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USGA GREEN SECTION RECORD

A Publication on Turf Management
by the United States Golf Association

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VOL. 8, NO. 2 **MARCH, 1970**

COVER PHOTO —
E. R. Steiniger receiving the Green Section Award from Henry H. Russell and Hord W. Hardin.

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1970 USGA Green Section Conference Subject: Are Your Maintenance Practices Up - To - Date?

E. R. Steiniger—10th Recipient of USGA Green Section Award

Eberhard R. Steiniger, of Laurel Springs, N.J., was named recipient of the 1970 Green Section Award of the United States Golf Association. The award is presented annually in recognition of distinguished service to golf through work with turfgrass.

Mr. Steiniger is the golf course superintendent at Pine Valley Golf Club in Clementon, N.J. He accepted the award during the Association's annual Conference on Golf Course Management in New York City on Friday, January 23. It was presented by Hord W. Hardin, of St. Louis, then President of the USGA, and Henry H. Russell, of Miami, Chairman of the Green Section Committee.

Mr. Steiniger was born and educated in Germany, came to the United States and began his golf career in 1926 under Norman Mattice at the Lakeville Country Club in Great Neck, N.Y.

He came to Pine Valley in 1927, took full charge of the course in 1933, and has remained ever since, except for four years of military duty during World War II.

Mr. Steiniger was among the earliest golf course superintendents to experiment with adaptation of turfgrass, and he was instrumental in selecting the C-7 Cohansey strain of creeping bentgrass that has been widely used on golf courses. It is one of the outstanding creeping bentgrass strains available today.

Today he maintains a 10-acre nursery at Pine Valley containing many selections of improved strains of golf turfgrasses, including both cool- and warm-season varieties.

He has worked with local, state, and national turfgrass organizations and held positions at the Executive Committee or Board of Directors level. He has been Vice-President of the Pennsylvania Turfgrass Council, Chairman of the Joseph Valentine Memorial Fund, President of the Philadelphia Golf Course Superintendents Association, member of the Board of Directors of the H. Burton Musser Foundation, Inc., and a member of the Board of Directors of the Rutgers University Turfgrass Advisory Board.

He is also a member of the USGA Green Section Committee and has given talks on turfgrasses, turf maintenance, and labor management. He has also contributed articles on golf turf to magazines, including the USGA Green Section Record.

Mr. Steiniger has varied interests. He is a Vice-President of the Laurel Springs Building and Loan Association and an Elder in the Laurel Springs Presbyterian Church.

He is the 10th recipient of the Green Section Award. Previous recipients were Dr. John Monteith, Jr., of Colorado Springs, Colo.; Professor Lawrence S. Dickinson, of Amherst, Mass.; O. J. Noer, Milwaukee, Wis.; Joseph Valentine, Ardmore, Pa.; Dr. Glenn W. Burton, Tifton, Ga.; Professor H. Burton Musser, State College, Pa.; Elmer J. Michael, Rochester, N.Y.; James L. Haines, Denver; and Dr. Fred V. Grau, College Park, Md.

Winter turf damage from heaving.

WINTER PROBLEMS — What They Look Like — What to do About Them

by **HOLMAN M. GRIFFIN**, Agronomist, USGA Green Section

Winter turf problems can be deadly, unpredictable, and the worst problems those who work with turf can encounter. The problems though, are not insoluable. We can examine how turf is damaged during the winter and, where possible, explain what can be done to lessen the problem.

Turf Killed at Time of Freezing

If the plant has not had time to "harden" properly it may die at the initial freeze. In this case, the plant is rapidly growing and may be in a rather succulent condition with a high content of water in its cellular structure. Water is in the sap solution and in intercellular spaces as well as within the cell proper. When rapid freezing occurs, ice crystals form within the cell, and the protoplasm (the vital part of the cell) may become disorganized. Intercellular ice of this kind will almost always cause severe damage or death.

When the plant is "hardened" by the gradual onset of cold weather and a slowing down of the growth process, the tissues lose much of their free water and the sap solution becomes more concentrated. Biochemical and biophysical changes cause the protoplasm to become hydrated with water in a "bound" or unfreezable form and death is less likely to occur.

When *slow freezing* occurs, water is slowly drawn out of the cells and all freezable water is crystallized in the intercellular spaces. If such a condition is not prolonged, the plant may escape injury.

Turf Killed at Time of Thaw

When freezing occurs, water is pulled from the cells and the cell wall is pulled inward. The protoplasm in the cell becomes plasmolized, or balled up. Unless the protoplasm is well supplied with bound or unfreezable water, it becomes brittle. Upon thawing, water rushes back into the cell through the highly permeable cell wall, and the protoplasm may be stretched and subjected to shear forces sufficient to destroy it. Under these conditions, turf is killed at time of thaw.

Turf Killed While Frozen

The work done by Dr. Jack Le Bean, of Lethbridge Experiment Station in Alberta, Canada, indicates that fungi in plants produce gases while the plant is frozen. These gases may cause death. This production of toxic gas and traffic on frozen turf are the two main causes of turf death while still in a frozen state.

Turf Killed After Thawing

Many of the common pathogens associated with winter injury are apparently very active, and their destruction may be most pronounced just after thawing begins and when the plant is striving to re-initiate growth.

When frozen soil begins to thaw, heaving may also occur. Heaving may cause a large portion of the root system to be pulled off. If crown tissue has also been damaged, little of the plant is left to support continued growth, and death occurs when the immediate energy supply is exhausted.

Desiccation

Desiccation is the drying out of soil and plant tissues. It may cause severe damage in winter if adequate moisture is not maintained. In the absence of snow cover, moisture may be lost from frozen soil by sublimation. This means that the moisture may pass directly from solid to gas without becoming a liquid which is of course the only form available to the plant. When this happens, plants simply die from drought.

Ice Sheets

The most comprehensive work on ice sheet damage has been done by Dr. James Beard of Michigan State University. Some of the mechanisms of ice sheet damage suggested by Dr. Beard are the depletion of oxygen, the accumulation of carbon dioxide and the leaching of cellular constituents. Although Dr. Beard has thus far reached no definite conclusions on the matter, his work indicates that direct effects of low temperature may be more important than any of the mechanisms of ice sheet damage.

What to Do When Winterkill Occurs

1. Water lightly and regularly until the plant can re-establish its root system.

2. Where no plant is left, replant following whatever renovation is possible with spiker and perhaps some vertical mowing or vertical slicing.

3. Gentle treatment of the turf as if the entire damaged portion were all new seedlings, which in effect it is, is called for.

Winter injury has been so widespread and severe recently that numerous experiment stations have begun to study the matter more critically. There has been a renewed interest in soil warming by the use of electric heating cables and in the use of various types of coverings.

Winterkill: Learn The Cause, Improve The Cure

by JAMES W. TIMMERMAN, Agronomist, USGA Green Section

Within the last five years, golf courses in the Northern United States have experienced winter injury as severe as any in history.

What are the causes of winterkill and what is known of their destructive action?

The ravages of winter are easily classed into six categories:

ASSOCIATED ICE SHEET DAMAGE

The extensive damage suffered from ice sheets during the 1961-62 winter season prompted considerable research. Investigated causes of ice sheet damage include:

1. Oxygen suffocation under the ice sheet.

2. Toxic accumulation of carbon dioxide and other breakdown products under the ice sheet.
3. Outward leaching of vital cellular constituents while submerged in water during thawing.
4. Outward diffusion of water from leaves encased in ice.
5. Direct low temperature injury.

The work of Dr. James Beard at Michigan State University, however, suggests that injury from the first four causes above normally does not happen until after 75 days. Ice sheets of this duration rarely occur in the United States. Injury, therefore, is apparently caused by direct low temperature kill.

Observations by Green Section agronomists conclude the following:

1. *Poa annua* is more severely injured than any other turfgrass found on northern golf courses.
2. A solid ice sheet must be in place 20 to 25 days before *Poa* is damaged.
3. Bentgrasses will subsist considerably longer.
4. Damage is always more severe on poorly drained soil which compacts readily.
5. Succulent turf experiences the greatest injury.

Severe damage to this green was caused by traffic allowed during a thaw period.

DIRECT LOW TEMPERATURE INJURY

Injury of this type is associated with freezing and thawing of water in the plant. Death results because of the harmful effects of ice crystals either within the cell or in intercellular spaces.

In the case of intracellular (inside the cell) freezing, injury is caused by a mechanical disruption of the protoplasm by the ice crystals. Generally, intracellular freezing always kills the cell. However, this apparently happens in nature only to unhardened plant tissue frozen rapidly. Hardened tissue undergo changes which resist intracellular freezing. These changes include:

1. A reduction of water within the tissue.
2. An increase in soluble carbohydrates.
3. A change in the type of proteins present.
4. An increase of bound water within the cell.

When intercellular (outside the cell) freezing occurs, death may or may not result, depending on the degree the protoplasm of the cell is affected. Injury to the protoplasm from intercellular freezing is different from injury from intracellular freezing. When the plant freezes slowly, water is drawn from the cell into the intercellular spaces where it freezes. If enough water is drawn out of the cell, the protoplasmic consistency is increased until with extreme dehydration it becomes brittle. Due to the water removal, the cell wall contracts and subjects the brittle protoplasm to tensions. Upon severe contraction the tension produced results in mechanical damage to the protoplasm. Further injury can result if the plant thaws rapidly. When this happens, water rushes back into the cell and the protoplasm may be stretched and subjected to shear forces sufficient to destroy it.

Hardened tissue, because of an increase in the bound (unfreezable) water, can resist this type of injury. Bound water permits the protoplasm to remain ductile when subjected to dehydration that would otherwise render it brittle. However, the extent of kill from intercellular freezing is governed by a number of factors. These are:

1. The degree of plant hardiness. Damage is more severe on less hardy plants than in hardened plants.
2. Plants frozen rapidly may show more injury than those frozen slowly.

3. Greater injury may occur with longer freezing periods than after short freezing periods at the same temperature.
4. Greater injury may occur if thawing is rapid than if it is gradual.
5. Repeated freezing and thawing may increase an injury from which the plant could have recovered after a single freezing.
6. Injury may increase after thawing if the plant is exposed to unfavorable conditions.

Based on the above findings, it appears that the chance for low temperature kill is greatest when the plant is in a reduced state of hardiness. Dr. Beard warns that the two most critical times for kill occur during late winter thaws and just after the spring thaw. Three or four days of warm temperatures result in a premature loss of hardiness due to an increase in hydration levels within the plant. Injury can occur if this is followed by a severe drop in temperatures to below freezing. He suggests other factors which also lead to increased hydration levels and thus to loss of hardiness.

