assume you have decided to get help. Your odds on getting competent help are not very good, unless you understand something about sportsturf drainage. There are many drainage engineers, landscape architects, and landscape contractors who are competent to design and/or install excellent drainage systems. Unfortunately, most of the people doing this work simply do not understand the rather special requirements of sportsturf. The proof of this statement is the fact that most of the natural turf football fields in the United States are grossly inadequately drained, even though many of these fields have been designed by reputable landscape architects and built by reputable contractors who employed reputable drainage engineers. There is, of course, no reliable way of being sure that you have hired the best help, but here are some questions you can ask that will shorten the odds:

*"What makes water move in sportsturf?"*

If your consultant replies "gravity," keep looking — you have not found your man. The correct answer is gravity and capillary attraction. An answer of gravity and the forces of adhesion and cohesion would also be acceptable. A simple answer of "gravity" indicates a simplistic approach to a complex problem.

*"Are you familiar with USGA specifications for golf green construction?"*

If the answer is "No," your consultant is probably

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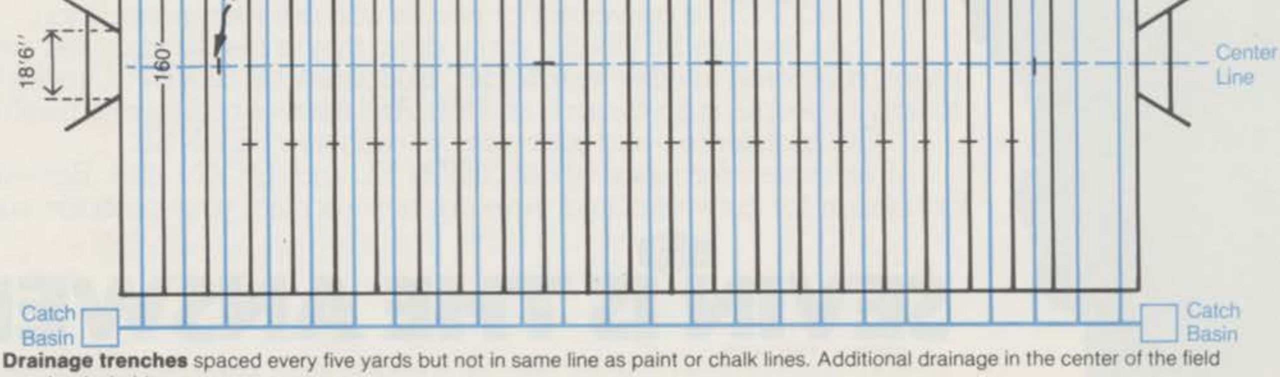
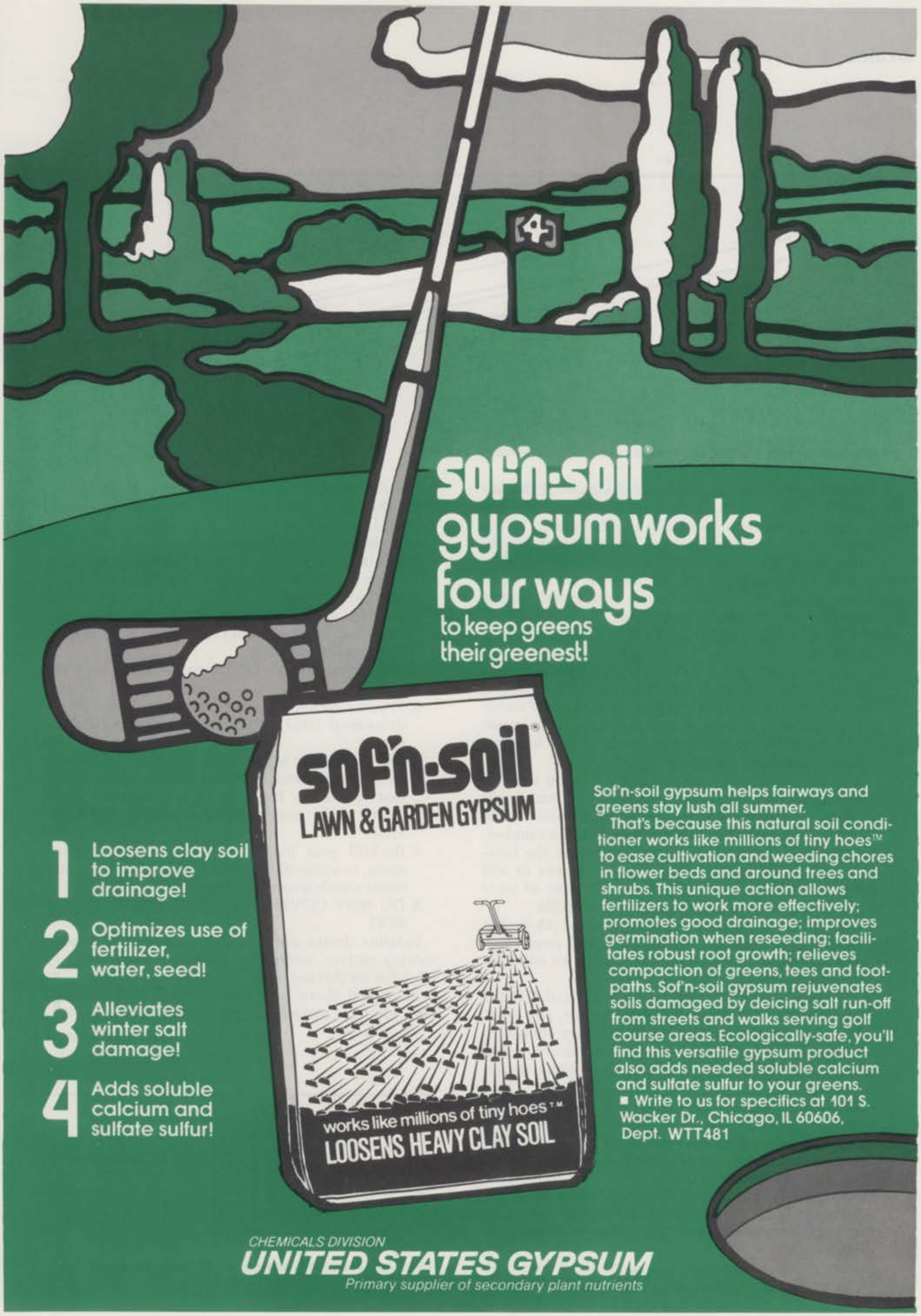



