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# Recent Technical Developments in Turf Maintenance

By John Monteith, Jr.

Address delivered February 3, 1933, before the National Association of Greenkeepers' Convention at Hotel Sherman, Chicago, Ill.

The layman is inclined to expect of scientific research a series of miracles or discoveries rather than a gradual development. This is due probably to the extensive publicity that immediately follows the announcement of some new discovery. As a matter of fact, a scientific discovery, which may be known everywhere within a brief period of a few days after it is announced, is usually the result of many years' work, with gradual developments, which even the discoverer himself may at the time not have been able to recognize as real developments.

It takes time to test new ideas. Unfortunately most of the new ideas of scientists, like those of the politicians, do not work. The scientist, before exposing his ideas to the public, is expected to test them out carefully in the laboratory; and if they do not work out as expected he has only himself to blame and no one hears anything of them. The politician, on the other hand, first tries out his ideas on the long-suffering public, and then if they do not work out he has another party to blame for interfering and everybody hears about it.

A good example of slow technical development with which we are all familiar is that of the automobile. This industry has kept a large staff of technical men busy for many years in improving the various parts of cars. There has been a steady improvement, and that improvement is still going on. It is probable, however, that no two research engineers would agree as to what were the technical developments in automobile design or manufacture in 1932. They can agree, however, on the outstanding developments over a period of years, for these have been exposed to the tests of road service.

In considering technical developments in turf culture it should be remembered that there is little research work on turf under way. When one considers the enormous capital investment in public and private golf courses in this country alone and the annual expenditures on their upkeep it is surprising that such a trivial amount of money is available for the study of the application of modern science to the building and care of golf courses. It is true that we have some appropriations for such work in this country, in Great Britain, and, recently, in other countries. Most of the funds available must be used for educational and service purposes rather than for technical developments.

It is amusing to hear what some greenkeepers and green-committeemen expect of the small number of men who are conducting research work on turf problems. If a new disease appears, a new treatment is expected within a few days. If unusual weather conditions bring about new turf disorders, the scientist is expected to have a full explanation and a remedy within a week—else of what value is he? Unreasonable demands of this kind signify an ignorance of the problem. The unreasonable demands that greenkeepers and others make of the technical man must therefore be ignored just as those that players make of greenkeepers and green committees must be ignored if there is to be any real progress.

During the present century there have been some fundamental changes in the methods used in growing plants, just as there have been changes in almost every other human activity. Farming has been decidedly changed as the result of the widespread replacement of horses and mules by automobiles and tractors. The replacement of animals by machines has necessitated the general use of commercial fertilizers to replace animal manure in maintaining soil fertility. The development of methods for controlling insects and diseases has also accomplished important changes in routine farm methods. These changes, which we regard as modern improvements, have certainly not made farming any simpler. They have made it necessary for the farmer to know more about his animals and plants and have also made it necessary for him to know something about machinery, fertilizers, fungicides, insecticides, and other things with which the farmer of a few years ago did not have to bother. Similar changes have gradually come about in greenkeeping, and with them have come problems which could not be solved with old methods.

One of the first turf problems to be subjected to scientific tests was that of the mysterious loss of turf from disease attacks. A systematic study of such losses during the past few years has shown that there are a large number of parasitic and nonparasitic diseases affecting golf course turf in this country. In many cases they have been confused, due to the similarity of symptoms; but it is now possible to readily identify many of them and to apply treatments according to their various causes. These ailments have been compared in a number of our Bulletin which has just been published, so I shall not dwell on them here. One of the interesting technical developments of this study has been the proof of the relationship between certain environmental conditions and the development of many of these ailments. In some instances some of the contributing factors have been suspected for many years but there had been no positive proof. In other instances little-suspected factors have been found to be important, whereas others that have been considered important have been proved to have little or no influence on these ailments.

From the study of fungicides for the control of brownpatch and dollarspot there has developed the information that fungicides containing mercury are the most effective against these diseases. This study has proved that practically all of the mercury compounds will check these diseases if properly applied. Furthermore, it has shown that the simple, less-expensive, inorganic mercury salts are as effective for this purpose as are the more complicated compounds which cost more to manufacture.

The development of arsenate of lead as a turf insecticide is a recent development. It has been shown that it has two distinct uses; that of poisoning the soil to check those pests that feed in the soil, and poisoning the grass for the control of insects which feed only on the leaves. Arsenate of lead and the mercury fungicides are weapons which technical men, within a comparatively few years, have given the greenkeeper to use in fighting pests.

The study of soil conditions as they affect the growth of turf has brought out some interesting information in recent years. In this country we have golf turf growing on a great variety of soils, and it is only natural that there should be found many differences in the response of grass to these varying soil types. Several years ago there were experiments performed which indicated that soils should be acid for the best growth of bent grass. The acid-soil theory was widely accepted, but recent developments have decidedly modified that theory. We now realize that many of the results attributed to acidity of the soil were actually due to other factors, which had been overlooked. Although it is still recognized that the bent grasses will thrive best in most soils if they are slightly acid, we know that the juggling of the acidity of the soil will not accomplish everything that was claimed for it. It has been shown that bent grasses grow best in some soils if they are decidedly acid, whereas in other soils the best growth may occur when they are alkaline. Therefore it is impossible to state that soils for golf course turf should be within certain prescribed limits of acidity. The study of soil acidity has naturally led to the study of other chemical conditions of the soil and has brought to light many instances of chemical deficiencies or excesses which were not suspected a few years ago.

In addition to the study of chemical conditions of soil there has been a study of physical conditions as they affect golf course maintenance. It has been shown that the physical properties of soil may be as important as the chemical properties in influencing the growth of grass, particularly on putting greens on heavy soils which are exposed to excessive trampling and consequent puddling. Various mixtures of soil and sand with different types of organic matter have indicated that putting green soils on most golf courses could be greatly improved both from the standpoint of play and of the growth of grass.

A study of the relation of height of cutting grass to the maintenance of turf and the control of weeds has pointed out a serious danger in our modern turf maintenance practices. This recent development has already been discussed on your program and in the Bulletin.

There have been many other additions to our technical information on growing grass, controlling weeds and other pests, improving soil, and similar subjects. The greenkeeper in recent years has also received much technical help from engineers in the design and production of the great assortment of machinery and watering systems now at his disposal. It is surprising how quickly the general public becomes so familiar with a new development that it is regarded as commonplace. Many of the comparatively recent developments in golf course upkeep are now so generally used that they are regarded as being almost as old as golf itself.

It was suggested that I call attention to the practical application and promises of recent technical developments in turf culture. The practical application and the promise of these developments rest with the greenkeeper and not with the technical worker. The technical man's job is done when he has shown the way to use a new material or device. He should then be free to turn in search of something else which possibly may replace entirely his last improvement. Only time can tell the full importance of any technical development. Time already has had an opportunity to tell something about the practical application of some of the developments I have mentioned. I can therefore give you a little from that story.

Greenkeepers make no exception to the rule that the self-styled practical man invariably views with suspicion any suggestion from the scientist, whom he erroneously calls the "theorist." As a matter of fact, the worst theorists are usually the practical men. If you want to hear a big assortment of theories on any subject, talk to some of the so-called "practical men" instead of most scientists. The scientist has to have theories, but he puts them to work and in most cases is able to keep them properly harnessed. On the other hand, when some practical men get theories they just play with them, then turn them loose to roam with many other wild theories. In time there is a stampede, and the poor practical man is overpowered by his wild herd of apparently harmless theories. Theories are like mustangs; they are all right if you know how to ride them. I know of nothing more pathetic than a practical man overpowered by theories unless it is the practical man so scared of theories that he will have nothing to do with anything which he suspects may have some time come in contact with a theory. We are all apt to forget that most of the things regarded as of greatest practical value today were once regarded as fanciful dreams and theories. Even such devices as railroads, automobiles, and airplanes were scoffed at by practical men not so many years ago.

All of the recent technical developments which I have mentioned have already found practical application on golf courses. On some courses they are all in general use. On other courses none of them are in use and will not be in use as long as those who are now in charge retain their positions. No educational program of yours, nor of any other organization, will change the practices of some men. The big majority of greenkeepers, however, are constantly changing methods to meet new conditions. Many greenkeepers are taking advantage of the new developments upon the direct advice from the technical men, while others are unknowingly taking advantage of them through the use of commercial products. Thanks to the alertness of American business and to the persuasiveness of modern salesmen, the "practical man" often takes, without knowledge, some of the products of the research workers whom he spurns. One amusing case of this type is perhaps worth telling here. One greenkeeper who takes no small pride in being extremely practical and who almost shudders when anyone mentions science was admittedly hard pressed with brownpatch. One time when he was admitting his difficulties I ventured the suggestion that he try a combination of corrosive sublimate and calomel. That was before any of the tests with these chemicals had been announced. He said he was interested, and I gave him the rates to use. Two or three years later I asked him about his brownpatch troubles and he informed me he had discovered a wonderful cure for brownpatch. I asked about it and was told that a salesman had urged him to try some new dope. He had done so, it had accomplished wonders, and he intended to continue to use it. He could not recall the name but he volunteered to take me to the shop to show me a label. On the way he informed me that he had tried the combination I had suggested but that it was worse than worthless. Fortunately, he did not notice my smile when he showed me the package, and to this day he probably does not know that the wonderful remedy he had discovered was the same mixture of corrosive sublimate and calomel which I had suggested to him earlier but which was put out by an enterprising chemical company under a trade name, following our recommendations exactly. There are many such instances where salesmen keeping in touch with technical developments are able to extend the application of these developments on golf courses.

There are many cases of abuse of technical information on golf courses. Unfortunately, most useful devices offer possibilities of abuse. The new improvements that add speed to automobiles not only add to the value of automobiles but add to their danger when in reckless hands. Many of the drugs which have done so much to relieve human suffering have in other hands wrecked lives. One could cite any number of such instances and could include most of the new developments in greenkeeping. Improved mowers and watering systems have made better turf over longer periods, but they have also contributed to the ruination of turf. New chemicals which have offered possibilities for improved playing conditions at lowered costs have by many been used to squander money and injure turf. As more technical information becomes available the more complicated the job of greenkeeping will become and the more efficiently can golf courses be maintained. On the other hand, the more complicated the job becomes, the greater the possibility for the uninformed greenkeeper to waste money and damage his turf. That obviously leads to the need of more educational programs such as this one to keep the greenkeeper informed. Only those who know little of science believe that foolish notion that science simplifies one's life. It adds many comforts and aids, but by no means simplifies one's existence. These days of moving mountain sides or performing other miracles by pushing a button many miles away are apt to give a wrong conception of science. It is all right to push the button provided some one has made all the complicated calculations and installations to make that push amount to something. There are some who are still foolish enough to believe that the aim of technical developments in turf culture is to make greenkeeping a push-button job. It tends rather to make the greenkeeper a far more effective and essential individual at the business end of a push-button connection. The practical application of these developments therefore is the job of the greenkeeper and not of the technical worker.