1. Poor surface drainage.
2. Inadequate internal drainage of soil (compacted soil).
3. Ice or snow accumulations which impair surface drainage and cause ponding and submergence of grass crowns.
4. Melting from beneath the ice and snow layer with no means of draining the water away from the grass crowns.

TRAFFIC

Traffic damage is becoming more of a concern because of increased winter play and use of the course for snowmobiling, skiing, and sledding. Injury is by two means: Mechanical injury to the grass plant, and injury due to soil compaction and displacement.

Mechanical injury from traffic includes, first, the attrition or wearing away of semi-dormant or dormant turf. Because the turf is not growing actively, above ground parts are not replaced. Damage of this type is particularly severe on partially or completely frozen soil which has no resiliency. Second, when the soil thaws to a depth of one-half inch or more and remains frozen below, traffic at this time can shear-off plant roots, resulting in death when growth resumes. Finally, traffic on frosted turf results in cellular rupture within the plant. This is especially injurious when the grass is in a reduced state of hardiness during late fall and early spring.

Injury of a less direct nature occurs when traffic is allowed on partially frozen or saturated soil. Obvious damage is footprinting and vehicular rutting. Less obvious damage is the soil compaction which results. This usually manifests itself as problem areas during the growing season and increased *Poa annua* invasion.

DISEASE

The two major diseases of concern in winter injury are *Typhula itoana* (grey snow mold) and *Fusarium nivale* (pink snow mold). These diseases initiate growth in the fall when the weather cools and humidity is high. Activity continues under a snow blanket, particularly if the ground remains unfrozen, and during cool, wet periods of spring when the incidence of kill is greatest. The optimum air temperature for development ranges between 32 and 45 degrees Fahrenheit, although *Fusarium* can remain active up to 65 degrees.

Injury in the spring from both diseases is noticed as small, roughly circular patches of pale-yellow turf. As the diseases progress, the patches enlarge and coelesce, resulting in rather large areas of blighted turf. *Typhula* will usually exhibit a characteristic halo of grayish-white mycelial growth at the margin of the patches, whereas *Fusarium* produces a pink mycelium. *Typhula* is further distinguished from *Fusarium* by the presence of small, reddish-brown fruiting bodies called sclerotia, roughly the size of a pinhead, embedded in the leaf and crown tissue of infected turf.

Recent research in Canada suggests that certain other fungi in plants can produce gases that can kill turf, apparently while the plants are frozen.

DESICCATION

Kill from desiccation is usually a problem in the Plains States, but the severity of injury suffered in the Northeast during the 1967-68 winter was the worst in 20 years. It brought out clearly the need for understanding its destructive power so that injury in the future can be avoided.

Death due to desiccation is actually a wilting process. Even though the plant is dormant, a low level of transpiration occurs. If the plant loses more water than the roots can supply, the plant wilts or "desiccates." This happens when the water in the soil is frozen or when the soil is dry or saturated. Injury is most severe on high, windswept areas, free from snow.

HEAVING

Heaving damage is caused by alternate freezing and thawing of the soil, which raises the plant above the soil level. Injury can be severe if the roots are severed. However, established sod is seldom injured. Heaving is most damaging to poorly anchored plants and on late fall- and early spring-planted grasses.

We can easily see, therefore, that winterkill occurs in a variety of ways. The key to avoiding extensive damage obviously lies in adequate preparation before winter strikes. Only by understanding the causes and methods of kill can the best available means of prevention be more effectively employed.

Winter Drainage Problems

by G. DUANE ORULLIAN, Agronomist, USGA Green Section

Winter damage to turfgrass poses a challenge to the management practices of any turfgrass specialist. A carefully planned program is essential for winter maintenance in most northern latitudes.

Winter injury is due to many causes, and we should prepare for the worst in order to achieve success. Control measures must vary according to cause or injury. Is it best to "act" to prevent winter problems, or wait until they occur and then "react" to them? Good preventative maintenance prior to winter will help avoid problems.

Unfortunately, many of our turf problems are a constant source of trouble throughout the year. Poor soil drainage is one of these and affects turf during both summer and winter.

ICE, WATER AND SUFFOCATION

Before going further, the following quote from Dr. John Monteith in the 1932 issue of the USGA Bulletin, Vol. 12, No. 4 might be considered:

> "A disease recognized on turf in 1914 was given the descriptive name—Brown Patch which led to much confusion. Another disease was later recognized and designated as 'Small Brown Patch.' Any casual student of turf knows that when turfgrasses are killed by any means, they usually turn to some shade of brown, therefore, if a sufficient percentage of grass is killed in an area, it is likely to form a browned patch!

Breaking up snow and ice sheet to allow for surface drainage of water on frozen soil. Ice sheets should be removed if they persist longer than three weeks.

Consequently, a great many injuries which produce browned patches of turf have been designated 'Brown Patch' without recognizing that the term was intended to apply to at least two or more types of injury."

The statement relates to disease problems, but it could easily be applied to winter damage. The following characteristics should serve as a guide to ice, water and suffocation problems in the winter:

1. The appearance of large irregularly shaped areas with the greatest damage in the center and tapering to the sides. If turf is brown or tan in color, chances are that the crowns are intact and that new growth can be initiated later on. If the turf is grey or "bleached out," it is probably dead.
2. Ice does not necessarily injure turf. It may, in fact, help to serve as an insulation against freezing. "Black Ice" will form over small depressions in the surface contours during alternate weather conditions of freezing and thawing. These pockets of ice serve to stimulate the grass beneath by serving as a lens during sunny days by increasing the surface temperatures from the sun's rays. Suffocation of turf will then take place for lack of oxygen. If ice melts, subsequent exposure to cold air or wind will also destroy the stimulated grass.
3. Water damage is generally associated with heavy, tight soils. Poorly drained areas that were problems during the summer frequently pose a threat to turf in winter. Waterlogged soils rob turf roots of needed oxygen for growth. The soil may freeze into a solid block with no air spaces. A "heaving" effect may then occur, tearing the turf roots apart and exposing them to surface conditions.

CORRECTIVE MEASURES

Rapid changes in winter weather, especially during the late winter—early spring transition period can be very injurious to turf. There may be combinations of circumstances causing injury that are beyond human control. Therefore, in addition to preparation for winter problems, the turf manager should be aware of situations that may require an immediate remedy. The following guide lines should be helpful in this regard:

1. Provide for good drainage both on surface and subsurface areas. Prior to winter, all drains should be checked out and seen to be functioning properly. Waterlogged areas should be noted and given special attention during the winter. If some areas are consistently wet, then recontouring of the playing surface and/or installation of tile lines will be necessary when weather permits. Where soil conditions are right for their growth, cool season grasses such as bluegrasses, bents, and fescues will generally survive winter very well.
2. Observe deposits of snow and ice, especially those that remain into the late winter. If ice deposits persist longer than three weeks, they should be removed. Prolonged ice coverage may cause a build-up of toxic gases that smother the turf.

   Where ice has adhered to grass blades, mechanical removal may increase turf injury. In some areas where air temperatures will permit, an early morning watering will help to melt the ice. In other areas, a light application of topdressing on greens and tees at one cubic yard per 4,000-5,000 square feet will also help to melt ice by absorbing the sun's rays and increasing surface temperatures. Care should be taken to avoid applying topdressing when turf sod is still frozen. Wheel tracks compressing the turf will cause ice crystals to rupture cell tissues.
3. Winter damage may occur in such unlikely places as slopes where snow and ice banks cause water to back up and suffocate turf. Even well drained soils are subject to this situation where they remain frozen at the time of water accumulation. In such cases, chopping a furrow into the ice may be necessary. Water should be dispersed over a large enough area that it will not collect somewhere else and duplicate the same problem.
4. Avoid close mowing in the late fall, especially bermudagrass in the transition zone.
5. Avoid overstimulation of turf during late fall; it may remain succulent and not harden over in the first cold days of early winter.
6. Make every effort to avoid extremes of wet or dry soil conditions going into the winter.

NOTE:

At the 1970 Green Section Conference, Dr. Joseph M. Duich, Professor of Agronomy, Pennsylvania State University presented a most interesting and valuable paper on bentgrass breeding and the new varieties of bentgrasses available. Dr. Duich's paper will appear in a later issue of The Green Section Record.

Winter Protection Through Sound Management

Tar paper roofing nails are all that are required for stabilizing plastic screening.

by **A. ROBERT MAZUR**, Agronomist, USGA Green Section

Despite the fact that low temperature kill, desiccation, and snow mold are all types of winter injury, they are very different in nature. Therefore, methods of eliminating or minimizing the effects of each form of winter injury differs.

Variety and Specie Tolerances

Different species as well as varieties of turfgrasses have varying degrees of winter hardiness. Many of our problems could be eliminated at the start by selecting turf varieties with a greater degree of winter tolerance. In the northern areas the selection of a turf variety, such as Toronto, with a proven tolerance to winter injury would reduce the amount and severity of problems. The selection of winter-hardy varieties is also important in the transition zone where warm-season grasses are used.

Management

Although other factors are important, management plays the key role in winter survival. The management operations you employ all season affect the winter hardiness of your turf areas. Management is particularly critical in the late summer and early fall. In the Northeast, fertilization should be stopped by mid-September to allow adequate time for the turf to harden off. If the turf is not forced by overstimulation with readily available sources of nitrogen or frequent irrigation, it will gradually reduce metabolic activity and establish a hardened state. In this hardened state, the plant has a minimum of unbound water which enables it to withstand the low temperatures which occur during the winter.

In all cases, traffic should be avoided on dormant turf. This should be particularly emphasized during wet, slushy periods. In addition to attrition, traffic packs the wet snow in close proximity to the crown tissue. As the temperature drops and the wet snow turns into ice, injury is eminent. This brings to light the importance of good drainage. By eliminating poorly drained areas, the superintendent can solve many of his perennial problems.

A regular program of thinning and topdressing should be underway to keep thatch in the desired proportions. Excessive thatch promotes elevated crowns and restricted roots. Elevated crowns are subject to low temperature kill while restricted rooting increases the susceptibility of the turf to desiccation.

Potassium should be applied early in the fall if it is to benefit the turf. If the muriate or sulfate of potash is not applied early enough to come into equilibrium with the soil, it may actually do more harm than good. These materials increase the salt index of the soil solution at a time when its effects can be magnified by freezing. High salt concentrations will serve to increase the detrimental effects of winter injury.