**Drainage trenches** spaced every five yards but not in same line as paint or chalk lines. Additional drainage in the center of the field may be desirable.

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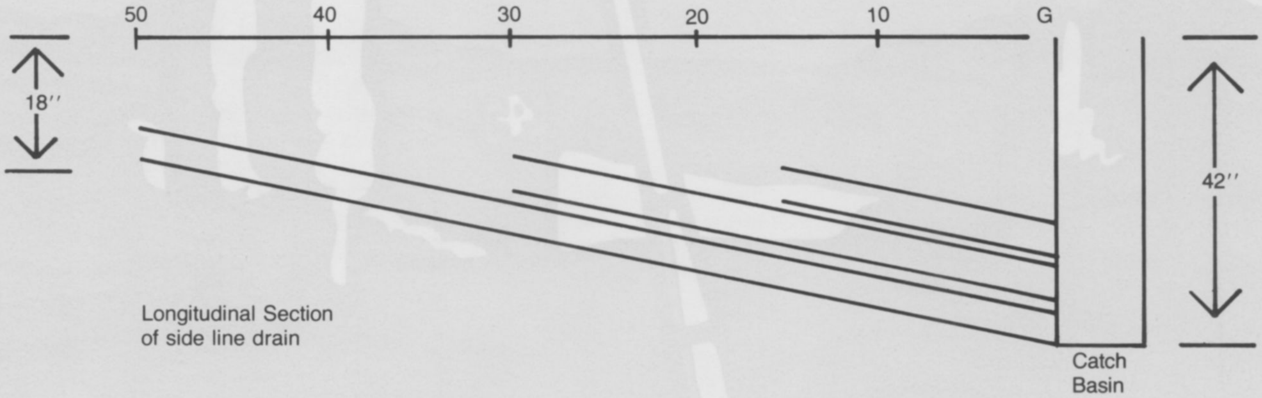
## **Drainage** *from page 46*




**Sideline drains** and field drains must have a slope of at least 1 percent.

insufficiently read on sportsturf drainage. If the answer is "Yes," ask the further question: "What is the purpose of the gravel blanket in a USGA green?" If the answer is "to improve drainage," keep looking. On the other hand, if he answers, "To conserve water when supplies are deficient and remove the excess when water is abundant," and if he can now explain to you how this is so, things are looking up.