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Soy beans are an excellent crop for use as green manure in preparing soil to serve as topdressing material for putting greens. The crop of soy beans should be plowed under when the plants are in bloom. From 30 to 95 days are required for soy beans to blossom, depending on the variety of soy bean planted and upon other factors that affect plant growth. If allowed to grow beyond the blossom stage the plants become woody and when turned under require more time for decomposition. At the time of blossoming the plants are still tender, have produced about the maximum amount of organic matter, and have acquired most of their nitrogen. When plants at this stage of growth are covered with about 3 inches of soil, decay will be accomplished within 35 to 45 days. Decomposition may be retarded if the plants are covered with less soil, because of insufficient moisture; and if covered with too much soil the exclusion of the air may retard decomposition.

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A screen of shrubs properly arranged around an exposed green is certainly attractive. Besides, it will do much toward keeping weed seeds from blowing upon the green and taking root.

# Control of Crabgrass and Other Turf Weeds with Chemicals

By Fred V. Grau

While the weed problem on golf courses is as old as the game itself, with the advent of the finer turf grasses and the increasing demand for finer playing surfaces the problem has become one of major importance. The cost of weeding constitutes one of the chief items in maintenance expense. Many methods and devices have been designed to simplify the problem, and some of these have been more or less successful.

The toxic action of certain chemicals on plants has long been known. As early as 1840 Liebig, in Germany, recognized that, as regards the growth of plants, substances fell into three groups—nutritive, indifferent, and toxic. Five years later certain generalities concerning the effect of arsenic compounds on plant growth were formulated. By 1895 the sulphates of iron and copper were being used in large quantities for selectively controlling mustard in the grain fields of North Dakota. Since that time there has been an enormous expansion of this phase of weed control in the United States and many other countries. The general use of chemicals for agricultural purposes has been largely prevented by their cost in relation to the margin of profit. On golf courses, however, where cost alone is not the all-important item and where fine, uniform, weed-free turf is the desired result, it appears entirely feasible that some method such as this may be employed.

In putting greens, species of crabgrass (Digitaria) are considered to occasion the most trouble. Fairways also are often severely damaged by the invasion of crabgrass, even though during the hot summer months it provides a good though somewhat coarse turf.

Crabgrass is strictly a summer annual. It appears rather late in the growing season, makes a rapid growth, and matures within about three months. After maturing seeds, or at the first touch of cool weather, it quickly becomes brown, and the patches of its dead and dying plants render turf unsightly, patchy, and uneven.

Due to its extensive shallow network of fine rootlets, crabgrass is able to compete successfully with turf grasses for moisture in the surface soil at a time when natural moisture is least available. Its moisture-loving nature is, however, evidenced by its profuse growth around the putting greens where the natural rainfall is supplemented by artificial watering. A single plant may produce as many as 200,000 seeds, which are known to be able to survive in the soil for many years. Actual counts under ordinary conditions show that as many as 400 plants may exist within an area of a single square foot in fairway turf in a low state of fertility. It produces seeds in abundance when clipped so close that the turf grasses are injured. Seeds are readily distributed through the agencies of wind, water, topdressing, stolons, and mowers. Turf grass seeds and seed mixtures ordinarily are seldom responsible for introducing crabgrass seed as an impurity. Soil once infested with a crop of seed will continue to produce crabgrass over many years even though no further seed production is permitted.

By effecting a control for crabgrass one more of the problems of the greenkeeper would be solved. Cultural methods, though in a degree effective in its control, have not been attended with great success. While hand-weeding, in conjunction with precautionary measures, is at present the only practicable method for keeping putting greens clear of crabgrass, these measures are admittedly out of the question for fairways and approaches, from the standpoint of cost and labor.

The need for weed-free putting greens has come more and more into the attention of the golfing public as putting surfaces have become more refined and improved. That the putting greens should receive the lion's share of attention is only natural. Although they comprise only about 3 per cent of the entire playing area of a golf course, upon them is dependent practically one-half of the play.

The importance of, and methods for, preventing weeds and weed seeds from being introduced into putting greens through the agencies of topdressing, water, commercial seed, stolons, mowers, and other factors have been discussed in the Bulletin for August, 1930. In spite of the usual precautionary measures there still remains a potent and inevitable source of infestation—seeds carried by wind, equipment, and the clothes and shoes of players and workmen. It is evident that to guard against introduction from this source some provision must be made for preventing viable seed from being produced in the fairway and approach areas.

This draws attention to those areas which are the most frequently neglected but upon which more attention should be centered, since the weeds found in the putting greens are, as a rule, those which abound in the surrounding areas. Aside from menacing the putting greens with the large amount of seed produced, weedy turf in the approach and fairway areas usually presents a poor playing surface. By effecting a control in these places the value of the control becomes twofold—not only is the green thus protected from the invasion of weed seeds but the playing conditions are improved as well. The patchy appearance caused by weeds is not only unsightly but is indicative of some of the devastating effects of these weeds. They prevent the normal development of turf grasses by robbing them of light, plant food, and moisture, and by competing with them for space in the soil sufficient for the proper development of the root systems. Annual weeds, although not the only ones which compete with the turf grasses, appear to be the more devastating.

Recognizing the need for an effective and cheap method of controlling weeds in turf, and in particular crabgrass, a series of experiments was conducted in 1932 for determining which of the more common chemical weedkillers appeared to be of the greatest promise. The experiments were begun in January of that year at the University of Maryland, College Park, Md., and in the following May were augmented by more extensive tests at the Arlington turf garden, near Washington, D. C. The experiments were conducted principally on lawn and fairway turf, primarily for the control of crabgrass, although observations were also made on other turf weeds present in the treated areas. With a few exceptions there has been no attempt in these experiments to effect chemical methods of control for weeds of the putting greens. It has been felt that it is more important, at least at the present time, to devise control methods for those weeds of the fairway and approach areas which serve as an ever-present source of infestation for the greens. In particular the object of the experiments was to find an effective weedkilling chemical which would show a high degree of selectivity,—that is to say, one which, while driving out the weeds, would not prove to be injurious to the grass, or at least only temporarily injurious. The experiments of the past season have indicated that this may be possible at a relatively low cost with a minimum outlay of labor and equipment and, which is more important, with but very little damage to the turf grasses.

Among those chemicals which have been used most frequently and have been widely tested for their practicability as weedkillers for turf and for agricultural purposes are common salt, kerosene, oils, gasolene, sulphuric acid, iron sulphate, copper sulphate, sodium arsenite, and sodium chlorate. In addition, some chemicals which are widely used on golf courses primarily as insecticides, fungicides, and fertilizers have, under certain conditions, been observed to have secondary effects in suppressing certain weeds. Among these may be mentioned sulphate of ammonia, arsenate of lead, corrosive sublimate, and other well-known materials. Only a few of the many chemicals tested have met the stringent requirements of a satisfactory turf-weed eradicant; namely, that it be safe, cheap, easily handled, selective in its action, effective in relatively small amounts, and cause no permanent injurious effects on either the soil or the desired vegetation. Of these, the factor of selectivity is the most important, as has already been pointed out. One of the most promising chemicals has the property of forming a dangerous explosive when mixed with finely-divided organic matter; another is extremely poisonous. These characteristics have been carefully considered, but the general use on golf courses of such highly-poisonous materials as arsenate of lead and corrosive sublimate indicates that, with proper warning as to the dangerous character of the materials, they may be used with comparative safety and freedom from undesirable effects.

In our experiments during 1932 considerable variations have been observed in the results obtained. This has been due to the complexity of the factors involved, which include the chemical used, temperature, rainfall, season, age and species of plants, and soil factors such as reaction, type, and moisture. While the observations of a single season are not sufficient evidence on which to base recommendations, certain definite effects have been noted. Some chemicals have shown a distinct promise for general use on golf courses for controlling certain weeds; others which have been reported in this capacity elsewhere have shown little or no promise, under the conditions of these experiments. Further, it has been shown that the application of practically any strong chemical to turf may, under certain conditions, be expected to cause a certain amount of injury. This also has been noted many times with the use of some fertilizers, fungicides, and insecticides. While this may be considered undesirable, it is no more objectionable than the digging of a weed. Digging disturbs the soil, turns up fresh weed seeds, and provides a favorable place where weed seeds may lodge and germinate. In these experiments the treatments which have been most effective on crabgrass have caused only temporary discoloration and, during the past season, have resulted in no lasting injury to either the grass or to the soil.

In presenting the following résumé of our progress during the past season with the more common weedkilling chemicals it must be borne in mind that a single season's work on a problem of this kind can be considered only preliminary and that therefore no recommendations can be offered at this time as to effective rates, methods, and times of application of any one of the chemicals mentioned. It is hoped, however, that a continuation and extension of the experiments will sufficiently clarify the attendant influencing factors so that definite recommendations may be made at a later date.

*Sodium chlorate.*—This has been successfully used on thistles, morning glory, and many other farm weeds over a wide area since 1925. More recently it has been used in the control of some of the more common turf weeds, including speedwell and ground ivy, in Ohio. It was included in these experiments despite its characteristic of forming highly inflammable and explosive mixtures when combined with finely-divided organic matter.

In our experiments, sodium chlorate has shown a great deal of promise for controlling crabgrass as well as certain other turf weeds. In some plots the control has been as high as 99 per cent. One of the most outstanding features in connection with this control on poor, weedy turf has been that the turf grasses, principally Kentucky bluegrass, have increased from a stand of about 40 per cent to a stand of 80 to 85 per cent from the date of treatment to December. The initial injury and discoloration has been slight and recovery has been rapid. Practically no crabgrass seed has been produced in these plots. Soil tests have shown that the treatments have had practically no effect on either the nutritive elements within the soil or on the soil reaction.

Additional tests have shown that sodium chlorate is promising for the control of milk purslane, which often becomes a nuisance in fine turf. Definite control has been observed for this weed in widely-separated locations. Chickweeds likewise have been observed to be controlled with this chemical.

At present prices the cost of sodium chlorate, at rates apparently effective on crabgrass, would amount to something less than $10 an acre.

*Ammonium thiocyanate.*—In the United States this was first tested for its weed-control value in Minnesota, where it has been recommended for the control of certain annual and perennial weeds troublesome principally in agricultural land. These previously-reported results commended its inclusion in our 1932 tests. Its non-poisonous, incombustible character appeared to be particularly desirable from the standpoint of safety.

In our experiments ammonium thiocyanate has shown considerable promise for controlling crabgrass. In some plots the control has been practically as complete as observed for sodium chlorate. In most cases the improvement of the turf, following a rather severe discoloration, has been marked, due mainly to the large amount of nitrogen contained in the chemical. This nitrogen is released in readily-available form upon decomposition in the soil. Rates effective on crabgrass have not been sufficiently heavy to control plantain, dandelion, and other perennial weeds and the stimulation of their growth, along with that of the grass, has likewise been marked.