In northern areas it has been the general practice to recommend late spring or early summer weed control. All herbicides adversely affect the metabolism of the turf to some extent, and it is not advisable to weaken the turf immediately before winter.

Late fall renovation and seeding should be avoided. Adequate time should be allowed for the turf to recover or become established prior to cold weather. Young seedlings are easily damaged by the thrusting action of freezing and thawing.

The old practice of aerating greens late in the fall and leaving the aeration holes open over the winter is a real gamble. Although this practice improved drainage around the crowns of the turfgrass, it increased the threat of desiccation. If late fall aeration is needed, it is advisable to topdress following the aeration. It has been our observation over the past few seasons that a late heavy topdressing at about twice the normal rate (2/5 yard per 1,000 square feet) has provided an extra measure of protection during winter.

Another drawback to fall fertilization is the reported increase in snow mold activity. The snow mold organisms, although not obvious, are active during the fall. An early fungicide treatment, about the time the leaves fall, has been shown to be the single most important treatment for the prevention of snow mold. A second application in early winter prior to permanent snow cover generally improves results.

It is obvious that turf areas should be mowed as long as leaf tissue continues to develop. Unmowed turf provides an excellent environment for the development of snow mold, particularly if snow cover is established before there is frost in the ground. Because screens and covers also provide an ideal environment for the development of snow mold, all areas that are to be covered should be treated before the covers are put in place.

Generally in the Northeast, moisture from natural sources is adequate in the fall for the development of a healthy turf. However, during the early spring after a dry, open winter there

Sod cutter with mole attachment is used to install heating cables.

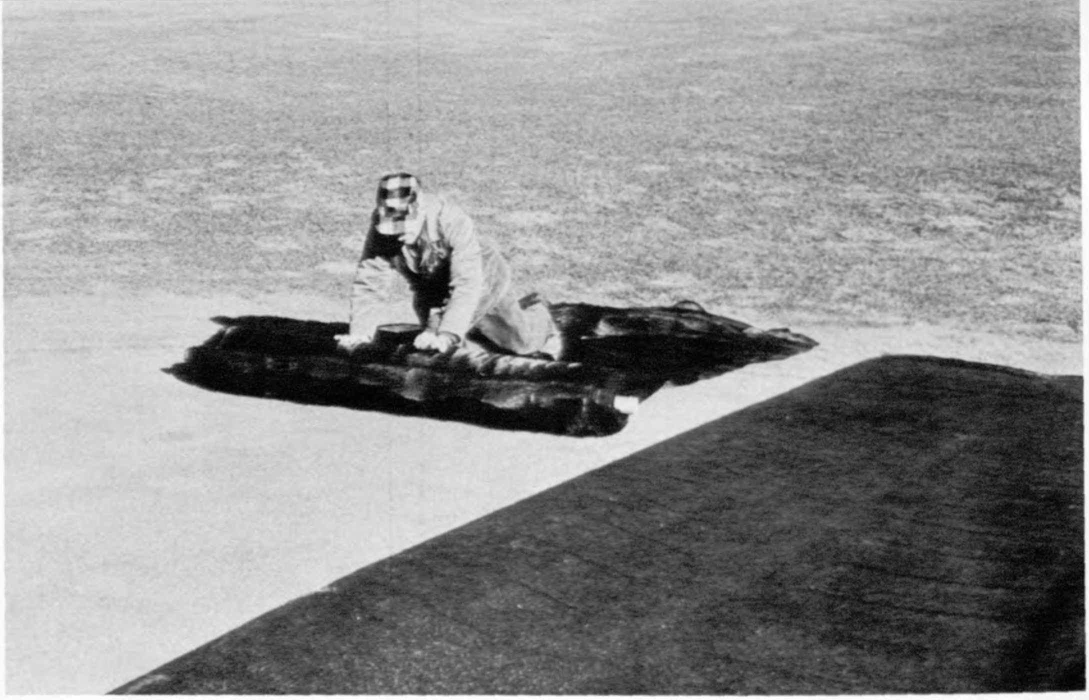
may often exist a need for supplemental water. The turf can be severely desiccated when subjected to drying winds without a snow cover. Moisture is constantly lost from exposed tissue and little if any moisture is being replaced by the root system. Moisture applied under these conditions will help to reduce or eliminate injury from desiccation.

Artificial Protection

When we talk of artificial protection, we are referring to that portion of ecology known as micro-climate. Micro-climate is the environmental condition which exists in close proximity to the turfgrass plants. By controlling moisture loss, restricting low temperature and buffering against any rapid temperature fluctuations, we can minimize or eliminate the damaging effects of winter weather. At our disposal we have tools such as anti-desiccants, protective screens and covers, and electric heating cables.

Although anti-desiccants have been used effectively on horticultural plantings, recent results have shown them to be ineffective in reducing moisture loss from turf during the winter.

Over the past eight or ten years, many different types of screens and covers have been tried



Plastic screening can be unrolled and spread over the green in a short time.

in the various sections of the country—at universities, by industry and on golf courses. Generally they have been a topic of mixed emotions. During difficult winters, all covers reduced or eliminate winter injury. During normal seasons the covered areas greened up two or three weeks earlier in the spring, but there was no difference between protected and non-protected areas by the time they were put into play.

The response of turf to the different materials was wide and varied. Factors such as the color of the materials and the amount of air exchange attribute to the varying results. Prior to the selection of a material, it might be advisable to check recently published results on the subject.

The critical factor associated with the use of protective coverings seems to be associated with the timing of their removal in the spring. The grass should not be allowed to grow too high, because it will require considerable time to get it back down to the desired height of cut without scalping. The second factor is that after the turf's uncovered, a sudden change to cold weather can injure the soft turf.

Heating cables provide another source of winter protection. They have been used alone and in conjunction with protective coverings. Heating cables have been used on athletic fields and their use on golf courses might be economically feasible on limited areas, such as practice greens, principally as a means of prolonging outdoor activity. However, it is extremely doubtful if this method will be used on golf courses to any extent because of the high cost of installation and operation.

In summary the best protection against winter injury is a sound management program supplemented by good drainage and sound judgment.

GREEN SECTION STAFF CHANGES

At the New York Meeting on Golf Course Management, Henry H. Russell, USGA Green Section Committee Chairman, announced the appointment of Lee Record as Mid-Continent Director of the USGA Green Section. Record joined the Green Section Staff in 1962 and has had extensive experience in the Eastern and Mid-Continent areas. He is a graduate of Colorado State University and had earlier experience as a golf course superintendent.

Dr. Paul Alexander announced his resignation from the staff effective January 1, 1970. Formerly an Associate Professor of Agronomy at Clemson University, he came to the Green Section on July 1, 1969. He now leaves to take up the new duties of Education Director for the Golf Course Superintendents Association of America.

Preparing the Course for Winter

The placing of a snow fence around greens and tees is an accepted practice in many areas.

by LEE RECORD, Director, Mid-Continent Region, USGA Green Section

Turfgrass management practices performed during the growing season are indirectly involved in preparing the golf course for winter. The condition of grass plants going into the winter cannot be overemphasized.

To "harden off" grass plants, restricted nitrogen feeding must begin in late summer. Nitrogen sources must be looked at closely within each management program. Kentucky bluegrass, for example, should have a 2 to 1 or 3 to 1 ratio of nitrogen to potassium for survival.

Potassium increases in plant tissue as fall and winter approaches if an adequate amount is introduced into the soil during the growing season. Potassium deficiency has been associated with increased winter injury. It takes 16 elements to produce a healthy plant. Carbon, hydrogen and oxygen will take care of themselves. Soil analysis should therefore be taken at random each year to see if minor elements are needed to help prevent excessive winter injury.

Timing of nitrogen applications is important to winter hardiness of the grass plant as it relates to disease. Nitrogen applications applied in autumn will encourage spring snowmold. Early fall fungicide applications on fairways, collars, approaches, tees and greens, however, have reduced or prevented *Fusarium sp.* and *Typhula sp.* organisms.

Reports of excessive use of arsenical compounds, cadmium and mercury fungicides and various herbicides encourage winter injury especially under anerobic conditions. Caution must be taken when using these materials, especially if toxic levels are being reached.

Topdressing greens in late fall, with up to three cubic yards of material per normal green size (5,000 sq. ft.) in split applications, has become common practice. This is done in effect to reduce or prevent winter injury. Two distinct advantages are gained through topdressing greens in late fall: 1) A buffer zone of soil between turf and ice accumulation is formed; 2) A buffer zone between turf and drying winds has been established, which obviously helps to prevent desiccation in late winter and early spring.

Placing brush or a snow fence around greens and tees is an accepted practice in many areas. A snow fence is normally placed around exposed, non-protected greens, while brush is placed on protected greens and tees. Snow fence and brush have aided the hunter, skiier, sled rider, etc., to keep warm by having an available wood supply. However, snow fence and brush have kept damage at a minimum in spite of winter traffic, especially with the use of snowmobiles.

Late fall renovation by thatching or deep vertical mowing is dangerous if an early fall or early winter is eminent. One month prior to a killing frost is reasonable time to have all renovation completed. July and August renovation may assure protection against severe winter injury.

Temperature relationships of well drained and poorly drained soils have a direct influence on winter injury to turfgrass. Greens with poor surface drainage normally are a problem because of excessive water and ice accumulation. A poorly drained soil may be expected to have a temperature range of 6 to 12 degrees Fahrneheit lower in the surface layer than a well drained soil. We know that heat passes from soil to water approximately 150 times faster than from soil to air. As water is added to the soil, air is decreased. When air is decreased by moisture in the soil, heat conductivity is increased. Because of these conditions, a well drained soil would tend to bring temperatures within optimum growth earlier in the spring.

When renovation of problem areas cannot be completed before winter, a sod cutter can be a quick and very satisfactory method of aiding surface drainage on greens. Cut a two-inch in depth sod strip running the length of the problem area off the green. Water runoff is improved during thawing periods of the winter, thus overwetness of low areas is reduced. Sod strips are placed in bunkers for "overwintering" and then replaced on the green the following spring. Chain saw slit trenches have also given satisfactory results in improving problem drainage areas.

A sod cutter is used for aiding surface drainage on greens.

In summary, we come to these conclusions: Nitrogen and minor elements have a direct bearing on winter hardiness of the grass plant. Disease may be eliminated with the proper timing of fertilizer and fungicide applications. Topdressing, the placing of brush and snow fence on and around greens is a sound management program. Perhaps the most important requisite of preparing the golf course for winter is that of drainage.

