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Spring floods caused much damage to courses along the upper Mississippi and in northern California, Colorado and Oregon. A Davenport, Iowa, course faced complete rebuilding job.

Few cheers for THAT year!

Floods, hurricanes, drought caused much damage, but crabgrass belt never had it better.

By CHARLES G. WILSON
Milwaukee Sewerage Commission

What happened to spring? As one northern superintendent told us: "This was my first year to take a winter vacation in Florida. I goofed in not taking the grass with me." The poet, Jones Very, wondered what happened to "spring's early flowers" a century ago.

"I looked to find Spring's early flowers,
In spots where they were wont to bloom;
But they had perished in their bowers;
The haunts they loved had proved their tomb!"

What Very would have penned in the Spring of 1965 we shall never know, but there certainly was enough tragedy in turfgrass circles at that time to spur on the most laggard of poets.

Spring flood damage was intense along the upper Mississippi and in northern California, Colorado and Oregon. The municipal course in Davenport, Iowa, was faced with a complete rebuilding program when the waters receded. Other flood plain courses suffered as badly, or to a lesser extent. Oregon was especially hard hit, and the rains returned again in fall to damage courses as far south as San Diego. Hurricanes also took their toll of turf in Florida and Louisiana, especially where salt water inundated playing areas. Gulf Stream was hard hit. There, only Otto Schmeisser's paspalum planting withstood the high salinity in fairways. It actually seemed to thrive on the added salts.

The Northeast continued through another year of unprecedented drought. Water restrictions were imposed in many areas and some courses had to fight for enough to keep tees and greens moist while letting the fairways go. The water restrictions resulted in more complaints about fairyring disease than ever before. These fungi desiccate turf rapidly in the familiar irregular rings where lack of water is limiting growth on thatched areas. A possible blessing in disguise was the reduction of annual bluegrass and deeper root system where water restrictions prevailed.

Even Kentucky bluegrass failed to grow properly in the northern Midwest and parts of Canada last spring. Opening day was delayed three weeks or longer. Normally, winter killed *Poa annua* comes back fast from fresh germinated seed in the soil. Such was not the case in spring, 1965. Growth was poor from Milwaukee, north, until late May because of cold weather. Fortunately, when good weather came, growing conditions were also good, although wet in the Midwest throughout the summer.

Summer temperatures were mild in notorious trouble spots in the lower Midwest and the Eastern crabgrass belt. Oscar Bowman at Old Warson summed it up best of all with the statement: "If you couldn't grow bent greens in St. Louis this summer, chances are you never will." The temperature and/or management changes also benefited U-3 bermuda fairways. They were never better and the superintendents seem to be getting the upper hand on spring dead spot by growing turf rather than hay. Now this dread malady has spread to Tennessee, the Carolinas and Georgia. Golf courses there should watch with interest Missouri's efforts to combat this so-called disease by management. This spring may tell the story. Budgetwise, it won't be as expen-

Continued on next page

Another year of unprecedented drought was experienced in the Northeast. Many areas were under water restrictions and as a result there was a new high in fairyring complaints.

FEW CHEERS

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sive as costly disease sprays, if it works.

The South is looking with interest on a new grass that may replace Tifgreen on putting surfaces. Called "Tifdwarf," it seems to be an off-type vegetative mutant that was found almost at the same time at Sea Island, Georgia, and Florence, South Carolina. Burton at Tifton reports Tifdwarf, after three years of testing, has several advantages over Tifgreen. Like Tifgreen, it must be planted vegetatively but outranks it in putting qualities. Tifdwarf may turn purple in color with the first frost because of a high content of anthocyanin pigment. This can be offset with winter overseedings.

Speaking of overseedings, 1965 was the first year of recognition that "other crop seeds" may be causing many of our turf weed problems. Seed laws were made to protect agriculture. Noxious farm weeds seldom bother the golf course. They vanish with close mowing or can be readily removed with 2, 4-D and related herbicides; it is the "other crop seed" that can cause trouble in turf areas. New York has found many lots of cool-season grass seed to be contaminated with *Poa annua.* Juska at the U. S. Dept. of Agriculture reports foreign Kentucky bluegrass imports to be especially high in this pesky weed. By law, New York now insists the number of *Poa* seeds be listed on the tag. Other states are following suit, because U. S. production may have annual bluegrass as a contaminant in Kentucky bluegrasses, bents and fescues.