At present prices the cost of ammonium thiocyanate, on the basis of crabgrass control, would correspond favorably with that of sodium chlorate.

*Arsenic pentoxide.*—The successful use of arsenic pentoxide in New Zealand for controlling many weeds in putting turf has suggested its inclusion in the present experiments. While it is extremely poisonous, as are all arsenicals, and toxic in relatively small quantities, its use should be no more hazardous than the use of arsenate of lead or corrosive sublimate.

In these experiments arsenic pentoxide has not shown promise of successfully controlling crabgrass and its presence in the soil has not proved injurious to either the grass or the soil in the concentrations at which it was used. A high percentage of control has been observed for plantain, white clover, chickweeds, ground ivy, knotweed, and pennywort. Control for the last-named weed has been observed both on putting greens and on lawns.

Present observations indicate that the use of arsenic pentoxide on weeds for which it has been observed to be effective, in spite of a higher cost of unit weight, would entail even a lower cost than either sodium chlorate or ammonium thiocyanate.

*Sodium arsenite.*—The extensive use of sodium arsenite for the control of weeds in Hawaii, as well as its use for controlling chickweeds as reported in the Bulletin as early as July, 1921, suggested its further trial in these experiments on crabgrass. It has not shown much promise in this direction, but results on other weeds have compared favorably with those obtained with arsenic pentoxide. Effects on the soil, on vegetation in general, and other characteristics are likewise similar.

*Sodium arsenate.*—This has been used to a limited extent for killing weeds. Its reported successful use in the South for controlling Dichondra suggested its inclusion in these tests. While, like all arsenicals, it is extremely poisonous, it is not as highly toxic, pound for pound, as either of the arsenicals previously mentioned. Larger quantities of it may be used with less danger of seriously damaging the turf grasses. Sodium arsenate, under the conditions of the experiments, has not controlled crabgrass, but, on the basis of equal quantities of water-soluble arsenic, it has given results on other turf weeds comparable with the pentoxide and the arsenite.

*Lead arsenate.*—This has been in general use on golf courses for insecticidal purposes for a number of years. Many instances have been given where, as a secondary effect, it has entirely controlled chickweed and, in some cases, crabgrass. In our experiments it has not controlled crabgrass, but under some conditions it may have value for controlling chickweeds. The control, however, has not been definite under all conditions. If used primarily for weedkilling purposes, the cost would become prohibitive.

*Iron sulphate.*—The early and extensive use of iron sulphate for controlling dandelions and other weeds in lawns has, to many, become a familiar story. Some instances have been reported where its use at a certain stage of growth controlled crabgrass for several seasons. Our experiments have indicated that this chemical does not control crabgrass but, on the contrary, has been observed to have a slightly stimulating effect on it. The seed production in the treated plots has been unusually heavy.

*Sulphate of ammonia and iron sulphate mixed with soil.*—The use of a mixture of sulphate of ammonia, iron sulphate, and soil as a topdressing material, first successful in South Africa, has given excellent results in suppressing many weeds on lawns and golf courses in the British Isles and, with certain modifications under some conditions, in Canada. It was hoped that it might be successfully applied to the control of crabgrass in this country even though crabgrass has not been included in the lists of weeds reported controlled elsewhere by this mixture. Under the conditions of the experiments, however, by its monthly use during one season crabgrass has not been controlled, but on the contrary its growth and seed production have been greatly stimulated.

*Sulphate of ammonia and iron sulphate mixed with sand.*—This mixture differs from the one immediately preceding in that it has been prepared by fusing the mixture, followed by pulverizing. In the Bulletin for December, 1927, its preparation is described, as well as its reported successful use on certain weeds of Bermuda turf in South Africa. Certain preliminary tests on Bermuda turf in Florida have likewise indicated its value as a turf-weed eradicant. The 1932 experiments, while not sufficiently extensive, have indicated that it has little or no value for controlling crabgrass in the latitude of Washington, D. C.

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## A Convenient Storm Shelter

Shelters to protect golfers from sudden showers are much-needed accommodations on many golf courses, particularly in regions where heavy downpours of short duration are apt to occur at any time. There are many interesting structures built on golf courses to provide protection for this type of storm. One of the objections to many of these shelters is that they must be large in order to furnish protection from storms coming from different directions. An interesting shelter has been built on the Boca Raton course at Boca Raton,

Storm shelter equipped with revolving shield

Fla., by O. Sproule Baker, as shown in the accompanying illustration. This simple shelter consists of four permanent upright posts supporting a small roof. The main feature of the shelter is a large board shield revolving about a central axis, set on a concrete base, and fastened above to the rafters. During showers the shield may be swung around so that the seat will be on the lee side. On the opposite side from the seat has been fastened half of a metal washtub over which hose is looped. This shelter therefore provides a place where hose which is used in that vicinity may be neatly put away while not in use.

# Effect of Temperature and Moisture on Occurrence of Brownpatch

By Arnold S. Dahl

The conditions tending to encourage the development of the brownpatch disease of turf have been a subject of much speculation and theorizing in recent years. The cause of the disease is specific; it has been proved to be the fungus *Rhizoctonia solani*. This fungus is usually present in the soil, and when conditions are favorable it becomes active and attacks the grass.

It has been generally observed that brownpatch is most prevalent during hot, wet periods of the summer, and that with a change from these conditions the fungus usually becomes inactive. There are so many other conditions that encourage attacks of the disease that it is impossible to predict just when the disease will be active without taking into consideration all conditions that might be influential. Many greenkeepers have attempted to predict its occurrence and many have been able to do so with a certain degree of accuracy. An experienced greenkeeper will express the opinion that it is brownpatch weather, and he will probably be right; but, if one were to question his reason for the statement, he could not tell exactly what the conditions are that will cause the disease. Often, however, the disease occurs when there is no characteristic "brownpatch weather," and as a result greenkeepers are apt to become confused. It is impossible to select a particular condition and to forecast the occurrence of the disease by that condition alone. Attempts have been made at such forecasting but have not proved successful.

## Effect of Temperature

Brownpatch is more responsive to temperature changes than to any other environmental condition. The correlation of temperature and occurrence of the disease is readily noticed by greenkeepers because they themselves are directly affected by changes in temperature. Since brownpatch was first observed it has been noticed that the disease occurs usually when the temperature is high, and that when the temperature becomes cooler for a period the fungus becomes inactive.

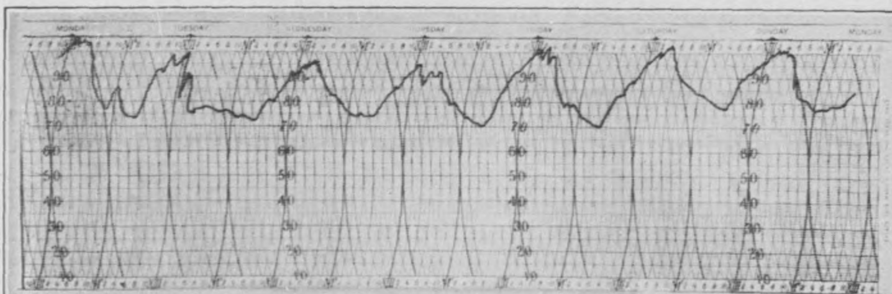
The optimum temperature for the occurrence of brownpatch is dependent on two factors: (1) the optimum temperature for the fungus (the temperature at which the fungus grows most rapidly); and (2) the influence of temperature on the resistance of the grass to attacks by the fungus.

Although a fungus has an optimum temperature at which it makes its best growth, it will also grow rapidly at temperatures higher or lower than the optimum. In 1924 and 1925 experiments were conducted in a laboratory of the University of Wisconsin to determine the effect of temperature on the growth of the brownpatch fungus. The purpose of these experiments was to find the limits of temperature between which the fungus grows as well as to find the temperature at which it makes its best growth. The results showed that the optimum temperature for the fungus is about 83 degrees (Fahrenheit). There was rapid growth at 72 degrees and fairly good growth at 94 degrees. Below 61 degrees there was very little growth and none at all at 39 degrees. The fungus also failed to grow at 104 degrees. From this study it was apparent that the optimum temperature range for the activity of the fungus is from about 72 degrees to 94 degrees, and that above or below this range very little growth takes place. These results, confirming the observations which had been made up to that time, were published in the June, 1926, number of the Bulletin, together with a discussion of several other factors that affect the occurrence of brownpatch.

The optimum temperature for the fungus, however, is not always the optimum temperature at which parasitism takes place. The condition of the grass plays an important part. A high temperature may be unfavorable for the plant and favorable for the fungus, so that the leaves of the grass are easily invaded by the fungus. The weaker the grass the more easily is it invaded, and therefore the optimum temperature for parasitism may be above the optimum temperature for the fungus. It is necessary to point out here that temperature alone does not determine the occurrence of disease, but that moisture, light, and general condition of the plant also play an important part. Attacks of the disease often occur at temperatures higher and lower than the optimum, and often attacks do not occur even when temperature is at the optimum.

#### Field Observations on Effects of Temperature

Beginning in 1924 records of climatic conditions and occurrence of disease have been kept at the Arlington turf garden, for the summer period from June to mid-September. A continuous record of



**Record of air temperature taken from hygro-thermograph chart. These temperatures occurred over a plot at Arlington turf garden from July 21 to July 28, 1930. On each day during this period severe attacks of brownpatch occurred on the garden. New patches of the disease were evident on each day. Note that the temperature did not fall below 70 degrees at any time during the period.**

temperature and relative humidity has been obtained by means of a recording hygro-thermograph. These records have been checked with the records of the United States Weather Bureau and have been found to be closely in agreement. A record of rainfall has also been kept at the turf garden. In conjunction with the records of climatic conditions the occurrence of brownpatch has been carefully recorded each day over the period. The records note whether the disease is very active or only slightly active. The records of temperature confirmed the results of the laboratory work indicating that the disease occurs during the hottest weather of the year and that as soon as the temperature rises and remains above 80 degrees for some length of time the disease is apt to occur. The disease rarely occurred when the temperature remained below 75 degrees throughout the day.

Later L. S. Dickinson, of Massachusetts State College, reported observations which led him to believe that the disease occurs only after a fall in temperature with a subsequent rapid rise to the optimum temperature range. He reported that the temperature must fall to somewhere between 64 and 68 degrees and then rapidly rise to between 80 and 85 degrees in order that attacks of disease might occur. He attributes this to the fact that the resting bodies of the fungus require chilling to between 64 and 68 degrees to germinate. He further states that the fungus attack of the grass ceases above 90 degrees, and that below 62 degrees the fungus growth is destroyed. These results did not check with the observations that had been made at Arlington turf garden over a period of years from 1924.