An Ecological Study of Annual Bluegrass

by JAMES B. BEARD, Department of Crop and Soil Sciences, Michigan State University, East Lansing, Michigan

Unfortunately, too much emphasis has been placed on the control of annual bluegrass and not enough thought given to the characteristics, adaption and cultural requirements of this species.

Annual bluegrass (*Poa annua* L.) is generally considered to be a weed and is seldom intentionally planted. However, under frequently irrigated, close cut, high fertility conditions found on fairways, tees and greens, annual bluegrass will tend to invade, persist and become a major component. The cultural program is frequently adapted to meet the specific requirements of annual bluegrass when it becomes the predominant species.

The two primary approaches to the encroachment of annual bluegrass are (a) control by either cultural or chemical means, or (b) adoption of cultural practices, including environmental manipulation, which will maintain annual bluegrass as a vital component. To achieve either alternative, it is important to have a basic understanding of the environmental conditions and cultural practices which either enhance or impair the growth and development of annual bluegrass. A knowledge of these basic principles will aid in the selection of a turfgrass cultural program which will either provide the maximum possible assurance that the annual bluegrass will persist under adversity such as environmental stress, or insure that the desirable turfgrass species such as creeping bentgrass, Kentucky bluegrass, and bermudagrass have the maximum capability to compete successfully with the encroaching annual bluegrass.

PLANT CHARACTERISTICS

The first consideration when working with annual blue grass is whether it can be identified. Annual bluegrass can be easily distinguished when in the flowering stage. However, identification when it is in the vegetative growth stage requires more specific characteristics. (Table 1.)

Considerable variation in the growth habit of annual bluegrass has been demonstrated by research conducted at Michigan State University. Annual bluegrass is generally considered a bunch type or noncreeping species. However, strains have been collected from close cut, irrigated turfs which have a prostate to creeping habit of growth with rooting observed at the nodes of the creeping stems (Figure 1). Two contrasting annual bluegrass strains have been isolated with all degrees of variation occurring in between. The bunch type, noncreeping strains generally are prolific seed producers and tend to behave as annuals. The prostrate, creeping strains are more restricted in the degree of seed formation and they behave more like perennials.

Vegetative Characteristic	Turfgrass Species: Annual bluegrass	Turfgrass Species: Bentgrass
Bud-shoot	Folded	Rolled
Leaf tip	Boat-shaped	Pointed
Leaf cross section	V-shaped	Flat
Stem cross section	Flat	Round
Midrib	Prominant	Indistinct

Table 1. Five vegetative characteristics which can be utilized for distinguishing annual bluegrass from bentgrass.

* This research was partially supported by a research grant from the United States Golf Association Green Section to Michigan State University. The assistance of William Eaton, James Fischer, Jerry Lapp and David Martin during these investigations is acknowledged.

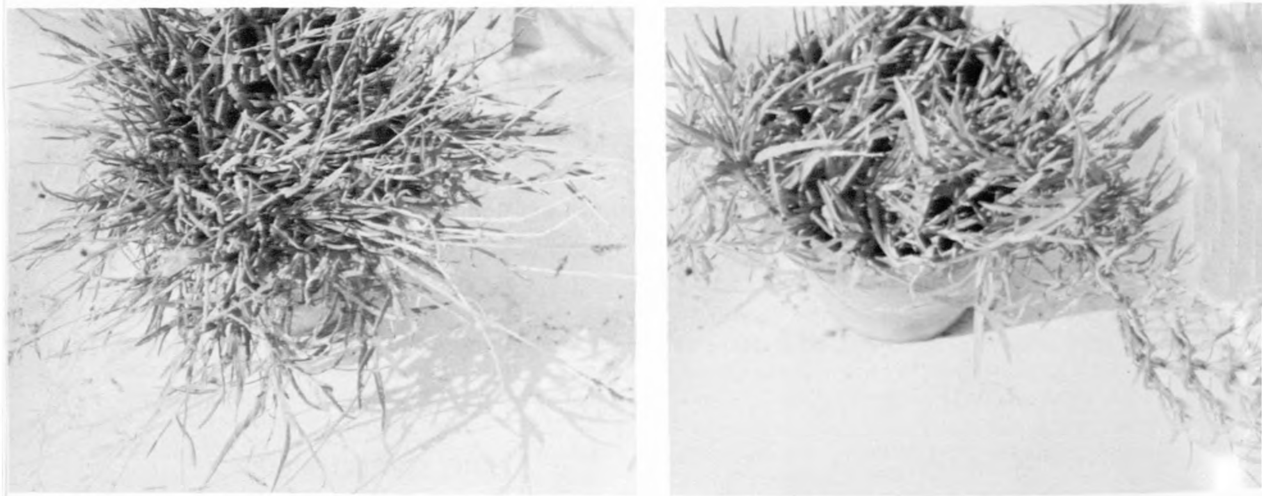


Figure 1. Illustration showing a noncreeping, annual type with prolific seed formation (left) in comparision to a prostrate, perennial type with restricted seed development (right).

Annual bluegrass forms a very fine textured turf of high shoot density, uniformity and overall turfgrass quality when maintained under optimum cultural, environmental and soil conditions. The color of an annual bluegrass turf is usually a light green to greenish yellow. Annual bluegrass has a diminutive, low growth habit which permits close mowing.

Contrary to common belief, the rooting depth of annual bluegrass is similar to that of the bentgrasses and Kentucky bluegrasses. Perhaps one of the reasons annual bluegrass is thought to have such a limited root system is the high susceptibility to wilt and drought stress.

Also, annual bluegrass is capable of growing on compacted, poorly aerated soils where bentgrass and Kentucky bluegrass do not persist. Under these conditions the rooting depth of annual bluegrass is quite shallow. However, when annual bluegrass is grown under comparable soil conditions to Kentucky bluegrass and bentgrass, the rooting depth is quite similar.

DISSEMINATION

The propagation of annual bluegrass is primarily by seed. A single annual bluegrass plant growing in western British Columbia has been found to produce over 360 seeds between May and August. Seed formation occurs throughout the growing season, but is most intense during the late spring period. The seedheads can be quite objectionable during the peak flowering period and will seriously reduce the quality of putting greens. Seed formation can occur even at cutting heights of 0.25 inch. A large percentage of the seeds formed at close cutting heights is viable since annual bluegrass has the unique capability of producing ripened, viable seeds on panicles excised from the plant only 24 to 48 hours after pollination.

Certain strains of annual bluegrass, particularly the annual types, possess a seed dormancy factor. As a result, annual bluegrass seed can remain in the soil for one or more years. When proper soil moisture, temperature and light conditions occur, these seeds are then capable of germination and production of new plants. Seed germination is most active during the moist, cool period of late summer. A secondary period of seed germination occurs in late winter and early spring. Alternating temperatures of 60-75 degrees Fahrenheit are most favorable for seed germination of annual bluegrass.

ENVIRONMENTAL ADAPTATION

Annual bluegrass is a native of Europe, but it is widely distributed throughout the world. It is generally referred to as an annual. However, strains have been found which are capable of persisting as perennials under moderate, nonstress environmental conditions. Where environmental stresses occur during either the winter or summer, which result in injury and thinning, annual bluegrass tends to behave more as an annual. In the warm, humid climate regions it behaves as a winter annual. The optimum temperatures for annual bluegrass shoot growth are in the range of 60 to 70 degrees Fahrenheit while optimum root growth is favored by slightly lower temperatures in the range of 50 to 60 degrees.

One of the more objectionable characteristics of annual bluegrass is the lack of tolerance to

Heat Hardiness	Category	Relative Low Temperature Hardiness
Zoysiagrass Bermudagrass	Excellent	Creeping bentgrass
Tall fescue	Good	Kentucky bluegrass Colonial bentgrass
Colonial bentgrass Creeping bentgrass Kentucky bluegrass	Intermediate	ANNUAL BLUEGRASS Red fescue Tall fescue
Red fescue ANNUAL BLUEGRASS Perennial ryegrass	Poor	Perennial ryegrass Zoysiagrass Bermudagrass

Table 2. The relative heat and low temperature hardiness of nine turfgrass species.

environmental stress. This is why it is widely referred to as a turfgrass weed. In the following discussions, the tolerance of annual bluegrass to various environmental stresses will be presented in tabular form in comparison to the other commonly used turfgrasses. The comparison with other species should offer a better perspective relative to the adaption, overall adaptation, and characteristics of annual bluegrass. The rankings are a general representation for the species and may vary somewhat with the particular variety.

Annual bluegrass is inferior to the bermudagrasses, bentgrasses and Kentucky bluegrasses in terms of hardiness to heat stress. (Table 2). Studies at Michigan State University have shown that annual bluegrass is killed at temperatures of 104 to 106 degrees Fahrenheit. The plants exposed to this level of temperature stress were maintained under moist conditions. Injury could occur at even lower temperatures if combined with a moisture stress. Annual bluegrass also ranks very poor in terms of low temperature. Low temperature kill occurs at temperatures 5 to 10 degrees higher than for Kentucky bluegrass or bentgrass. The soil temperature is of greater concern than the air temperature.

Annual bluegrass also lacks tolerance to a deficit or excess of moisture. It has a much higher wilting tendency than most other commonly used turfgrasses (Table 3) and also is poorer in overall drought resistance (Table 4). Species with an extensive rhizome system have greater drought resistance because of their ability both to survive extended moisture stress in a dormant state and to initiate new growth from the rhizomes once favorable moisture conditions reoccur. The relative tolerance of annual bluegrass to submersion is also inferior to bermudagrass, bentgrass, zoysiagrass and Kentucky bluegrass (Table 4).

Category	Relative Wilting Tendency
Very Low	Zoysiagrass Red fescue Bermudagrass
Medium	Kentucky bluegrass Creeping bentgrass Perennial ryegrass
High	ANNUAL BLUEGRASS

Table 3. The relative wilting tendency of seven common turfgrasses.

Annual bluegrass is relatively poor in tolerance to certain of the stresses placed upon it by man. The relative smog tolerance of annual bluegrass is very poor (Table 5). This is becoming a problem in certain urban areas having a persistent concentration of smog and may become a problem in other urban areas unless atmospheric pollution problems are corrected. Annual bluegrass also ranks low in tolerance to wear created by man (Table 5). Wear as used in this discussion is the direct effect of the traffic on the vegetation itself rather than on the soil.

The relative shade adaptation of annual bluegrass is quite good compared to most turfgrasses (Table 6). In the cool, humid climatic regions annual bluegrass is one of the better species for use on shaded tees on golf courses. It should be noted that shade adaptation is the only environmental characteristic in which annual bluegrass ranks favorably compared to most of the other commonly used turfgrasses.