*"What drains better, all sand (A) or sand mixed with stone(B)?"*

If he answers "A" and can explain why, maybe you have found your man. In "B" the capillary attraction of the sand acts as a barrier blocking the passage of water. In "A" the sand is deep enough to develop a hydraulic head sufficient to overcome much of the blocking effect of capillary attraction.

Let us assume you have decided to do the job yourself. Of course, the actual system you install will depend on many factors such as the availability of various materials and their relative cost, the number, location and depth of existing catch basins, the location and depth of existing French drains or slit trenches, the crown of the field, the size of your budget, and the equipment you have available.

We will assume your field is crowned 18 inches (which is ideal) and that you have a 42 inch deep catch basin near each corner of the field. Later we will consider alternatives.

Drainage work should start at the lower end. If this is done and you are caught by wet weather, any work which has been completed will help dry things up when the rainy spell is over. If you start at the high end, no part of the system can work until the entire system is finished.

Since we assumed that catch basins were in place and of adequate depth, your first step would be to start with the sideline drains. These should be located several yards outside the playing surface and should be at least 18 inches deep at the shallow end, and should slope toward the catch basins with at least a 1% slope. Although larger sizes of pipe are often used, we prefer four-inch perforated plastic pipe since we object to a wide trench.

If additional capacity is needed, stack four-inch pipes on top of another. Allow one pipe for each 15 yards to 20 yards of side line drained. If catch basins were also available at the 50 yard line, this would reduce the pipes required. Other circumstances could increase the number.

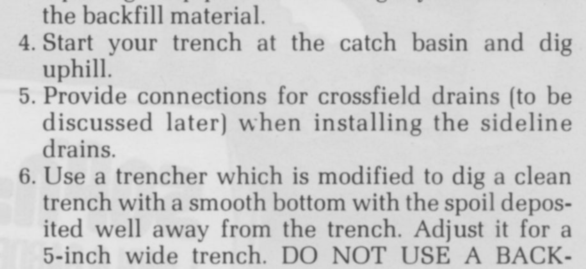
Keep in mind these points.

1. Minimum depth should be at least 18 inches.
2. Slope should be at least 1% if possible.
3. Use one perforated flexible corrugated 4-inch pipe for each 15 to 20 yards of side line trench. Openings in pipe should be slightly smaller than the backfill material.
4. Start your trench at the catch basin and dig uphill.
5. Provide connections for crossfield drains (to be discussed later) when installing the sideline drains.
6. Use a trencher which is modified to dig a clean trench with a smooth bottom with the spoil deposited well away from the trench. Adjust it for a 5-inch wide trench. DO NOT USE A BACKHOE.
7. Backfill your trench with pea gravel, crushed stone, or some other stable, highly permeable material which is compatible with the pipe used.
8. DO NOT COVER TRENCH WITH SAND OR SOD.

Sideline drains are intended primarily to remove moving surface water (see diagram). They are very effective for this use only.

Your next chore is to install crossfield drains and here you have some decisions to make. The effective-

*Continues on page 50*




**Stacking four-inch pipes** easier than larger pipe.

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ness of slit trenches in removing underground free water and loosely bound water is proportional to

$$\frac{\text{depth of trench}}{\text{distance between trenches.}}$$

Trench width is immaterial. We refer to the above ratio as the DI (drainage intensity) rating of the field. Thus a field with trenches two-feet deep on four-foot centers would have a DI rating of 2/4 or .5, which is very good.

Since in this example, your sideline trenches had a minimum depth of 18 inches, it would be well to dig your crossfield trenches to this same depth. We suggest that you use two-inch pipe designed for direct burial in sand. For backfill we recommend a uniform medium sand (1/4 to 1/2 mm or 32-60 mesh). A suitable alternative would be a uniform course sand. A third choice would be a concrete sand. Mason sand should be used only if it has been tested for permeability and for compatibility with the particular pipe. Under some circumstances you might wish to use 2mm to 4mm grit instead of sand, but in this case, you must use a pipe with larger openings.