TABLE 1.—OCCURRENCE OF BROWNPATCH AT ARLINGTON TURF GARDEN OVER THE 5-YEAR PERIOD 1927 TO 1931 AT VARIOUS TEMPERATURE RANGES

| Temperature ranges in degrees Fahrenheit | Number of days included | Occurrence of the disease | |
|---|---|---|---|
| | | Number of days | Percentage of days |
| *Maximum temperatures* | | | |
| 60 to 64 | 1 | 0 | 0 |
| 65 to 69 | 8 | 2 | 25 |
| 70 to 74 | 11 | 3 | 27 |
| 75 to 79 | 40 | 17 | 42 |
| 80 to 84 | 74 | 42 | 57 |
| 85 to 89 | 90 | 61 | 67 |
| 90 to 94 | 82 | 59 | 71 |
| 95 to 99 | 53 | 38 | 72 |
| 100 and over | 28 | 24 | 85 |
| Total | 387 | 247 | 64 |
| *Minimum temperatures* | | | |
| Below 60 | 64 | 17 | 27 |
| 60 to 64 | 95 | 57 | 60 |
| 65 to 69 | 106 | 72 | 67 |
| 70 to 74 | 103 | 84 | 82 |
| 75 to 79 | 18 | 15 | 83 |
| 80 to 84 | 0 | 0 | 0 |
| *Minimum temperatures (summarized)* | | | |
| Below 64 | 137 | 58 | 42 |
| 64 to 68 | 112 | 77 | 68 |
| Above 68 | 137 | 110 | 80 |

In an analysis of temperature records for a 5-year period (1927 to 1931) at Arlington turf garden the maximum and minimum temperatures were tabulated from the charts of the recording instruments. The relation of the occurrence of brownpatch to various ranges of maximum and minimum temperatures is shown in Table 1. The ranges of temperature presented in the table, it will be noted from the first column, are 5-degree ranges. In the second column is shown the number of days included within the respective 5-degree ranges of temperature. In the third column is shown the number of these days on which brownpatch occurred on the turf garden. The percentage of the number of days on which the disease occurred, to the total number of days on which observations were made, is shown, for the respective 5-degree ranges of temperature, in the fourth column.

The table shows that, during the period over which these records were taken, brownpatch occurred 64 per cent of the time. This percentage would probably vary greatly in different parts of the country. It may also vary on different courses in the same locality, depending on the variety of grass, soil conditions, locations of greens, and cultural practices. The high percentage of days on which brownpatch occurs at Arlington turf garden because of its geographical location, makes it an ideal place for a study of this kind.

It may be noted from the table that the higher the temperature the greater the percentage of days on which disease occurred. It shows that when the maximum temperature was over 100 degrees, as it was on 28 days during the 5-year period, brownpatch occurred on 24 of those days, or 85 per cent of the time. When the maximum temperature is above 90 degrees there is the chance that brownpatch will occur about 74 per cent of the time. The fungus does not grow well above 100 degrees, and that temperature may be reached for only a short time during the day; but it is probable that the higher the maximum temperature the higher the temperature has been during most of the day, and probably during the night as well. At least it is definite that brownpatch rarely occurs when the maximum temperature is below 75 degrees.

Analysis of the minimum temperatures also shows that the higher the minimum temperature the more frequent the occurrence of this disease. The table shows that when the minimum temperature was above 70 degrees brownpatch occurred 82 per cent of the time; below 60 degrees the disease occurred only 27 per cent of the time. The earlier report stated that the fungus did not grow vigorously below 60 degrees and did not reach a growing state until the temperature rose to 65 degrees or 70 degrees, so that one would not expect the disease to occur at the lower temperatures. The disease occurs with more frequency when the minimum temperature remains above 70 degrees than it does when the minimum temperature falls below 70 degrees. Therefore it is apparent that the fungus does not need a chilling temperature to become active. In the table the records are also tabulated for minimum temperatures of 63 degrees and below, 64 to 68 degrees, inclusive, and 69 degrees and above. This indicates that the fungus is most active without a chilling period. It is evident from the table that while the fungus is more active at the higher temperatures, there is no definite point above which it occurs and below which it does not occur. It indicates that other factors are also important in the occurrence of the disease.

### Effect of Temperature of Water

Inquiries have been received as to the effect watering putting greens with cold water from deep wells has on the temperature of the turf. It has been suggested that the decreasing of the temperature of the turf might make conditions more favorable for fungus development particularly on hot days, and others have suggested that watering greens during the night might lower the temperature of the turf to such an extent that brownpatch might not develop.

Experiments were made to lower the temperature of turf by means of ice water. It was found in several experiments that applying ice water directly from a sprinkling can held close to the turf lowered the temperature an average of 9 degrees. In the different tests the decrease in temperature varied from 5 degrees to 12 degrees. The tests were made both early in the morning and during the heat of the afternoon, and there was not a great difference noticed in the decrease when the initial temperature was either high or low. The usual watering of a green lowered the temperature 2 degrees. In one test ice water was sprinkled through a regular sprinkler from a power spray machine. The temperature of the water in the spray tank was 32 degrees; at the end of 100 feet of ¾-inch hose, 46 degrees; when sprinkled through the air and caught in a pan, it was 76 degrees; and the turf, after sprinkling an amount equal to 2½ inches of rainfall, was 76 degrees. The temperature of the turf at the beginning of the experiment was 78 degrees and the air temperature was 80 degrees. This experiment shows that water quickly approaches air temperature when sprinkled through the air and that cold water does not greatly decrease the temperature of turf. Sprinkling with ice water did not decrease the temperature of the turf any more than the usual watering, and that was only 2 degrees. When a decrease in temperature did take place through the addition of water, the original temperature quickly returned. From these experiments it has been concluded that watering greens with cold water has no appreciable effect on the temperature of the turf, and has no effect on the development of diseases except that the added moisture may cause more favorable conditions for fungus growth, and some well water may contain chemicals in solution that in time may affect grass growth.

### Laboratory Experiments with Temperatures

Experiments were carried on in a laboratory at the University of Wisconsin in 1931 which were devised to give more facts as to the relation of temperature to the growth of the fungus. Resting bodies (sclerotia), were used in these experiments to find what their reaction would be to constant and changing temperatures. This work was planned with the view of correlating it with the observations in the field. In these experiments six strains of the fungus which had been isolated from grass were used together with strains isolated from diseased plants of cabbage, sugar beet, cotton, potato, and pea. All of these strains were the same fungus, *Rhizoctonia solani*, and all were proved pathogenic (capable of producing brownpatch) by experiments in the greenhouse. However, there were differences in their vigor in attacking grass. Five of the strains, three from grass, and those from cotton and peas, were very pathogenic; two strains, both from grass, were medium; and three, those from cabbage, potato, and sugar beet, were only slightly pathogenic.

The resting bodies of these strains were germinated in sterile plates containing a suitable nutrient medium at different temperatures from 46 degrees to 104 degrees. The time that elapsed from the transfer of the resting bodies to their nutrient medium, until their germination, was recorded. It was found that the optimum temperature for germination was 83 degrees, and the average germination time at that temperature was 2 hours and 36 minutes. The resting bodies which germinated most rapidly were of the strains which were the most pathogenic. The sclerotia also germinated quickly at 90 degrees and 97 degrees, and at 75 degrees and 68 degrees. The germination time at 90 degrees and 97 degrees was less than at 75 degrees and 68 degrees, respectively. The average time of germination at 97 degrees was 48 minutes less than at 68 degrees. While the resting bodies are able to germinate easily at 97 degrees, the growth of the fungus after germination at that high temperature is extremely slow. The resting bodies also germinated slowly at 53 and 60 degrees. The limits for germination of the resting bodies are 46 degrees and 104 degrees. At these temperatures the resting bodies did not germinate for several days.

In 1930 Dickinson reported results of laboratory work with resting bodies of the fungus. From his experiments he concluded that the resting bodies required chilling in order to germinate and make their best growth. He stated that the resting bodies must be chilled to between 64 and 68 degrees and subsequently brought to a higher temperature before they germinated. As these results were at a variance with results that had previously been published and with observations that had been made over a period of years, they were also checked in this laboratory work.

Experiments were thus carried on in which the resting bodies were chilled at 66 degrees for 1 hour. The plates were placed in compartments at the desired temperatures and left there until they reached the temperature of the compartments. Then they were chilled for 1 hour and immediately returned to the original temperature. In general, the chilling did not decrease the time of germination, but in most cases increased it. Only with one strain did chilling decrease the time. With a starting temperature of 97 degrees, two strains germinated more quickly when chilled. However, in the case of 97 degrees the chilling carries the temperature of the culture through the optimum to the chilling temperature, and again through the optimum to the initial temperature, which accounts for the faster germination of the culture when chilled.

In all of the experiments there was a difference in the behavior of individual cultures. Some of the resting bodies germinated quickly and a few did not germinate at all. It was found that the percentage of germination of the sclerotia was greater when not chilled at the beginning temperatures of 75 and 83 degrees. At 97 degrees, however, the percentage of germination of the chilled was greater than the unchilled. Here, again, the chilled sclerotia, by passing through the optimum temperature, were given a condition favorable to germination, while those which were kept at 97 degrees constantly did not have that advantage. Experiments were made in which the sclerotia were chilled from initial temperatures of 75 degrees, 83 degrees, and 97 degrees, to temperatures of 59 degrees, 66 degrees, 70 degrees, and 73 degrees. In most cases, when chilled from 75 and 83 degrees to any of the chilling temperatures, the percentages of germination were less. When the initial temperature was 97 degrees the chilling increased to percentage of germination at all of the chilling temperatures of 59 degrees, 66 degrees, 70 degrees, and 73 degrees.

Experiments were also conducted to determine if the rates of growth of the fungus would be increased by chilling to any point. In these tests the cultures were first placed in a beginning temperature and then chilled for 1 hour and then returned to the initial temperature. The initial temperature was 83 degrees and the chilling temperature was 66 degrees. Eleven strains were used in these experiments and it was found that there was a variation in the behavior of the strains. At the end of 3½ hours only in the case of one strain did chilling increase the growth. After 17 hours seven of them had made their best growth when kept at a constant temperature, three had made their best growth when chilled, and one had remained unchanged. Thus in two of the cases where chilling increased the growth after 17 hours the effect took place after the resting bodies had germinated. In the averages for all the strains, the growth of the unchilled was 15 per cent greater than the chilled.

Three strains of the fungus isolated from grass were further tested in the same way. Initial temperatures of 75 degrees, 83 degrees, and 97 degrees were again used and the resting bodies were chilled from each of these temperatures to 59 degrees, 66 degrees, 70 degrees, and 73 degrees. It was found that in most cases the chilling had adverse influence on the growth of the fungus, no matter to what temperature it was chilled. This was true when the initial temperature was 75 degrees or 83 degrees. When the initial temperature was 97 degrees chilling to any of the chilling temperatures usually resulted in increased growth.