Relative Drought Resistance	Category	Relative Submersion Tolerance
Bermudagrass Zoysiagrass	Excellent	Bermudagrass Creeping bentgrass Zoysiagrass
Tall fescue Red fescue	Good	Tall fescue
Kentucky bluegrass	Intermediate	Kentucky bluegrass
Perennial ryegrass Creeping bentgrass	Fair	ANNUAL BLUEGRASS Perennial ryegrass
ANNUAL BLUEGRASS	Poor	Red fescue

Table 4. The relative drought resistance and submersion tolerance of eight commonly used turfgrasses.

Relative Smog Tolerance	Category	Relative Wear Tolerance
	Excellent	Zoysiagrass Bermudagrass
Kentucky bluegrass Zoysiagrass	Good	Tall fescue
Creeping bentgrass Perennial ryegrass Bermudagrass	Intermediate	Perennial ryegrass Kentucky bluegrass Red fescue
ANNUAL BLUEGRASS	Poor	ANNUAL BLUEGRASS Creeping bentgrass

Table 5. The relative smog and wear tolerance of some of the commonly used turfgrasses.

Category	Relative Shade Adaptation
Excellent	Red fescue
Good	ANNUAL BLUEGRASS Creeping bentgrass Zoysiagrass Tall fescue
Intermediate	Colonial bentgrass Perennial ryegrass
Poor	Kentucky bluegrass Bermudagrass

Table 6. The relative shade adaptation of nine commonly used turfgrasses.

SOIL ADAPTATION

Annual bluegrass is best adapted to moist, fine textured, fertile soils having a pH in the range of 5.5 to 6.5. It is capable of persisting in coarse textured, droughty soils if irrigated frequently. Annual bluegrass will not tolerate waterlogged soil conditions for an extended period, particularly if this occurs in conjunction with high temperature stress. The tolerance of annual bluegrass to compacted, poorly aerated soil conditions is excellent (Table 7). This is a common condition on greens, tees and fairways subjected to intense traffic. The ability of annual bluegrass to persist under compacted soil conditions and the lack of compaction tolerance of other turfgrasses such as creeping bentgrass is a significant factor in the encroachment of annual bluegrass into intensely used turfgrass areas (Table 7).

Category	Turfgrass Species
Good	Bermudagrass Zoysiagrass ANNUAL BLUEGRASS Perennial ryegrass
Intermediate	Red Fescue Kentucky bluegrass
Poor	Creeping bentgrass

Table 7. The relative tolerance of seven commonly used turfgrass species to soil compaction.

Cultural Requirements

Annual bluegrass requires a high intensity of culture for most favorable growth. Specfically, a cutting height of 0.7 inch or less is most favorable in order for annual bluegrass to achieve optimum aggressiveness and competitive ability (Table 8). This species is capable of forming a high quality turf at cutting heights as low as 0.2 inch. The fertilization requirement of annual bluegrass is also quite high with the nitrogen requirement ranging from 0.2 to 1 pound per 1,000 square feet per growing month (Table 8). The growth and encroachment of annual bluegrass is also stimulated by frequent irrigation which maintains moist soil conditions. Intense fertilization and irrigation will tend to stimulate thatching of annual bluegrass. If a thatch is permitted to develop, the tolerance to heat, cold, drought and disease stresses will be reduced even more.

It should be noted that the cultural and soil conditions under which annual bluegrass is favored are similar to those associated with golf greens and tees. The golf course superintendent can vary the turfgrass cultural practices to either encourage or restrict the encroachment of annual bluegrass. Judicious irrigation, insuring good internal drainage of the soil, and use of cultivation practices such as coring, grooving or slicing will provide environmental conditions which tend to discourage annual bluegrass and promote the development of a desirable turfgrass species.

Annual bluegrass is best described as opportunistic. It takes advantage of the weaknesses in the available turfgrass varieties and errors in the cultural program. Studies at Michigan State University have shown that annual bluegrass can be controlled through proper cultural practices and the use of a vigorous, adapted variety. Over a period of eight years the encroachment of annual bluegrass into certain strains of creeping bentgrass mowed at 0.25 inch has been prevented without the aid of herbicides. The encroachment and spread of annual bluegrass has been avoided through the use of a vigorous growing, disease resistant bentgrass variety and cultural practices which prevent turfgrass thinning caused by environmental stress or turfgrass pests. In contrast, adjacent plots of weaker bentgrass varieties have been prone to periodic injury and thinning which has resulted in the encroachment of annual bluegrass (Figure 2). Over a period of seven years the annual bluegrass population in the plots of inferior bentgrass varieties has increased to as high as 92 per cent. These data illustrate that annual bluegrass is an opportunistic type which takes advantage of the weaknesses in the turfgrass variety.

Annual bluegrass invades the turf at its weakest point. Most commonly the penetration point in the turf has resulted from (a) the effect of environmental stress caused by heat, cold or drought, (b) the action of bluegrass pests such

Cutting Height Requirement	Category	Nitrogen Fertility Requirement
Tall fescue Kentucky bluegrass Perennial ryegrass	High	Creeping bentgrass ANNUAL BLUEGRASS Bermudagrass
Red fescue	Intermediate	Kentucky bluegrass Perennial ryegrass
Zoysiagrass Bermudagrass	Low	Tall fescue Red fescue Zoysiagrass
ANNUAL BLUEGRASS Creeping bentgrass	Very low	

Table 8. The relative cutting height and nitrogen fertility requirements of eight commonly used turfgrasses.

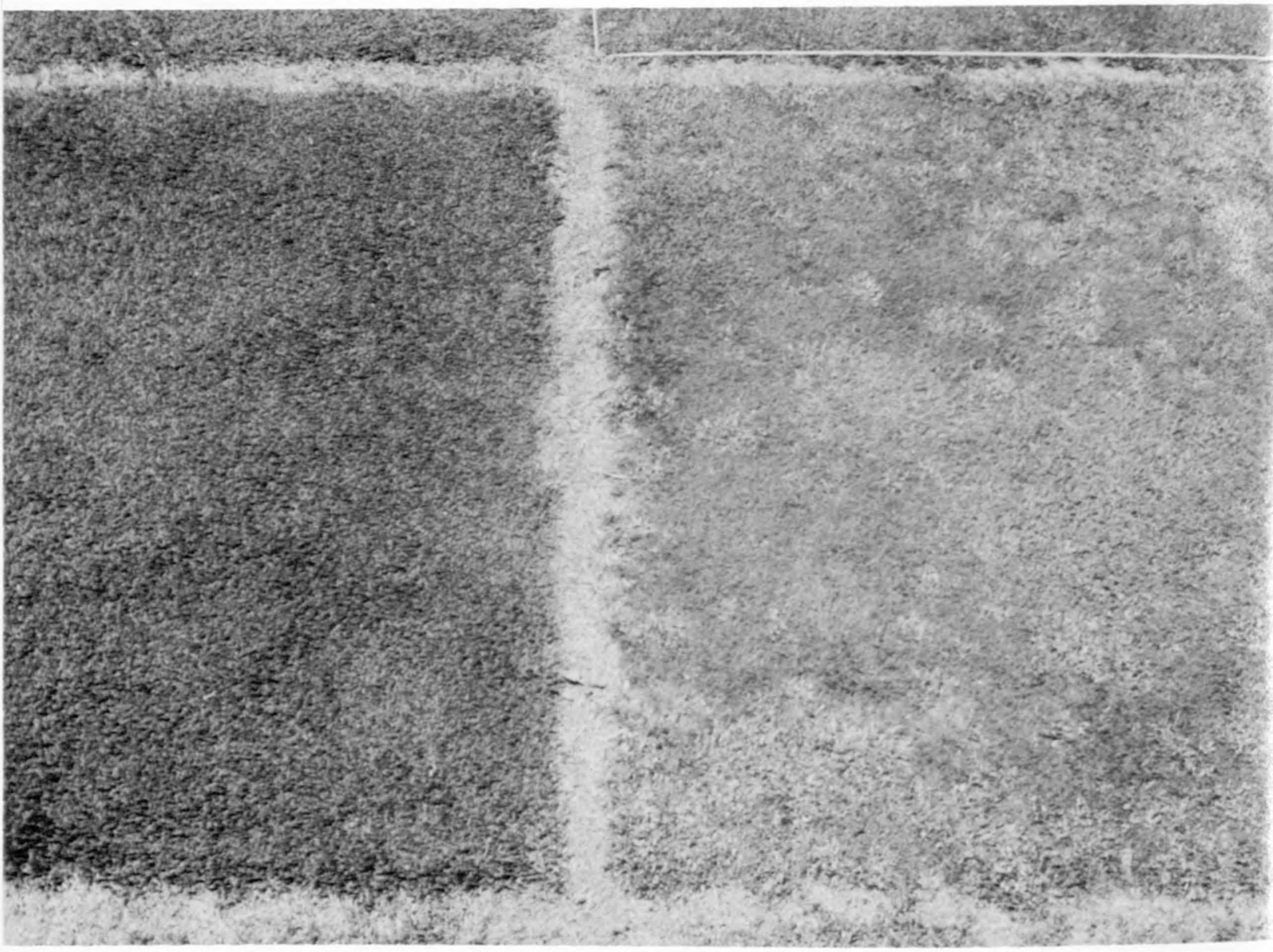


Figure 2. The degree of annual bluegrass encroachment into a vigorous disease resistant bentgrass variety (left) compared to a weak, disease susceptible variety (right).

as diseases, insects or nematodes, or (c) the action of man in the form of divots, ball marks or foliar injury to the turfs from a fertilizer or pesticide burn.

SUMMARY

Annual bluegrass consists of many variable strains ranging from annual to perennial, creeping to bunch, and prolific seed producers to strains which spread primarily vegetatively. Characteristically, annual bluegrass lacks tolerance to environmental stresses including heat, low temperature, drought, wilt, submersion, smog and wear. It is favored by compacted soils, close mowing, frequent irrigation, and high fertility. These are typical conditions found on greens, tees and fairways of golf courses.

Thus, the cultural practices and soil conditions on golf courses are ideal for the invasion of annual bluegrass. All that is needed is a weak point which permits annual bluegrass to encroach into the area. Failures in the cultural program or in the turfgrass variety used are the primary means through which annual bluegrass invades a turfgrass area. Once annual bluegrass invades an area, the degree to which it spreads and predominates will be contolled by the types of cultural practices followed and the particular atmospheric and soil environment which is maintained.