Today, in the northern belt, we still wonder what whims of nature prompt wholesale winter loss of turf in some locations, while others a few miles away come through in good condition despite a similar climate.

Certainly, climate, which is an average of weather happenings, doesn't give us the answer. Averages often are misleading. At their worst, reliance on weather averages could be harmful. It is rather like encasing one foot in ice and submerging the other foot in boiling water to obtain human comfort. On the average, it should work. So should planting cool-season grasses for year-round play in Miami, work on the average. The winter climate there is 69° F., with summer a balmy 78° F. Although ideal on the average, it just won't work. Indian Creek found this out in the late 1940's when they tried to grow bent greens on a year-round basis.

One day we shall know the weather extremes that are responsible for winter loss of turf. Michigan Turf Scientist Jim Beard is working on causes of winter failure. Toro Manufacturing Company's Jim Watson has shown us how plastic covers can be used to protect the grass. At Purdue, Daniels is working with heat cables and waxlike coatings to keep grass growing in cold weather and to retard drying out. Iowa's Roberts is researching nitrogen source influence on winter hardiness, while Keene at Kansas is developing more winter-hardy grasses through breeding and selection. Other turf researchers are making equally significant contributions that will make headlines.

Once we know the "why's" of winterkill, the corrections will be easy. Until then, those that protect the turf will fare the best. Fungicide should be applied to prevent snowmold on bent and *Poa annua* grasses, especially the greens. Precautions must be taken to prevent desiccation, and ice should be removed in spring, if it is bonded to the grass.

Annual bluegrass is the most treacherous winterkill species of all. A few northern resort courses still rely on *Poa* because play doesn't start until it has had a chance to recover. Those faced with more normal play should be doing everything in their power to replace *Poa* with more desirable bentgrasses. The old standby of pre-emerge treatment with lead arsenate still works well for some. Many Iowa courses still spray lead on greens during the summer to check existing *Poa* on a post-emergence basis. They include 1 to 2 ounces of lead arsenate per 1,000 sq. ft. with their fungicide program.

Calcium arsenate is still being used successfully on bent fairways, but at lower rates than first suggested by Purdue. Ed Riley, Manufacturers' Club, Philadelphia, has had amazing success with this product. Soil reaction seems critical with this material. The pH should be around 6.5, only slightly acid. Results

Continued on page 90

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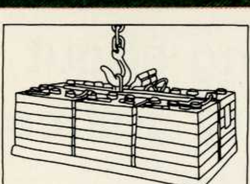

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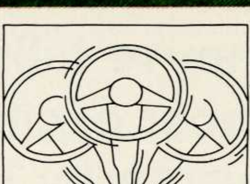

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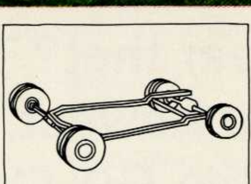

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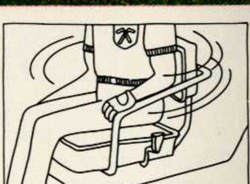

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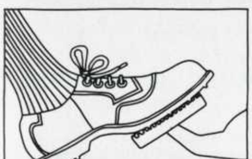

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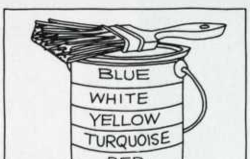