In another series of tests old sclerotia were compared with young sclerotia; these tests showed that, whether young or old, chilling did not increase the amount of growth in either 3½ or 17 hours.

## Effect of Moisture

Many observers have noted that brownpatch occurs more frequently during muggy weather and during seasons when there is much rainfall. An analysis of the records of moisture has shown that the occurrence of brownpatch can be correlated with moisture only in a general way. Although moisture is one of the important factors which influence the occurrence of disease, the methods of measuring and recording the moisture relationship are imperfect and for that reason definite correlations are not possible.

TABLE 2.—OCCURRENCE OF BROWNPATCH AT ARLINGTON TURF GARDEN OVER THE 3-YEAR PERIOD 1929 TO 1931 AT VARIOUS MAXIMUM AND MINIMUM RELATIVE HUMIDITIES

| | | Occurrence of the disease | |
|---|---|---|---|
| Relative humidity | Number of days included | Number of days | Percentage of days |
| Maximum below 80 per cent | 29 | 14 | 48 |
| Maximum above 80 per cent | 242 | 152 | 63 |
| Minimum below 50 per cent | 166 | 108 | 65 |
| Minimum above 50 per cent | 96 | 72 | 75 |

As in the case of the daily records of temperature taken at the Arlington turf garden, so also daily records of maximum and minimum relative humidity there have been taken, and in Table 2 are presented figures representing the relation of the occurrence of brownpatch at the garden to the relative humidity during the 3-year period 1929 to 1931. Relative humidity is the amount of moisture in the air in relation to what the air would contain if it were at the saturation point; it is expressed in percentage. The number of days on which the maximum relative humidity was above 80 per cent was recorded, also the number of days on which it was below 80 per cent, and these are shown in the second column of the table. In the third column is shown the number of days on which the disease occurred during the respective conditions. In the fourth column is shown the percentage borne by the number of days of the occurrence of the disease to the total number of days in each case. Similarly figures are presented for conditions pertaining to minimum relative humidities below and above 50 per cent.

From the figures obtained it would appear that when the maximum relative humidity is above 80 per cent there are 63 chances in 100 (63 per cent) that the brownpatch disease will be active, while below 80-per-cent relative humidity there are only 48 chances. It would also appear that where minimum relative humidity is above 50 per cent there are 75 chances in 100 that the disease will be active, while below 50 per cent the disease occurs 65 per cent of the time. These percentages show that while relative humidity may have some influence on the occurrence of the disease it is not a true measure of that factor, because so much of the disease occurs when the relative humidity is low.

An attempt was made to correlate the occurrence of dew with the presence of the disease, but it was found that it was impossible to tell from the available records whether or not dew had been present. There are many factors that influence the formation of dew, among which are relative humidity, falling temperature during the night, presence of clouds in the sky, velocity of the wind, and moisture in the soil. Determinations of the dew point at various hours of the nights apparently could not be correlated with the occurrence of disease.

TABLE 3.—OCCURRENCE OF BROWNPATCH AT ARLINGTON TURF GARDEN IN 1931 WHEN EVAPORATION AT NIGHT WAS BELOW AND ABOVE 30 CUBIC CENTIMETERS

| | Number of days included | Occurrence of the disease: Number of days | Occurrence of the disease: Percentage of days |
|---|---|---|---|
| Below 30 cubic centimeters | 82 | 66 | 80 |
| Above 30 cubic centimeters | 25 | 16 | 64 |

Records of evaporation of water at the garden were kept during the summer of 1931. Evaporation during the day showed no influence on the occurrence of the disease but it may have influenced the severity of the attacks which occurred. The evaporation during the night, however, could in a general way be correlated with occurrence of the disease. The evaporation of water is influenced by temperature, relative humidity, and velocity of wind. Therefore, it is to be expected that when evaporation is great the greens would be dry and less brownpatch would occur. This proved to be the case, as shown by Table 3. When the loss of water was less than 30 cubic centimeters brownpatch was active 80 per cent of the time, and when the loss was above 30 cubic centimeters the percentage dropped to 64.

TABLE 4.—OCCURRENCE OF BROWNPATCH AT ARLINGTON TURF GARDEN IN RELATION TO RAINFALL DURING JUNE, JULY AND AUGUST OF THE YEARS 1929, 1930, AND 1931

| | 1929 | 1930 | 1931 |
|---|---|---|---|
| Rainfall during June, July, and August | 11.66 inches | 7.14 inches | 14.66 inches |
| Percentage of this rainfall in the 3-year total | 35 per cent | 21 per cent | 43 per cent |
| Number of days during the 3 months on which brownpatch occurred | 43 days | 24 days | 52 days |
| Percentage borne by the number of days of annual occurrence to the total number of days of occurrence during the 3 years | 36 per cent | 20 per cent | 43 per cent |
| Proportion of number of attacks of brownpatch to inches of rainfall | 3.68 | 3.36 | 3.54 |

Table 4 shows the relation between rainfall and the occurrence of brownpatch at the garden. The records of the years 1929, 1930, and 1931 are tabulated and the percentages listed are based on the total rainfall and the total number of times the disease occurred during the 3-year period. This analysis shows a definite correlation between the rainfall and the number of days on which the disease occurred. As seen in the table, 1929 had 35 per cent of the 3-year total of rainfall and 36 per cent of the total number of days on which the disease occurred in the 3 years. The year 1930 had 21 per cent of the rainfall and 20 per cent of the disease, and 1931 had 43 per cent of the rainfall and 43 per cent of the disease. It was calculated from this table that the proportions between the amount of rainfall and the number of disease attacks during the years 1929, 1930, and 1931 were 3.68, 3.36, and 3.54, respectively. Although there is a great difference between the amount of rainfall and the number of disease attacks in the three years, there is close agreement in the proportion of rainfall to disease. This indicates that the greater the amount of water in the soil for a considerable period the greater the amount of disease that will occur. It has been noted on greens that those which are overwatered are troubled with disease frequently much more than those which are underwatered. For that reason great care should be taken that greens do not have too much water.

Although moisture is necessary in order that the brownpatch fungus may attack grass, the analyses of moisture records as here given show that it is not possible to predict the occurrence of the disease by these records. The reason for this may be that the soil moisture is the most important factor, and this is not measured by any of the methods that have been used. The amount of moisture in the air and the rate of evaporation are also factors which must be considered. The disease may thus occur when one factor is favorable and another unfavorable, so that it is practically impossible with present information to determine which factor is most responsible for the encouragement of the attack of the disease.

# Effect of Watering Putting Greens on Occurrence of Brownpatch

By Arnold S. Dahl

The watering of putting greens is a necessity in most sections of the United States in order to maintain turf of the quality demanded by present-day golfers. There is a wide difference of opinion as to the amount of water necessary to keep turf in best growing condition. Bent grasses are supposed to require an abundant supply of water, but there is a difference of opinion as to what constitutes an abundant supply. There is, therefore, much variance in the amount of water that is applied and in the time of its application. It is impossible to make a general recommendation as to the amount of water that is necessary to keep turf healthy and vigorous because of the special factors that affect the water after it has been applied. If a soil is heavy and poorly drained, only a small supply may be an abundance, while light sandy soils require a much larger supply to meet the needs of the grass. It is impossible also to predict how much water will be necessary during any particular season, because of the variation in the amount of rainfall. The amount of water that should be applied during a wet season would not be sufficient during a dry season. However, it is possible to determine whether a green has too much or too little water at any time during a season.

It has been observed for several years that brownpatch is more prevalent when greens are soaked with water. Recommendations have been made that greens be watered in the morning rather than in the evening, because of the knowledge of the moisture requirements and other growth characteristics of the fungus causing the disease. There have been no adequate experiments which have tested what would be the most favorable amount of water or the best time of application. For the purpose of conducting such an experiment, arrangements were made in 1932 with a golf club near Washington, D. C., to allow the Green Section to use two greens on its course and to make provision for fertilizing, treating with fungicide, and watering. The club continued to maintain the greens in other respects and to keep them in play throughout the experiments. Each of the two greens was divided into quarters. The first quarter was heavily watered in the morning, the second lightly watered in the morning, the third heavily watered in the evening, and the fourth lightly watered in the evening. These quarters were given similar treatment otherwise. The experiment began late in June and continued until mid-August. The rainfall during the three months, June, July, and August, was more than 6 inches below normal.

The quarters were watered between 6 and 8 o'clock in the morning and 6 and 8 o'clock in the evening. The heavily watered areas were watered for 50 minutes and the lightly watered areas for 10 minutes. The hose line delivered approximately 16 gallons of water a minute.

The lightly watered quarters were given enough water to keep the grass in a healthy condition. That the grass was growing sufficiently to keep a good putting surface was evidenced by the amount of clippings that were removed. At no time during the experiment was there any general wilting of the grass due to lack of water. Although the grass was not growing as vigorously as may have been desirable, the turf was maintained in a good putting condition. The purpose of the experiment was to apply as little water as possible and still hold a good covering of grass so as to observe the occurrence of brownpatch under that condition. These areas were not soft enough to hold any but well-played pitch shots which, as discussed in the February, 1932, number of the Bulletin, is the desirable condition of the turf from a playing standpoint.

It is recognized that in a wet season the amount of water that was applied on these lightly watered areas would have been excessive. In a drier season, on the other hand, it might not have been enough to keep the grass alive. Similarly on greens with different soil conditions, the amount of water applied to areas thus lightly watered might be too light to maintain turf or too heavy for best growth of grass, depending on whether the soil was light and well-drained or heavy and poorly drained. It is impossible to prescribe the exact amount of water to be applied to turf that will provide the best growth of grass. Thus the amount of water that was applied to these plots is not to be taken as recommended rates of watering. Each green should be studied individually, in relation to the type of soil, drainage, and water-holding capacity in order to determine the amount of water that it should receive, and the amount that it receives from rainfall should be considered before the amount to be applied can be determined.

The amount of water that was applied to the heavily watered quarters was five times that applied on the lightly watered sections. It was desired to keep the turf and soil soaked with water in order to observe the occurrence of brownpatch under that condition. The amount of water that was applied in these experiments kept the soil soggy at all times and induced a very vigorous and rank growth of the grass. There was, however, no evidence of direct injury from excess water, although had the experiment continued longer such damage might have occurred. The amount of water that was applied to the heavily watered plots also might have been more or less than the amount that would have been necessary to water heavily the same greens in some other season, or indeed greens with different soil types or with more or less effective drainage. The amount that was applied in these experiments kept the soil soggy and was too much to keep the grass in the best growing condition.

At intervals during the course of the experiment, treatments of corrosive sublimate were made at the rate of 1 ounce to 1,000 square feet. This rate was used to check the disease and to provide for only a short period of protection, since the object of the experiment was to test the effect of watering greens on the frequency of disease attacks. Thus the attacks of disease were more frequent than would have been the case had higher rates of application been made.