Suppressing Poa Annua on Longmeadow Fairways

by **Leon V. St. Pierre,** Superintendent, Longmeadow Country Club, Longmeadow, Mass.

We had one frustrating *Poa annua* season after another! By mid-New England summer, the fairways were decimated with dead *Poa* in spite of all our efforts to hold on. Ugly to look at and no fun to play, it was an annual blow to the membership's ego, pride and golfing enjoyment. Something had to be done.

In late August, 1966, Longmeadow Country Club decided to undertake a long range program of *Poa annua* suppression. We would follow a project similar to the one already in progress on a neighboring Massachusetts golf course, Belmont Country Club. Plans were made. Budgeting was approved. Materials were purchased and, in the fall of 1966 we started the long journey.

Fairway Overseeding—1966

Our first thought was to increase the permanent grass population on our fairways. Overseeding was accomplished after aerifying the fairways at least six times and verti-cutting them one time. A cyclone seeder mounted on the rear of a scooter was used for seed distribution. Fairways were then dragged with mats and finally mowed with old units to break up the clods and to firm the seed into place.

It is my judgment that this seeding program was largely wasted. The new seeds were simply lost by crowding and competition from the *Poa annua* crop during the spring of 1967.

1967 First Year of Full Treatment

The spring of 1967 was a late one with cold and wet weather predominating into May. On May 11 the first application of a 48 per cent tricalcium arsenate granular material was made at the rate of two pounds per 1,000 square feet to all fairway areas. A second treatment was applied in early June at the rate of one pound per 1,000 square feet. This provided approximately 1.5 pounds of actual toxicant per 1,000 square feet.

During the first week of August, all fairways were sprayed for broadleaf weeds as well as for knotweed. A combination of 16 ounces dicamba plus eight ounces of MCPP was applied for each acre. Two weeks later we aerified the fairways six times and again followed with a vertical mowing operation to a ½-inch depth. Fairways were then overseeded with a mixture of 28 pounds of Astoria bentgrass, eight pounds Seaside bentgrass and four pounds of Penncross bent per acre.

This seed mixture was purchased in the spring of 1967 when the price of Penncross was down. However, our second lot of seed was ordered when the price of Penncross was prohibitive for us and we altered the mixture to 70 per cent Astoria and 30 per cent Seaside bentgrass. We therefore used two seed mixtures on our fairways. We have since learned that it is better not to use Penncross on fairways, even if the price of seed is in line. The reason for this is the rapid thatching nature of Penncross.

It was felt that liming was not needed on the fairways at this time and fertilizer types such as 20-0-10 and ammonium sulfate were used to bring the pH level down, thereby favoring bentgrass development.

The 1968 Fairway Program

As we went into our second year of fairway improvement, an application of tricalcium arsenate was made to all fairway areas at the rate of four pounds per 1,000 square feet on May 1. A second application was applied on May 26, 1968, at two pounds per 1,000 square feet. The next 30 days were followed by cloudiness and rain. The poorly drained areas and swales lost all of their grass cover and remained in this condition until late summer. The soil structure here varies from Windsor sand (a droughty soil) to Scantic silt loam (a heavy textured, poorly drained soil).

Some knotweed found its way back on fairways by mid-July. Therefore, during the last week of July and the first part of August, we sprayed for control of knotweed with 16 ounces of Banvel D-4S and eight ounces of Mecopex per acre.

On August 6, 1968, we began our third season of overseeding. The same process of aerification and vertical mowing was followed. Again, Astoria bentgrass made up 70 per cent of the mixture and Seaside bent the other 30 per cent. This mixture was applied at the rate of 40 pounds per acre. We had a marvelous catch of seed this time. As the overseeding program progressed, the areas needing overseeding continually grew smaller and smaller.

The 1969 Program

The first application of tricalcium arsenate was made to our fairways on April 29, 1969, and again at the rate of four pounds per 1,000 square feet. The summer was sunny and cool. An application of ammonium sulfate was made on May 27 at the rate of 100 pounds per acre.

We then experienced over 21 days of cloudiness and rain that produced vast areas of dead grass caused by wet wilt. To overcome this, the aerification and vertical mowing programs were started on August 21. The same seed mixture of Astoria and Seaside bentgrass was used at the rate of 40 pounds per acre and matted in at the time of seeding. As in the past, the fairways were mowed with old units in order to break up the soil cores and sod clods. An irrigation after the mowing operation helped to settle the surface contours and provided moisture for the germinating seedling.

To sustain the newly developing turf, a 21-0-10 fertilizer was applied on September 11 at the rate of 110 pounds per acre. Unfortunately, germination and growth of these newly seeded areas did not appear to be as rapid and aggressive as it was in the preceding years.

OUR CONCLUSIONS

Our program is now going into its fourth year. Personally, I am very gratified with the results. We no longer find it necessary to cool off the fairways with light syringing even on the hottest summer afternoons. I feel it is essential for this program to continue. It started as a 5-year undertaking and we have one more year to go. After this goal is achieved, I believe that a light yearly application of a *Poa annua* suppressent material will be necessary.

The cost of a *Poa annua* suppression program can be part of a regular golf course maintenance budget without too much of a strain to the average country club. The following breakdown of materials will illustrate our costs for one season:

Tricalcium arsenate—400 bags	$2,800.00
Dicamba—6 gallons	200.00
Mixed bentgrass seed	2,500.00
The Aero-blade (including seeder)	1,500.00
Total	$7,000.00

The most difficult part of this type of program is not financial. The most difficult time comes when the *Poa* starts to fade away in midsummer and with it the pride and golfing enjoyment of the membership. It is a 5-year program at best, but well worth the patience!

SUPER SAM by Paprocki

Some Effects of the Annual Application of Pesticides to Turfgrass

by **HERBERT T. STREU**
Department of Entomology and Economic Zoology,
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Control recommendations for most insect and nematode pests of turfgrass include periodic applications of a variety of pesticides. Entomologists usually develop these recommendations through testing programs which normally consist of evaluation of a number of candidate materials for effectiveness against a specific pest, such as chinch bugs, sodwebworms, grubs, etc.

The effects of these short range tests are usually well known, but, when these recommendations are incorporated into a turfgrass maintenance program, it means using pesticides annually, usually over long periods of time. The overall effects of extended usage are not well known, and it has been the objective of research at Rutgers to evaluate some of these effects. This program has been underway since 1962 using certain pesticides, including carbamate, organochlorine, and organophosphate type materials.

Annual applications of pesticides to the same red fescue-Kentucky bluegrass utility turf after four years have resulted in large differences in the overall quality of that turf. Increased density and clipping yield were found to be related to chinch bug control and population suppression of a spiral and a stylet nematode. Large differences in per cent crabgrass were related to growth differences.

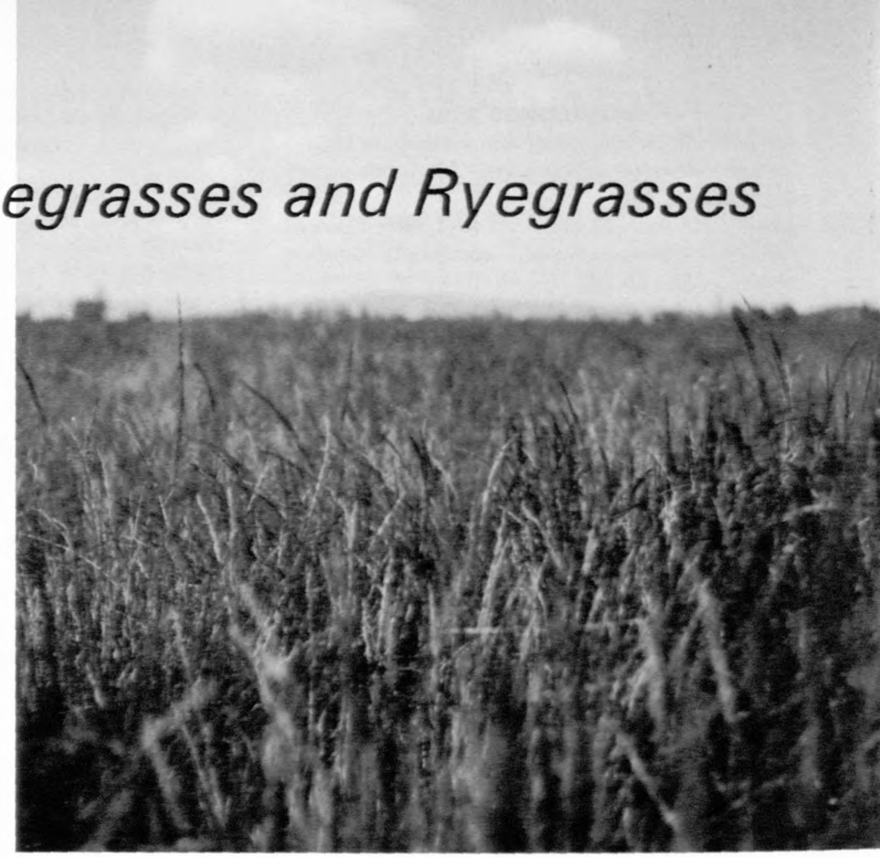
Chinch bug populations in chlordane treated areas were more than 2½ times greater than in control areas after four years, and over four times greater after five years, suggesting interference with some population-limiting mechanism. Red fescue succession was also observed in the organophosphate treatments after five years. Plots treated with ethion were found to consist of almost 54 per cent red fescue compared to only 7 per cent in untreated areas.

Estimates of numbers and kinds of surface inhabiting arthropods over a 12-month period using pitfall traps have shown that large differences in types of animals exist at different seasons. Some differences in springtail and mite populations have also been found between pesticide treatments. Of greater importance, however, is the trapping of very large populations of red-legged earth mites in mid-winter, followed by large spring populations of clover mites. Both mites have been found to produce heavy damage to grass blades through feeding activity. At the same time, differences in pesticide treatments have been recorded, ethion apparently exerting a long term effect on the total arthropod populations including the two above-named mites.

Long term usage of pesticides has also been shown to affect certain plant parasitic nematodes, as well as earth worm activity. Crabgrass germination was shown to be associated with spring earthworm surface activity.

Cumulative differences in growth response due to annual treatments have been related to the activity of several important soil and surface-inhabiting animals, including certain plant parasitic nematodes, surface and soil inhabiting springtails, red-legged earth mites and clover mites. Large increases in chinch bug populations in chlordane-treated plots may be related to decreases in surface inhabiting predatory mites in these treatments.

New Bluegrasses and Ryegrasses



by C. REED FUNK, Rutgers University, New Brunswick, N. J.