The trench is filled close to the surface with the grit which is topped with about the same size calcined clay. The pipe must not be laid in grit or gravel since soil particles could pass through the gravel and block the tiny slits. Pipe which has larger openings should be used in gravel.

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## Do not try to improve the drainage of the soil by adding sand and mixing it with existing soil.

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Your next step is to figure out the cost per foot of trench and to compare this with your budget. This will enable you to determine how many feet of drain you can afford. Ideally you would want uniform close spacing over the entire field. If you cannot afford this, then at least design the most used portion of the field to a DI rating of .33. Figure 5 is one such design.

If your budget is too slim to cover this pattern, then simply work on the wettest or most used areas of your field this year and plan to add more trenches in future years.

Two ways to supplement trench drainage are sand injection and sand grooving, processes developed by Cambridge Soil Services of America.

Sand Injection is our process of injecting a nine-inch-deep, .6 inch wide band of sand into the soil. Because costs per lineal foot are dramatically less than slit trenching, it is economically feasible to place the slits close enough to obtain DI ratings as high as 1, although we would typically use a spacing of 18 inches yielding a DI rating of .5. Sand Injection is most effective if combined with slit trenches which ideally should be on 7½ foot centers, although 15-foot centers would be quite acceptable.

Sand Grooving is our process of cutting four-inch-deep, .5 inch wide grooves in the turf and backfilling the grooves with sand. Since the grooves are on eight-inch centers, this yields a DI rating of .5. Our Sand Groover can be adjusted to simultaneously top dress the field with sand. This should be done whenever practical since sand topdressing is the best way to preserve the integrity of the sand grooves, the injection slits and the slit trenches.

Working with a flat field complicates things a bit but the same principles apply. Since your drainage will inevitably be slower, there is no longer any need for stacked sideline drains; a single four-inch perforated pipe in gravel will be sufficient. Since the field is flat, the crossfield drains must be dug deeper at the sidelines than in the center. In designing your system, bear in mind that the depth at the shallow end should generally be 18 inches and that a slope of 1% is desirable, but slopes as low as one half of 1% can be tolerated. Although in theory the same formulas apply, in practice a more intensive drainage system is required to achieve the same degree of dryness because the drainage system must handle the surface water as well as the subsurface water. On a flat field, sand top dressing and dressing out depressions with sand are also more important than on a crowned field.

A crowned field is clearly preferable to a flat one. If your field is flat, it will probably be more cost effective to increase the intensity of the drainage than to crown the field. If your field is so irregular that it requires extensive regrading, then it would probably be well to crown your field in the process.

A word of caution - *do not try to improve the drainage of the soil by adding sand and mixing it with existing soil.* This will generally make the drainage worse, not better. Internal drainage is dependent on soil pore space. Uniform coarse sand will have perhaps 40% large pore space and will drain very well while uniform loam may have 40% pore space most of which is very small and will drain very poorly. If we mix sand into the loam, we do not increase the size of the pore spaces but simply reduce the number of pore spaces present. See figure 6.

You have no doubt read of the harmful effects of a layered soil. These bad effects are very real and very serious but they stem primarily from having a layer with many small (capillary) pore spaces over a layer with few capillary pore spaces and many large pore spaces. A layer of uniform medium sand over sportsturf will not produce the undesirable effects associated with a layered soil.

Our final minor point, paint clogs soil pores. If your slit trenches are located exactly on the five yard lines, in time they will likely become clogged with paint. It is easy to modify a sod cutter to remove a 4 inch wide 2 inch deep strip. The top 2 inches of your slit trenches should be replaced whenever they become clogged.

Placing the slit trenches exactly on yardage strips will cause them to become clogged more quickly but even if they were placed elsewhere you would still have the clogging of the soil on the yardage stripes and this soil should be replaced whenever the turf deteriorates. Of course the slit trenches can become sealed by play in wet weather, but if you have followed the design set forth in this article, any clogging which does occur will be limited to the top two inches and can be easily remedied as explained above. Of course a better procedure is to prevent clogging in the first place. This can be accomplished by a regular program of sand top dressing. **WTT**