The plots were watered daily by hand, one-half in the morning and one-half in the evening. The approximate amount of water which each plot received is given below:

Green No. 1 Heavy watering, 522 gallons to 1,000 square feet or .84 inch a day.

Green No. 1. Light watering, 104 gallons to 1,000 square feet or .17 inch a day.

Green No. 2. Heavy watering, 463 gallons to 1,000 square feet or .74 inch a day.

Green No. 2. Light watering, 92 gallons to 1,000 square feet or .15 inch a day.

Green No. 1 had a Washington creeping bent turf and was built of a very heavy soil. It was situated high on the course but the underdrainage was poor. The green sloped slightly to the front and had some low areas on one corner. It was somewhat smaller than No. 2, and for that reason received more water on each unit of area. On this green the soil quickly became soggy on the heavily watered area because of its poor texture, and some of the water ran down the approach to the green, as was evidenced by the green turf there as contrasted with the grass of the fairway which was dry from lack of rainfall. At any time of the day free water could be pressed from a plug of turf cut from the heavily watered area. The quarters were not watered during heavy rains, which occurred only occasionally during the experiment. The lightly watered area received enough water to keep the grass growing and healthy.

PERCENTAGES OF AREAS OF TWO PUTTING GREENS COVERED WITH PATCHES OF BROWNPATCH UNDER LIGHT AND HEAVY AND MORNING AND EVENING WATERING

| Date of Readings | Morning watering Light | Morning watering Heavy | Evening watering Light | Evening watering Heavy |
|---|---|---|---|---|
| *Green No. 1 (Washington bent on heavy, poorly drained soil)* | | | | |
| July 7 | 10 | 50 | 10 | 40 |
| July 13 | 15 | 50 | 30 | 40 |
| July 18 | 0 | 50 | 0 | 40 |
| July 25 | 0 | 70 | 0 | 60 |
| July 29 | 5 | 70 | 40 | 50 |
| August 8 | 10 | 30 | 10 | 40 |
| Average | 7 | 53 | 15 | 45 |
| *Green No. 2 (mixed bent on loamy, well-drained soil)* | | | | |
| July 7 | 10 | 60 | 30 | 60 |
| July 13 | 15 | 60 | 50 | 60 |
| July 18 | 10 | 40 | 20 | 50 |
| July 25 | 0 | 30 | 0 | 60 |
| July 29 | 5 | 30 | 20 | 60 |
| August 8 | 30 | 60 | 30 | 80 |
| August 11 | 20 | 80 | 30 | 60 |
| Average | 13 | 51 | 26 | 61 |
| *Average of both greens* | 10 | 52 | 21 | 53 |

Green No. 2 had a mixed bent turf and was built of a good loam soil and had good underdrainage. It was situated in the bottom of a ravine with a small brook running in front of it. Since it was much better drained and did not receive as much water on each unit of area because of its larger size, it did not become as soggy as did green No. 1. However, free water could be pressed out of plugs cut from the turf several hours after it had been watered. The lightly watered quarters on this green received only sufficient water to keep the turf growing, while on a few occasions the turf on limited high areas began to exhibit symptoms of moisture deficiency, especially on the section watered in the evening, which dried out more during the day; no turf, however, was lost from lack of water.

The amount of water that was applied on a quarter directly affected the amount of disease which occurred on that area. Readings of the percentage of the area of the quarters which was diseased were made at intervals during the course of the experiment. These percentages are given in the accompanying table. On an average of all the plots there was three times as much disease when the turf was heavily watered as when the turf was lightly watered. Not only was there less disease on the lightly watered plots but the disease that did occur there was not nearly as serious. The patches on the heavily watered areas were badly diseased and did not respond to the fungicidal treatments as readily as the patches on the lightly watered areas. On green No. 1, which was turfed with Washington bent, which is fairly resistant to brownpatch, the difference was even greater, there being nearly five times as much disease on the heavily watered areas as on the lightly watered areas. Green No. 2 was turfed with mixed bent, which was more susceptible to brownpatch, and although the soil was not as soggy as that of green No. 1, there was more disease. On this green there was over twice as much disease on the heavily watered areas as on the lightly watered areas.

The results of the test showed that when the greens were heavily watered there was approximately the same amount of disease on both morning- and evening-watered quarters. On green No. 1 the morning-watered section lay slightly lower than the evening-watered section, and more disease occurred on the former. On the first of August the evening- and morning-watered treatments were reversed and the greater amount of disease still persisted on this same plot, which was then, however, being watered in the evening. On green No. 2 the plot heavily watered in the evening had 10 per cent more disease than the plot heavily watered in the morning. On the heavily watered areas on both greens, the difference between the morning and evening-watered quarters is so small as to be insignificant. The topography of the two greens is a factor that may have affected the difference in amount of disease on the heavily watered sections on each green. However it illustrates the danger of accepting the results of any experiment confined to a single putting green.

The areas which were lightly watered, however, demonstrated that the morning watering materially reduced the amount of disease. On both greens there was twice as much disease on the areas lightly watered in the morning as on those lightly watered in the evening. When climatic conditions were favorable for fungus development, the disease always occurred on both sides, but there was always more of it on the areas watered in the evening, and the patches were more seriously diseased. At the time of several of the readings the disease was equal on both portions, but at other times there was much more disease with the evening watering, and in one case there was 8 times as much disease with the evening watering as compared to the morning watering.

This experiment substantiates observations made elsewhere that the amount of water and the time of watering greatly influence the frequency and severity of brownpatch on putting greens. The amount of water that was applied on the heavily watered turf was more than is usual on most courses, yet it is not unusual to find greens that have been overwatered in which the soil contains more water than was contained in the areas here involved. Putting greens constructed of heavy soil should be watered with especial care, since the soil does not allow the water to drain away quickly and the soil remains soggy for long periods. Water should be applied to greens only when necessary, and this is determined by examination of the soil. It is advisable to keep the soil a little on the dry side, rather than too wet.

When greens are watered moderately much less disease will occur when watered in the morning than in the evening. When water is applied in a reasonable amount in the morning, the turf soon dries, and if dew is present the drying is more rapid than if no water had been applied. When watered in the evening, however, the surface of the soil and the leaves are wetted much earlier than normally wetted by dew, and usually remain wet much longer because the larger amount of water in the soil due to the recent watering encourages an abundance of dew. Therefore turf that is watered in the evening not only is wet earlier in the evening but also remains wet much longer in the morning, thus creating conditions under which fungus development may be rapid for a long period of time.

From the results here given it is evident that the careful use of water greatly diminishes the amount of brownpatch that occurs on putting greens. It is, therefore, apparent that the cost of controlling this disease can be greatly reduced by correct watering.

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## Books and Pamphlets for the Greenkeeper's Library

**By Kenneth Welton**

The Green Section has frequently been asked to recommend books and pamphlets of value to those interested in turf culture. Several years ago we included in our exhibits and golf shows a collection of books and pamphlets containing information directly or indirectly related to golf-course maintenance. Many who saw this exhibit asked that a list of books and bulletins of interest to greenkeepers be published. In response to these requests the Green Section published a greenkeeper's library in the Bulletin for June, 1929. The following list is more complete and is a revision of the list published in 1929. Although no attempt has been made to include all the literature in this field the list has been selected to cover a wide range as a basis for a greenkeeper's library. While several books and other publications are offered under each classification it is not intended that all are necessary for the greenkeeper's library. Ordinarily only one book on each subject is needed, together with United States Department of Agriculture publications and state publications which apply particularly to those problems in which the greenkeeper is interested. A large number of the United States Department of Agriculture bulletins and state bulletins are included, which, although dealing chiefly with farm problems, contain information applicable to golf-course construction and maintenance.

The publications are grouped in the list with books first, United States Department of Agriculture bulletins and circulars second, followed by state and other publications. An attempt has been made to include the more recent publications and editions except in cases where older literature is still useful. In some instances the books have been revised many times, and it is well in ordering to mention the date or edition given in the list. The bulletins published by the United States Department of Agriculture may be obtained for a nominal sum from the Superintendent of Documents, Government Printing Office, Washington, D. C. State bulletins may be obtained by writing to the issuing institutions at the addresses given. Books may be procured through dealers in textbooks and technical publications or from the publishing house indicated.

Information regarding all subjects connected with golf course construction and maintenance is distributed through various numbers of the Bulletin of the United States Golf Association Green Section. The purpose of the Bulletin is to digest and publish in a form that the layman can easily understand, information regarding various phases of turf culture. Much of this information is the result of research and experimentation conducted by the Green Section. Work reported by other investigators and information on related subjects such as may be found in the books, bulletins, and circulars contained in this list is included in the publication. In this way Bulletin readers are kept up-to-date in the developments in the field of fine turf culture and may only wish to refer to the various publications given in the list for supplementary reading. Only a few of the Green Section Bulletin numbers are given. In these cases the numbers are the more recent publications and are either wholly or in a large part devoted to the subject under which heading they may appear.

**Architecture**

Golf Architecture. Colt and Alison. Charles Scribner's Sons. 1920.
Golf Architecture. Mackenzie. Simpkin, Marshall, Hamilton, Kent and Co., Ltd. London. 1920.
Golf Architecture in America. Thomas. Times-Mirror. 1927.
The Links. Hunter. Charles Scribner's Sons. 1926.
The Architectural Side of Golf. Wethered and Simpson. Longmans, Green and Co. 1929.

**Birds**

Bird Houses and How to Build Them. U. S. D. A. Farmers' Bul. 609.
Common Birds of Southeastern United States. U. S. D. A. Farmers' Bul. 755.
Homes for Birds. U. S. D. A. Farmers' Bul. 1456.
How to Attract Birds in Northeastern United States U. S. D. A. Farmers' Bul. 621.
How to Attract Birds in Northwestern United States. U. S. D. A. Farmers' Bul. 760.
How to Attract Birds in Middle Atlantic States. U. S. D. A. Farmers' Bul. 844.
How to Attract Birds in East Central States. U. S. D. A. Farmers' Bul. 912.
Golf Clubs as Bird Sanctuaries. National Association of Audubon Societies, 1974 Broadway, New York, N. Y.
Birds as an Adjunct to the Golf Course. The Bulletin, U. S. G. A. Green Section, Vol. 10, No. 5.

**Botany**

Botany for High Schools. Atkinson. Holt. 1910.
Botany, an Elementary Text-book. Bailey. The Macmillan Co. 1909.
Botany for Secondary Schools. Bailey. The Macmillan Co. 1913.
Fundamentals of Botany. Gager. P. Blackiston's Son and Co. 1916.
General Botany. Gager. P. Blackiston's Son and Co. 1926.

Gray's New Manual of Botany. Edited by Robinson and Fernald. American Book Company. 7th Edition.
Plant World. Gager. University Society. 1931.
Principles of Plant Culture. A Text for Beginners in Agriculture and Horticulture. Goff. The Macmillan Co. 1916.
Principles of Plant Physiology. Raber. The Macmillan Co. 1933.