An exciting group of new turfgrass varities is being developed at turfgrass institutions throughout the United States and Europe. Many should be of value for improving golf course turf. Before any new variety is used extensively it should be thoroughly tested to determine its value, area of use, and particular management requirements.

New Bluegrass Varieties

Kentucky bluegrass is the most widely used lawn-type turfgrass in the northern United States. It is hardy, attractive, and widely adapted. The usefulness of Kentucky bluegrass on fairways and tees will be greatly enhanced as varieties become available that are capable of producing a denser, more dependable turf under conditions of close mowing. New varities including Warren's A-20, Sodco, Pennstar and Fylking have much to offer. They will be followed by even better selections and hybrids being generated by expanding turfgrass breeding programs.

FYLKING Kentucky bluegrass (Plant Patent 2887) was discovered in Southern Sweden over a quarter century ago by the Swedish Seed Association. A moderate amount of seed is currently being produced in the United States by the Jacklin Seed Company.

Good resistance to both stripe smut and the *Helminthosporium* leaf spot and crown rot disease gives Fylking a considerable advantage over most other bluegrass varieties. Fylking is also moderately resistant to current races of stem rust, but it is fairly susceptible to dollar spot and powdery mildew. This variety produces an attractive, dense, moderately low-growing turf of a rather fine texture. This leafy appearance is maintained during May and June when most other bluegrasses become quite stemmy, producing seedheads and unwanted pollen. Abundant rhizome production results in a tightly knit sod. Therefore, periodic thatch control is normally advantageous in maintaining the best condition.

An attractive, rich, moderately dark green color is developed in early spring, and, is maintained into late fall even under moderately adverse growing conditions, such as low fertility and incipient drought. The rather decumbent growth habit and improved disease resistance of Fylking allows it to tolerate moderately close mowing. However, it should be pointed out that excessively close mowing places considerable stress on any bluegrass variety and weakens its ability to resist disease and prevent weed invasion. The rather fine leaves of Fylking tend to bend over, especially at higher cutting heights. Thus a neater appearance will be achieved with moderately close mowing.

Fylking has performed very well in mixtures with other bluegrass varieties as well as with the improved varieties of fine fescue and perennial ryegrass.

PENNSTAR Kentucky bluegrass was released by Pennsylvania State University in 1967 after extensive testing as PSU K5 (47). This variety originated as a single, apomictic plant obtained from the progeny of a selection made by Professor H. B. Musser. Seed production problems are currently delaying the widespread availability of this promising variety. Pennstar has good resistance to *Helminthosporium* and stripe smut, the two diseases which normally cause the greatest amount of damage to Kentucky bluegrass. The variety is also moderately resistant to current races of stem rust. It is fairly susceptible to powdery mildew and dollar spot. Pennstar produces an attractive, fairly dense, tightly knit, moderately low-growing turf of a rather fine texture and a pleasing, moderately dark green color. It has medium tolerance of close mowing and performs very well in mixtures.

WARREN'S A-20 Kentucky bluegrass has better overall disease resistance than any other commercially available variety. It has good to excellent resistance to *Helminthosporium*, stripe smut, powdery mildew and stem rust. Turf produced by this variety is attractive, dense, upright, of medium leaf width and has a pleasing, moderately dark green color. A-20 will tolerate rather close mowing. Unfortunately, this elite variety will not reproduce true by seed and must be propagated vegetatively like Zoysia.

WARREN'S A-34 Kentucky bluegrass might well be considered for moderately shaded areas on the golf course. This is a vigorous, disease resistant variety with significantly better shade tolerance than other Kentucky bluegrass varities currently available. When maintained at a two-inch mowing height, this variety will tolerate shade up to 65 per cent of the daylight hours. A-34 also does rather well in full sun, producing a very aggressive, dense, medium green turf with moderately good resistance to *Helminthosporium* leaf spot, stripe smut, stem rust and powdery mildew. A-34 is primarily available as sod, but seed supplies are being increased.

SODCO Kentucky bluegrass was released by Purdue University in 1967. A moderate amount of seed should be harvested in 1970. Sodco is a blend of four selections similar in growth habit and general appearance. They are Anheuser Dwarf, RI-10, AQ-6, and 16-BB-56. All have an attractive, rich, dark green color, wide leaves, and a rather decumbent growth habit with a fairly slow rate of vertical growth. They also appear to have good resistance to the *Helminthosporium* leaf spot and crown rot disease and should be able to tolerate rather close mowing.

KENBLUE Kentucky bluegrass represents an attempt to reconstitute the type of Common Kentucky bluegrass formerly harvested from the naturally occuring bluegrass stands of the famous blue-grass region of Kentucky. Currently, much of the seed being sold as Common Kentucky bluegrass is actually seed of a single strain variety such as Newport which has been selected for its high seed production potential. Kenblue is an erect growing variety with a rapid rate of vertical growth and is highly susceptible to the *Helminthosporium* leaf spot and crown rot disease. It will not tolerate the close mowing desired on golf course fairways and tees. Nevertheless, it does have considerable genetic diversity and has a record of proven performance for use on areas receiving high cut and moderately low fertility. It appears to be especially valuable for use in the southern part of the bluegrass region.

Bluegrass Varietal Blends

We expect a great deal in performance from our turfgrass varieties. They are grown on a wider range of soil, environmental and use situations than any other plant species. We want our turfgrass plantings to be permanent and durable as well as attractive and easy to maintain. All varieties can be expected to show some weakness as plantings become widespread and stands become aged. A diversity of many good varieties should offer considerable protection against unforeseen problems. Many of the elite bluegrass varieties of the future will undoubtedly be blends of complimentary components. Current research at Rutgers strongly suggests that a variety with combined resistance to both the *Helminthosporium* and stripe smut diseases should be included in all bluegrass blends used in regions where these diseases may be a problem.

New Perennial Ryegrass Varieties

Perennial ryegrass is a cool-season grass best adapted to maritime climates. It is most useful in places such as Britain, the Netherlands, and New Zealand, where winters are mild and summers moist and cool. As ryegrass is brought into more continental type climates, increasing problems with poor winter or poor summer performance may be encountered. No ryegrass variety will tolerate a Minnesota winter or a Washington, D.C., summer as well as a good bluegrass.

The new turf-type perennial ryegrass such as Manhattan, NK100 and Pelo are a considerable improvement over Common perennial ryegrass in their various turf characteristics. In fact, many people fail to recognize them as ryegrasses. They are finer leaved, more attractive, denser, lower-growing, more persistent, and have better turf-forming properties. They are quick and easy to establish and will grow on a wide range of soil types. The new ryegrasses are normally easier to mow than common perennial ryegrasses, but they can be very difficult at times. Frequent cutting and a sharp mower helps maintain top quality. The improved ryegrasses have generally done very well on the sandy costal plain soils of Long Island. Further research and experience is needed to fully assess their specific usefulness in other areas. A good bluegrass variety should normally be included in any ryegrass mixture.

NK100 perennial ryegrass originated primarily from plants surviving for many years in old pastures of the British Isles. These plants were crossed with common perennial ryegrass from Oregon. Plants with good persistence, a leafy growth habit, good turf quality and an attractive, bright, medium dark green color were selected from these crosses to develop NK100. This variety has been very successful on Long Island with many stands persisting for over 10 years.

PELO perennial ryegrass was developed in the Netherlands. This variety has an attractive, bright, moderately light green color. It is leafy and has shown comparatively good resistance to rust and Fusarium snow mold.

MANHATTAN perennial ryegrass was recently released by Rutgers University. Most of the parental plants of Manhattan were selected from old turf areas in Central Park located on Manhattan Island in New York City. Manhattan has an attractive, rich, moderately dark green color. It produces a turf of finer texture, greater density and a somewhat slower rate of vertical growth than other available ryegrass varieties.

NORLEA perennial ryegrass is a moderately short-lived variety developed in Canada. It is attractive, leafy and moderately low growing. This variety can be very useful as a nurse or companion grass if quality seed not contaminated with annual ryegrass is used.

Warm Season Grasses We Should Know About

by **JAMES B. MONCRIEF**, Director, Southern Region, USGA Green Section

BERMUDAGRASSES (Cynodon dactylon)

The search for superior bermudagrasses is continuing both by selecting from old turfgrass areas, and developing new crosses. Many strains of turf-type bermudas have been collected by Dr. Wayne Huffine and Associates, with the most recent releases from Tifton, Ga. Yet with all these numbers, the perfect specimen is still being sought.

The latest is Tifdwarf. Released in April, 1965, it is being used in most new plantings even though it turns a purplish color during cold weather. Height of mowing will affect this condition. In most areas other than in south Florida it should be overseeded.

Tifdwarf will make an excellent putting surface if it is managed properly, although and some high handicappers say it makes too fast a putting surface. It forms a tight turf, is a low-growing prostrate type of grass that has a wide range of maintenance levels. It was first sold as a low maintenance level grass, but the best putting surface is achieved when it receives 1½ to 2½ pounds of nitrogen per 1,000 square feet per month using a 4-1-2 ratio.

Because tifdwarf is sensitive to some chemicals, it is advisable to grow healthy turf to minimize weeds. Sod webworms will leave other grasses in preference to Tifdwarf. The grass has a very dark green appearance which attracts the adult stage of this insect.

In summary, Tifdwarf gives an outstanding performance during warm weather and a poor one during cold weather.

Tifgreen, released in1956, is not a new grass, but it is still used very much on greens.

Two of the best fairway grasses in the South, although not new, are Tifway and Ormond. Tifway was released for fairways and tees. It is a stiff grass with a deep green color. In the West, it has a tendency to thatch, but in the South, it has made an excellent playing turf where adapted.

Santa Ana bermuda was released in California in 1966 by Dr. Victor Youngner. It is smog resistant and has proven to be salt tolerant. It should be good for tees and areas where wear resistance is necessary.

Newer bermuda selections are showing much promise, but they are not yet ready to be released for general use; however, P-16 should be in general use soon.

ZOYSIAGRASSES
(Zoysia japonica)

Zoysia is used mostly on home lawns in the South and very little is seen on golf courses. Occasionally we find it sodded around the edges of bunkers to reduce trimming requirements. This has not always proven satisfactory because bermudagrass frequently will overrun the zoysia when bermudagrass maintenance is favored.

Florida University has more than 90 selections of zoysias, and most of the F-1 hybrids have been established in single plots. The selection F-2-108 japonica type is a rapidly growing variety, relatively free of problems. There is no doubt that more zoysia will be used in the future.