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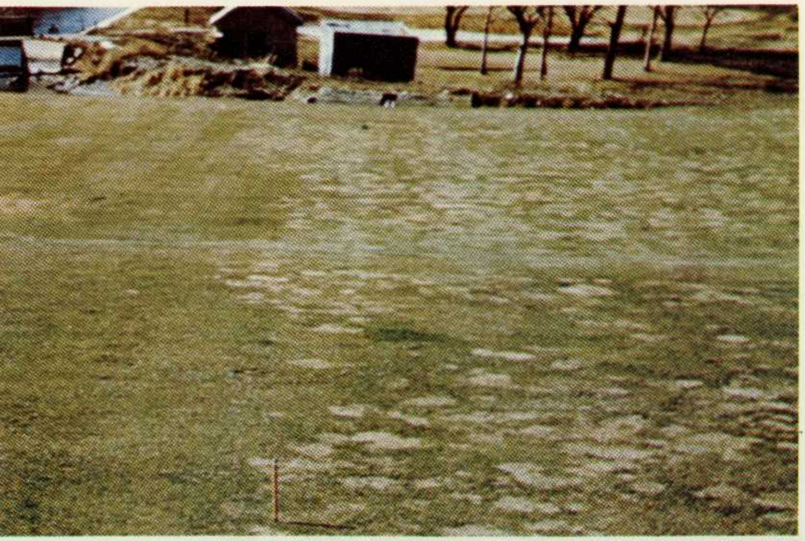
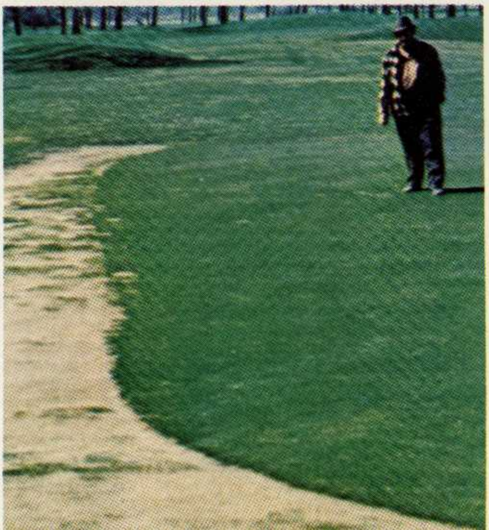


Mercury compounds are very useful in the prevention of the snowmold diseases. Without preventive treatment, turf is frequently ruined completely.

Poorly drained areas seem particularly susceptible to the ravages of winterkill. Here a low area in bentgrass-Poa annua turf has been killed because of inadequate drainage.



This putting green is constructed of a permeable soil mixture; the collar, of native soil. It appears the better drained areas can better survive winterkill conditions.

Study winterkill, then fight it!

Understanding this unpredictable foe is essential to any success in preventing damage.

By DR. MARVIN H. FERGUSON
Golfdom Agronomy Consultant

Winterkill is one of the foremost dreads of the turfgrass grower. The damage can be deadly and it is largely unpredictable. Winterkill occurs on Bermudagrass in the upper South, on *Poa annua* and sometimes on bentgrass in New England and the Midwest. In the Great Plains states where cold drying winds are prevalent, desiccation can ruin almost any kind of turf.

If we ever are to achieve any degree of success in the control of winter injury, we must first seek to understand *why* turf is killed some years and escapes in other years when the weather seems to be just as cold. An examination of some of the physiological principles involved may point the way to more successful methods of management.

As a starting point, we may ask, "When is the plant killed? At the time it freezes? At the time of thaw? At some point of time between the first freeze and the final thaw? After thawing has occurred and growth has begun?" It appears that winterkill can occur at any of these times, depending upon environment and the condition of the plant.

A study of so technical and complicated a subject without the use of scientific jargon (meaningless to all but plant physiologists) is quite difficult. Therefore, the reader is warned that many statements in this article are greatly oversimplified. At the 1964 annual meetings of the American Society of Agronomy, the subject was treated at considerable length and detail by Dr. James Beard of Michigan State University, Dr. Jack LeBeau of the Lethbridge Experiment Station of Alberta, Dr. J. R. Watson of the Toro Manufacturing Company of Minneapolis, and by this writer. Readers interested in the more technical aspects of the subject can be directed to sources of literature by any of these men.

Killed at time of freezing—Reverting to the question of *when* the actual killing takes place, we may first examine the case where killing occurs at the time of freezing. Usually, if plants are killed by initial freezing, it happens when the onset of freezing temperatures is very rapid and when plants have not had time to become "hardened."