### Chemistry

An Introduction to Organic Chemistry. Holmyard. E. Arnold and Co. 1930.
Chemistry for Students of Agriculture and Home Economics. Burrell. McGraw-Hill Book Co.
Elements of Chemistry. Foster. D. Van Nostrand Co. 1932.
Introductory General Chemistry. Brinkley. The Macmillan Co. 1932.
Introduction to Chemistry. Timm. McGraw-Hill Book Co. 1932.

### Clearing Land

Boring Taprooted Stumps for Blasting. U. S. D. A. Farmers' Bul. 600.
Clearing Land. U. S. D. A. Farmers' Bul. 974.
Clearing Land of Brush and Stumps. U. S. D. A. Farmers' Bul. 1526.
Use of Explosives in Blasting Stumps. U. S. D. A. Circular 191.
The Bulletin. U. S. G. A. Green Section. Vol. 8, No. 3.

### Diseases

Diseases of Economic Plants. Stevens. The Macmillan Co. 1922.
Manual of Plant Diseases. Heald. McGraw-Hill Book Co. 1933.
Turf Diseases and their Control. The Bulletin. U. S. G. A. Green Section, Vol. 12, No. 4.

### Drainage

Land Drainage and Reclamation. Ayres and Scoates. McGraw-Hill Book Co. 1928.
Land Drainage. Powers and Teeter. John Wiley and Sons. 1932.
Tile Drainage on the Farm. U. S. D. A. Farmers' Bul. 524.
Tile-Trenching Machinery. U. S. D. A. Farmers' Bul. 1131.
Analyses of Drain Tile Testing. Univ. of Minn. Agri. Exp. Sta. Bul. 52. St. Paul.
Drain Wet Fields. Univ. of Wis. Bul. 365. Madison.
Farm Drainage. Univ. of Oreg. Bul. 178. Eugene.
Installing Farm Drainage Systems. Ohio State Univ. Agr. Col. Ext. Service. Vol. 18, No. 10. Wooster.
Pump Drainage on the University of Wisconsin Marsh. Univ. of Wis. Res. Bul. 50. Madison.
Tile Drainage. Mich. Agri. College Special Bul. 56. East Lansing.

### Entomology

Destructive and Useful Insects—Their Habits and Control. Metcalf and Flint. McGraw-Hill Book Co. 1928.
Fundamentals of Insect Life. Metcalf and Flint. McGraw-Hill Book Co. 1932.
Introduction to Entomology. Comstock. Comstock Pub. Co. 1924.
Insects and Diseases of Ornamental Trees and Shrubs. Felt and Rankin. The Macmillan Co. 1932.
Injurious Insects. O'Kane. The Macmillan Co. 1912.
Insect Pests of Farm, Garden and Orchard. Sanderson. John Wiley and Sons. 1931.
Manual of Tree and Shrub Insects. Felt. The Macmillan Co. 1924.
Textbook of Practical Entomology. Balfour-Browne. Longmans, Green and Co. 1932.
Textbook of Agricultural Entomology. Smith. The Macmillan Co. 1931.

### Fertilizers

American Fertilizer Handbook. Ware Bros. Co. Published annually.
Fertilizers and Manures. Hall. Dutton. 1920.
Fertilizers and Crop Production. Van Slyke. Orange, Judd & Co. 1932.
Fertilizers. Voorhees. The Macmillan Co. 1926.
Handbook of Fertilizers. Gustafson. Orange, Judd & Co. 1932.
Manures and Fertilizers. Wheeler. The Macmillan Co. 1913.

Theory and Practice in the Use of Fertilizer. Baer. John Wiley and Sons. 1929.
Cocoa By-Products and their Utilization as Fertilizer Materials. U. S. D. A. Bul. 1413.
Conservation of Fertilizer Materials from Minor Sources. U. S. D. A. Misc. Publication 136.
Cyanamid, Its Uses as a Fertilizer Material. U. S. D. A. Cir. 64.
Field Experiments with Atmospheric-Nitrogen Fertilizer. U. S. D. A. Bul. 1180.
Home Mixing of Fertilizers. U. S. D. A. Leaflet 70.
Analyses of Commercial Fertilizers. Clemson Agr. College. Clemson, S. C.
Analyses of Commercial Fertilizers and Ground Bone; Analyses of Agricultural Lime. N. J. Agr. Exp. Sta. New Brunswick.
Artificial Manure from Straw. N. Y. State Agr. Exp. Sta. Bul. 573. Geneva.
Commercial Fertilizers, Agricultural Minerals. Calif. State Dept. of Agr. Spec. Publication. Sacramento.
Commercial Fertilizers and Soil Acidity. N. J. Agri. Exp. Sta. Cir. 266. New Brunswick.
Fertilizers: What They Are and How To Use Them. Mich. Agr. Exp. Sta. Bul. 133. East Lansing.
Fertilizers: What They Are and How To Use Them. N. J. Agri. Exp. Sta. Extension Bul. 79. New Brunswick.
Fertilizer Materials and Mixed Fertilizers. N. J. Agr. Exp. Sta. Bul. 541. New Brunswick.
Fertilizers and Crops and Marsh Soils. Wis. Agr. Exp. Sta. Bul. 392. Madison.
Inspection of Commercial Fertilizers. Mass. Agr. Exp. Sta. Amherst.
Nitrogenous Fertilizer Materials. Univ. of Tenn. Agr. Exp. Sta. Cir. 9. Knoxville.
Report on Inspection of Commercial Fertilizers. Conn. Agr. Exp. Sta. New Haven.
Soils and Fertilizers. Ontario Agr. Col. Bul. 322. Guelph, Ontario, Canada.
Studies of Various Factors Influencing the Yield and the Duration of Life of Meadow and Pasture Plants. Cornell Univ. Agr. Exp. Sta. Bul. 424. Ithaca.
The Agricultural Value of Specially Prepared Blast Furnace Slag. Penn. State Col. Bul. 220. State College.
The Fertilizer Review. Vols. 1-7, Washington, D. C. Published quarterly.
Thirty Years Experience with Sulphate of Ammonia. Mass. Agr. Exp. Sta. Bul. 204. Amherst.
The Bulletin, U. S. G. A. Green Section. Vol. 11, Nos. 3, 4, and 5.

**General Operation and Construction**

Golf Course Manual. Civic Development Department, United States Chamber of Commerce, Washington, D. C.
Municipal Golf Courses in the United States. United States Golf Association. New York.
Municipal Golf—Construction and Administration. Playground and Recreation Association of America. New York.

**Golf Course Construction**

The Bulletin, U. S. G. A. Green Section. Vol. 8, No. 8.

**Grasses**

A Textbook of Grasses. Hitchcock. The Macmillan Co. 1914.
First Book of Grasses. Chase. The Macmillan Co. 1922.
Forage Plants and Their Culture. Piper. The Macmillan Co. 1924.
Grass. MacSelf. Cecil Palmer, London. 1924.
Turf for Golf Courses. Piper and Oakley. The Macmillan Co.
Bermuda Grass. U. S. D. A. Farmers' Bul. 814.
Carpet Grass. U. S. D. A. Farmers' Bul. 1130.
Cultivated Grasses of Secondary Importance. U. S. D. A. Farmers' Bul. 1433.
Genera of Grasses of the United States. U. S. D. A. Bul. 72.
Identification of Grasses by Their Vegetative Characteristics. U. S. D. A. Bul. 461.
Important Cultivated Grasses. U. S. D. A. Farmers' Bul. 1254.
The Vitality of Buried Seeds. Bur. of Plant Industry, U. S. D. A. Bul. 83.
The Vitality and Germination of Seeds. Bur. of Plant Industry, U. S. D. A. Bul. 58.

Timothy. U. S. D. A. Farmers' Bul. 990.
A Handbook of Nebraska Grasses. Nebr. State Exp. Sta. Bul. 148. Lincoln.
An Analytical Study of the Putting Greens of R. I. Golf Courses. R. I. Exp. Sta. Bul. 212. Kingston.
Commercial Bents of Canada. Annual Report, Nat. Mus. of Canada. Ottawa, Ontario, Canada.
Experiments with Turf Grasses in New Jersey. N. J. Agr. Exp. Sta. Bul. 497. New Brunswick.
Farming with Bluegrass. Ky. Agr. Exp. Sta. Bul. 269. Lexington.
Fodder and Pasture Plants. Ottawa Ministry of Agr. Ottawa, Ontario, Canada.
Grasses of Illinois. Univ. of Ill. Agr. Exp. Sta. Urbana.
Grasses of Indiana. State of Ind. Dept. of Agr. Purdue.
Grasses of Pennsylvania. Penn. Dept. of Agr. General Bul. 384. State College.
Maryland Grasses. Univ. of Maryland Bul. 328. College Park.
Pasture Experiments. W. Va. Univ. Bul. 235. Morgantown.
The Maintenance and Improvement of Permanent Pastures. Conn. Agr. Exp. Sta. Bul. 155. Hartford.
The Persistence of Certain Lawn Grasses as Affected by Fertilization and Competition. R. I. Agr. Exp. Sta. Bul. 217. Kingston.
Classification of Redtop and Common Bent Grasses. The Bulletin, U. S. G. A. Green Section. Vol. 10, No. 3.
Grass Seed Production, Sources and Harvesting. The Bulletin, U. S. G. A. Green Section. Vol. 10, Nos. 11 and 12.

### Landscape

An Introduction to the Study of Landscape Design. Hubbard and Kimball. The Macmillan Co. 1929.
Landscape Gardening. Simonds. The Macmillan Co. 1920.
Book of Landscape Gardening. Waugh. Orange, Judd & Co. 1926.
Practical Landscape Gardening. Gridland. De La Mare. 1927.
The Complete Garden. Taylor and Cooper. Doubleday. 1921.
The Natural Style in Landscape Gardening. Waugh. Badger. 1917.
Planning and Planting the Home Garden. Murray. Judd. 1932.
Growing Annual Flowering Plants. U. S. D. A. Farmers' Bul. 1171.
Herbaceous Perennials. U. S. D. A. Farmers' Bul. 1381.
Planting the Roadside. U. S. D. A. Farmers' Bul. 1481.
Roses for the Home. U. S. D. A. Farmers' Bul. 750.
Transplanting Trees and Shrubs. U. S. D. A. Farmers' Bul. 1591.
Tree Surgery. U. S. D. A. Farmers' Bul. 1178.
Trees for Roadside Planting. U. S. D. A. Farmers' Bul. 1482.
Hardy Woody Plants. Mass. Agri. Exp. Sta. Bul. 267. Amherst.
Landscape Plants for Northern Golf Courses. The Bulletin, U. S. G. A. Green Section. Vol. 12, No. 3.
Landscape Work on Golf Courses. The Bulletin, U. S. G. A. Green Section. Vol. 10, No. 7.