The zoysias are most resistant to injury from disease and insects, and they are also more cold-tolerant than most warm season grasses. Slow coverage has been one of the main disadvantages. However, a variety called Midwest is a relatively fast-growing type.

ST. AUGUSTINEGRASS
(Stenotaphrum secundatum)

There's a new problem on St. Augustine called SAD; St. Augustine Decline. First noted in South Texas, it has been found to be caused by a virus. If the chinch bugs continue their western migration from Florida and SAD virus continues to spread eastward from Texas, St. Augustine research will be challenged. Several strains are now showing a tolerance or resistance to the virus, and work is underway to develop and screen strains for resistance.

The arsonates are very toxic to St. Augustinegrass. They discolor it greatly but the grass recovers in most cases, except where the rate exceeds four times normal.

The main disadvantages of St. Augustine are its susceptibility to chinch bugs, diseases, (particularly brown patch), and more recently a virus.

The advantages of St. Augustine is rapid growth and shade tolerance.

CENTIPEDEGRASS
(Eremochloa ophiuroides)

Centipede is used very little on golf courses and found only on fairways or in roughs. It is a coarse grass used mainly for its low maintenance requirements.

Oaklawn and Tennessee Hardy are the most satisfactory varieties because of their cold tolerance.

Florida University (Dr. G. C. Horn) has 12 centipede grasses that have been selected and are believed superior. There should be much to look forward to in future centipede selections.

Brown patch disease is very active on centipede and hard to control in some areas of Florida.

New grasses are in production and seed growers are interested in quality as well as quantity.

Important Steps to Automatic Irrigation

by **JOHN DUNLAP**, Superintendent, Oakwood Club, Cleveland, Ohio

A great deal has been written and said about automatic irrigation systems in the past 10 years—some of it good and some bad. Many of the first automatic systems were badly engineered and also poorly installed; consequently many people objected to them. In recent years equipment advances and new technologies have greatly increased the reputations of automatics.

The new super automatic systems are very large investments, costing up to $200,000. Any project of this magnitude takes careful planning and engineering. What is involved in getting one of these systems into the ground?

Planning and design should begin at least a year before it is to be installed. Contact qualified irrigation personnel to help lay out a basic plan. After the basic plan is made, the superintendent should then go over it and make all necessary changes so that the system is custom designed to water this particular course as effectively as possible.

The next step is to contact as many equipment manufacturers as possible and get some of their equipment for testing. It is quite surprising to see performance differences between various makes of equipment. You should decide which type of electric valve will do the best job, whether you prefer electric or hydraulic operation, and what type of pipe you think will best fit your needs. But choose carefully because there are no bargains, and beware of people offering "deals."

Above all, do not design the system to a present cost. Design to meet your specifications of performance, then put this plan out for bids to good irrigation installers. Beware of plumbing contractors bidding on such installations—they rarely have the experience necessary to install something this complex.

When bids are received, turn them and the contracts over to your club lawyers. Be sure everything is down on the contract. In the final analysis, the lowest bid does not necessarily represent the best value, so here again choose

carefully. Even though the system will probably be installed by an outside contractor and his crew, it is the course superintendent's responsibility to see that the system is installed properly.

Important Items

Planning should start at least a year ahead so that the contract can be signed several months ahead of actual installation date, and the installer can have time to order material and have it delivered to the site. Delays caused by lack of piping and sprinkler materials are very costly. When the paper version of the system design is transferred to the course, the superintendent should be responsible for the placing of all sprinkler heads and, where necessary he should also be perpared to make field changes if they will improve upon the basic design.

The pumping facility of a super-automatic is very important. Many systems have been installed with much too small a GPM capacity, and this impaired the proper programming of the system. The GPM should be adequate to run all controllers simultaneously without loss of pressure. This is of particular value when a syringe cycle is included in the system, since a syringe cycle must be completed in as little time as possible to be of value. A good syringe cycle should be able to wash off the entire golf course in no more than 30 minutes, and in order to do this the pumping capacity for most systems should be at least 1200 GPM: Better yet, around 1500 GPM.

Consider some type of pressure regulating valve so that main line pressure will remain constant at all times no matter if 1 or 20 heads are in operation. All pump controls should be fully automatic and should be kept as simple as possible. This is one area where designers tend to over-design. Flow switches and pressure switches still give the best pump control available and are almost completely free of trouble.

The master control is the heart of an automatic system. Without a master control panel the superintendent becomes a virtual slave of the system. With every change in the weather, he must visit all the controllers and reschedule the watering program. With a master control he can change, stop, or start all watering cycles from his office. This convenience will pay for itself many times over because the superintendent will easily change his watering program to match day-to-day weather changes instead of letting it go as previously programmed.

After the system is installed and in operation, you can expect to spend at least a year balancing and adjusting it for perfection. Time clocks must be adjusted to compensate for various soil conditions. Nozzle sizes on some sprinklers will have to be changed and pressure might have to be adjusted at individual heads to give proper operation.

All of the things we have mentioned sound like a lot of work. And they are. But when you are finished you will have a most efficient irrigation system and it will be able to give you quality control of the water that is applied to the course.

On the left the hose and sprinkler, an early method of irrigation, and on the right the modern, controlled method of automatic irrigation.

What's New in Weed Control?

Faulty application will never get the job done. Note streaking and good control of Poa annua where material was applied but note the prevalence of Poa annua in the misses.

by **ALEXANDER M. RADKO,** Eastern Director, USGA Green Section

The concept of the pre-emergence herbicide is not new. It has been a reality and in practice for more than 30 years. The name, however, is new, and as a result of the advances in research, the term "pre-emerge control" has evolved. It means something to everyone engaged in turfgrass work as a special class of herbicides.

Herbicides are generally classified as post emergence and pre-emergence materials. As the names imply, the post emerge herbicides are applied after the weeds have emerged, germinated or grown while the pre-emerge herbicides are applied in advance of weed seed germination. The action of the pre-emerge herbicide is especially attractive because, if it works as it's supposed to, the weed is killed early, its life cycle is short circuited before it's had a chance to produce seed. This specifically is the reason why annual plants such as crabgrass and *Poa annua* are troublesome, because of their prolific capacity for seed production.

In the early days of golf course management, lead arsenate was used principally for earthworm control, but with repeated use it was noted in isolated cases that this material had a definite deterrent effect on crabgrass and *Poa annua*. After some study it was decided that its action was one of killing the seedling plants soon after germination, and so lead arsenate was the first of the pre-emerge herbicides to be used on golf courses in the United States.

It is interesting to note that in the 1921 Bulletins of the Green Section of the United States Golf Association, Piper and Oakley wrote that "crabgrass is perhaps the worst of all summer weeds on putting greens, but on fairways it is the main desirable despite the fact that the heavy turf keeps the ball from rolling much."

Some could conclude that this weed became the serious pest that it is today because of the early respect of such noteworthy turf specialists. However, a more plausible explanation is the sure fact that there was nothing they could do about it: They had to live with it. Crabgrass remained a serious problem through the late 1940's when chemicals were developed which gave promise of good control.

Poa annua falls in the same category. It, too, enjoyed a great head start because there were no early positive selective controls. Now this is changing. We have good chemical controls and some are of the post and some of the pre-emerge variety; but after 30 years of uninhibited growth and seed production, is it any wonder that we are still in serious combat with *Poa* and crabgrass?

Pre-emerge herbicides have been especially prominent in the control of *Poa annua* and silver crabgrass. Some of the materials being used are lead arsenate, calcium arsenate, DCPA, DMPA, bandane, bensulide, terbutol, benefin, trifluralin, siduron and others being tested by researchers that are presently identified only by code number.

Among the new ones there is a class of herbicides available that will prevent *Poa annua* from producing seed. The advantage of a pre-emerge herbicide is that the active control agent comes in contact with the weed in the seedling stage when it is most vulnerable to herbicidal action. However, its effect on desirable grasses is not all positive; there is some negative effect, principally with root restriction. Also, because seeds of crabgrass and *Poa annua* germinate over a period of several months, there is a period of residue presence for each of these pre-emerge herbicides (except siduron) which also makes it all but impossible to improve the turfgrass stand by overseeding desirable grasses during this time. Hence, the period during which the renovation program is in effect becomes a trying one for the superintendent and golfer alike.

These new herbicides positively will kill *Poa annua*. It then becomes important to advise all concerned that where *Poa annua* comprises a large portion of the turf, the transition to a desirable turf stand will take a minimum of *from two to five years!* Pre-emerge herbicides require accurate dosage adjustments in relation to turf species, weeds, and environmental conditions such as temperature, soils and moisture. The year 1969 was very poor for pre-emerge treatment in most of the Northeast. Unusually heavy rainfall completely nullified the herbicidal effect of some pesticides; the arsenicals, on the other hand, became more active with increased available moisture. Therefore, there is always an element of chance concerned with the use of the pre-emerge materials because nature plays such an important role in their action in any given year. Before any large-scale work is undertaken, it is advisable to test promising materials for a few years in order to work out important details for your specific conditions.

We have come a long way in the selective control of weeds. We have a long way yet to go, but the prospect of a weed-free golf course is becoming less and less the impossible dream.

Poa annua—a perennial problem—this fairway went out without benefit of herbicide so it will be back from seed to repeat this performance annually when summer stress is on. This is one of the reasons why this grass is considered a weed.

USGA GREEN SECTION RECORD
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TURF TWISTERS

WEEDS & SPRING

Question: Should broadleaved weeds be controlled during the spring or the fall? (Maine)

Answer: Because all chemicals weaken or temporarily injure the turf, you should consider in which season your grasses are most likely to suffer injury and make your herbicide application accordingly. If you have a history of winter injury in your area, it would be best to apply the herbicide in the spring. If you have experienced primarily summer injury in your area it would be best to delay broadleaved weed control until the fall.

ICE & WINTER

Question: During the first week of March we had a total coverage of three feet of snow on greens. The first six to eight inches above the surface of the green is snow, which is covered by an inch layer of ice, which in turn is covered by another two feet or so of snow. Should we remove the covering totally or in part? (Massachusetts)

Answer: Presently you are not in any danger. As long as the ice layer is not directly on the surface of the green I don't foresee any problems. If the snow is still present toward the end of the month you might remove all but four inches. If an ice layer does form on the surface of the green, it would be best to crack or punch holes in the ice layer. This would allow air circulation, yet still afford the green protection against desiccation. An application of a dark material, such as top-dressing or a natural organic fertilizer, will also help in ice removal. If the green is predominately *Poa annua*, any ice sheet should be removed after 25 days.