A rapidly growing plant has a high proportion of water. This water is present in the sap solution and may occur within the cells and, in some cases, the intercellular spaces. The protoplasm, the vital part of the cell, may under these conditions contain a relatively small proportion of the total water. When a plant has time to "harden," the tissues lose much of the free water in the sap, the sap solution becomes more concentrated, and biochemical and biophysical changes cause the protoplasm to become hydrated with water in a "bound," that is, unfreezable form.

When slow freezing occurs, the first ice crystals form in the spaces between cells, and more and more water is drawn out of the cells into these intercellular spaces until all the freezable water has been crystallized. If such a condition prevails for a short while and then thaws occur, the plant may escape being damaged.

When rapid freezing occurs in un-

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hardened plants, ice crystals may form within the cell and the protoplasm may be disorganized. It is generally believed that such intracellular ice induces fatal injury at the time it is formed.

Killed at time of thaw—When freezing occurs in plant tissues, water is withdrawn from cells and ice crystals are formed in the spaces between cells. The withdrawal of water causes cell walls to be pulled inward. The protoplasm within the cell becomes balled up or "plasmolyzed." Unless the protoplasm is well supplied with "bound water" it becomes brittle. Upon thawing, water rushes back into the cell through the highly permeable cell wall. Rapid "deplasmolysis" occurs and the protoplasm may be stretched and subjected to shear forces sufficient to destroy it.

It is reasonable to assume that prolonged cold which contributes to the brittleness of the protoplasm would be conductive to greater injury. It is also likely that repeated freezing and thawing would become increasingly harmful.

Killed at some period between freezing and thawing—One of the older theories about ice damage held that the ice crystals ruptured the cell walls. This theory has been discredited. It appears not to be the case in most plants. In turfgrasses, however, where traffic is a factor, it appears very likely that physical damage by ice crystals is a serious cause of injury.

Dr. LeBeau's work in Alberta indicates that fungi in the plants produce gases that kill the plants. This production of gases apparently occurs while the plant is frozen. Here, then, are two situations wherein the plant succumbs at sometime between freezing and thawing.

Killed after thaw and growth has apparently begun—Many of the more common pathogens (the causal agents of disease) associated with the winter injury of turf grasses appear most active when snow goes off and temperatures are beginning to rise. It seems likely that these plants are killed after thaw or at the time of thawing.

Heaving of the ground often results in plants being left almost out of the soil and it sometimes causes a considerable portion of the root system to be pulled off. It also has been noted that a considerable portion of the crown tissue may have been destroyed, leaving relatively little vascular tissue to transport moisture and nutrients. In these cases, plants may be alive and they may begin growth, but die because moisture and nutrients are completely exhausted.

Desiccation—Desiccation, the drying out of the soil and of the plant tissues, is a commonly blamed condition for winterkill. In the absence of a snow cover, moisture may be lost from a frozen soil through the process of sublimation. This is a process whereby water passes directly from the solid to the vapor phase—from ice to moisture vapor without passing through the liquid phase.

It is difficult to determine whether turf killed under these conditions dies sometime during the winter or in spring when growth functions begin. Such plants simply die from drouth.

Ice Sheets—One of the puzzling conditions associated with winterkill is the effect of ice sheets. It has been demonstrated that *Poa annua* dies relatively soon under an ice sheet, but that bent and bluegrass are quite hard to kill. Dr. James Beard of Michigan State University has investigated this matter but has not reached definite conclusions.

Some of the mechanisms suggested are the depletion of oxygen, the accumulation of carbon dioxide, and the leaching out of cellular constituents. Dr. Beard's work appears to indicate that the direct effects of low temperatures may be the most important.

How to prevent it—Having examined briefly the several mechanisms which operate to produce winterkill, let us consider steps which may reduce the effects of cold.

1. Don't fertilize and water turf so generously that it approaches cold weather in a soft and succulent condition.

2. Use ample phosphorus and potash in the periods before winter. Abundant nitrogen appears to be less detrimental if it is balanced by the use of phosphorus and potash.

3. Apply a protective fungicide. There

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