### Lawns

Lawn-Making. Barron. Doubleday, Page and Co. 1923.
Lawns and Sports Greens. MacSelf, W. H., and L. Collingridge. London. 1932.
Lawns. Rockwell. The Macmillan Co. 1929.
The Lawn. Dickinson. Orange-Judd Co. 1930.
Planting and Care of Lawns. U. S. D. A. Farmers' Bul. 1677.
Better Lawns. N. J. Agri. Col. Ext. Bul. 76. New Brunswick.
Better Lawns. Ohio Agri. Exp. Sta. Sp. Cir. 18. Wooster.
Care of Lawns and Pastures. Ohio Agr. Exp. Sta. Cir. 106. Wooster.
Illinois Seed and Weed Control Laws. Ill. Dept. of Agr. Bul. 330. Urbana.
Lawn Management Facts. Mass. Ext. Leaflet 85. Amherst.
Lawns in Florida. Agr. Exp. Sta. Bul. 209. Gainesville.
Lawns. Ohio Agri. Col. Ext. Bul. 129. Wooster.
Lawn Grasses and Lawns. Ohio State Univ. Crop Talk No. 37. Wooster.
Lawns. Penn. State Col. Cir. 143. State College.
Lawns and Lawn Making. Univ. of Minn. Agr. Exp. Sta. Cir. 136. St. Paul.
Persistence of Certain Lawn Grasses. R. I. Agr. Exp. Sta. Bul. 217. Kingston.
Soil Practice for Lawns. Ohio State Univ. Timely Soil Topics No. 46. Wooster.
Spraying Lawns with Iron Sulphate to Eradicate Dandelions. N. Y. Agr. Exp. Sta. Bul. 466. Geneva.

## Miscellaneous

Agricultural Mathematics. Plant. McGraw-Hill Book Co. 1930.
Civil Engineers' Pocket Book. Frye. D. Van Nostrand. 1913.
Elementary Cost Accounting. Schlatter. Wiley. 1927.
Elementary Surveying. Medaugh. Lord Baltimore. 1925.
Elements of Accounting. Taylor and Owens. The Macmillan Co. 1930.
Elements of Plane Surveying. Barton. Heath. 1913.
Farmers' Accounts Simplified. Whitcombe and Tombs. London. 1931.
Fraser's International Golf Yearbook. Fraser Pub. Co. New York.
Golfers' Year Book. Golfers' Year Book Co. New York.
Scotland's Gift Golf. Macdonald. Charles Scribner's Sons. 1928.
Spalding's Golf Guide. A. G. Spalding & Bros.
Year Book. United States Golf Association. New York.
Tractors in Arkansas. Ark. Agr. Exp. Sta. Bul. 186. Fayetteville.

## Pests

American Moles as Agricultural Pests and as Fur Producers. U. S. D. A. Farmers' Bul. 1247.
Common White Grubs. U. S. D. A. Farmers' Bul. 940.
Curculios That Attack the Young Fruits and Shoots of Walnut and Hickory. U. S. D. A. Bul. 1066.
Cutworms and Their Control. U. S. D. A. Farmers' Bul. 739.
Earthworms as Pests and Otherwise. U. S. D. A. Farmers' Bul. 1569.
Flytraps and Their Operation. U. S. D. A. Farmers' Bul. 734.
House Ants: Kinds and Methods of Control. U. S. D. A. Farmers' Bul. 740.
Insects Injurious to Deciduous Shade Trees and Their Control. U. S. D. A. Farmers' Bul. 1169.
Poison Ivy and Poison Sumac and Their Eradication. U. S. D. A. Farmers' Bul. 1166.
Remedies and Preventives Against Mosquitoes. U. S. D. A. Farmers' Bul. 444.
Rodent Pests of the Farm. U. S. D. A. Farmers' Bul. 932.
The Argentine Ant as a Household Pest. U. S. D. A. Farmers' Bul. 1101.
The Bluegrass Webworm. U. S. D. A. Tech. Bul. 173.
The Chinch Bug in Relation to St. Augustine Grass. U. S. D. A. Cir. 51.
The Common Mole of Eastern United States. U. S. D. A. Farmers' Bul. 583.
The House Fly. U. S. D. A. Farmers' Bul. 851.
The Japanese Beetle. U. S. D. A. Cir. 419.
The Stable Fly; How to Prevent Its Annoyance and Its Losses to Livestock. U. S. D. A. Farmers' Bul. 1097.
Trapping Moles and Utilizing Their Skins. U. S. D. A. Farmers' Bul. 832.
Traps for the Japanese Beetle. U. S. D. A. Cir. 130.
Webworms Injurious to Cereal and Forage Crops and Their Control. U. S. D. A. Farmers' Bul. 1258.
Control of Japanese Beetle in Lawns. Penn. Dept. of Agr. Bul. Vol. 8, No. 14. State College.
Cutworms. Mass. Agr. Exp. Sta. Ext. Cir. 31. Amherst.
Cutworms, Poisoned Bait for. Miss. Agr. Exp. Sta. Cir. 62. State College.
Japanese Beetle Control. N. J. Dept. of Agr. Cir. 90. New Brunswick.
June Beetles or White Grubs in Michigan. Mich. State Col. Agr. Exp. Sta. Cir. 132. East Lansing.
Spray to Prevent the Attack of the Japanese Beetle. N. J. Agr. Sta. Cir. 168. New Brunswick.
The Clover-Leaf Weevil. Cornell Sta. Bul. 411. Ithaca.
The Common Garden Mole in Iowa. Iowa Agr. Exp. Sta. Cir. 88. Ames.
The Effectiveness of Calcium Cyanide in Poisoning the Pocket Gopher. Univ. of Minn. Agr. Exp. Sta. Bul. 27. St. Paul.
Control of Porto Rican Mole-Cricket, or Changa, on Golf Courses. The Bulletin, U. S. G. A. Green Section. Vol. 6, No. 9.
Japanese Beetle Control on Turf. The Bulletin, U. S. G. A. Green Section. Vol. 6, No. 2; Vol. 7, No. 2; Vol. 8, Nos. 2 and 11.
Sod Webworms and Their Control. The Bulletin, U. S. G. A. Green Section. Vol. 12, No. 1.

## Physics

Textbook of the Physics of Agriculture. King. Orange, Judd & Co.

**Journals**

Golfdom. (Monthly.) Chicago, Ill.
The National Greenkeeper. (Monthly.) Cleveland, Ohio.
Newsletter. (Monthly.) Fall River, Mass.
The Pacific Greenkeeper. (Monthly.) San Gabriel, Calif.
Parks and Recreation. (Monthly.) Rockford, Ill.

**Southern Golf Course Problems**

The Bulletin of the U. S. G. A. Green Section. Vol. 9, No. 11; Vol. 10, No. 1; Vol. 11, Nos. 9 and 10.

**Soils**

American Peat Deposits, Their Characteristic Profiles and Classification. Dachnowski-Stokes. Gebruder Borntraeger. Berlin.
Introduction to the Scientific Study of the Soil. Comber. Longmans, Green & Co. 1932.
A Student's Book on Soils and Manures. Russell. 2nd Ed. The Macmillan Co.
Nature and Properties of Soils. Lyon and Buckman. The Macmillan Co. 1922.
Productive Soils. Weir. Lippincott. 1923.
Principles of Soil Microbiology. Waksman. 2nd Ed. Williams & Wilkins. 1932.
Soil Management. Bear. John Wiley and Sons, Inc. 1931.
Soil Management for Greenkeepers. Cubbon and Markuson. Published by authors, care of Mass. State College. Amherst. 1933.
Soil Characteristics. Emerson. McGraw-Hill Book Co. 1925.
Soil Management. King. Orange, Judd & Co. 1914.
Soils and Fertilizers. MacSelf. Butterworth. 1932.
Soil Conditions and Plant Growth. Russell. Longmans, Green & Co. 1932.
Soils. G. W. Robinson. D. Van Nostrand Co. 1932.
Soil and Civilization. Whitney. D. Van Nostrand Co. 1925.
The Soil. Hall. 2nd Ed. Dutton.
The Soil and the Microbe. Waksman and Starkey. John Wiley & Sons. 1931.
Aeration and Air Content. The Role of Oxygen in Root Activity. Clements. Pub. No. 315. Carnegie Institute of Washington. 1921.
Grouping Soils on the Basis of Mechanical Analysis. U. S. D. A. Cir. 419.
Factors and Problems in the Selection of Peat Lands for Different Uses. U. S. D. A. Bul. 1419.
Methods of Determining the Hydrogen-ion Concentration of Soils. U. S. D. A. Cir. 56.
Moss Peat, Its Uses and Distribution in the United States. U. S. D. A. Cir. 167.
Principles of Liming Soils. U. S. D. A. Farmers' Bul. 921.
Quality and Value of Important Types of Peat Material. U. S. D. A. Bul. 402.
Some Mutual Relations Between Alkaline Soils and Vegetation. U. S. D. A. Agr. Report 71.
Some Methods for Detecting Differences in Soil Organic Matter. U. S. D. A. Tech. Bul. 211.
Steam Sterilization of Soil for Tobacco and Other Crops. U. S. D. A. Farmers' Bul. 1629.
The Absorption of Phosphates and Potassium by Soils. U. S. D. A. Bur. Soils Bul. 32.
The Physical and Chemical Characteristics of Certain American Peat Profiles. U. S. D. A. Tech. Bul. 214.
A Test for Water-Soluble Phosphorus. Mich. Agr. Col. Tech. Bul. 101. East Lansing.
Soils and Fertilizers and the Maintenance of Soil Fertility by the Use of Manures, Green Manures and Fertilizers in Ontario. Ontario Agr. Col. Bul. 322. Guelph, Ontario.
The Effects of Artificial Farm Manures on Soils and Crops. Iowa Agr. Exp. Sta. Res. Bul. 127. Ames.
The Stimulation of Plant Response on the Raw Peat Soils of the Florida Everglades Through the Use of Copper Sulphate and Other Chemicals. Florida Agr. Exp. Sta. Bul. 190. Gainesville.
The Use of Peat in the Greenhouse. Mich. Agr. Exp. Sta. Spec. Bul. 194. East Lansing.

The Value of Limestone of Different Degrees of Fineness. Penn. Agr. Exp. Sta. Bul. 147. State College.
Soil Acidity and Lime for Bent Turf. The Bulletin, U. S. G. A. Green Section. Vol. 12, No. 5.

### Turf Culture

A, B, C of Turf Culture. Noer. The National Greenkeeper. 1928.
Golf Course Common Sense. Farley. Farley Libraries. Cleveland Heights, Ohio. 1931.
Turf for Golf Courses. Piper and Oakley. The Macmillan Co.
The Journal of the Board of Greenkeeping Research. (British Golf Unions.) St. Ives Research Sta., Bingley, Yorkshire, England.
The Bulletin of the United States Golf Association Green Section, Washington, D. C.

### Water Supply

Farm Plumbing. U. S. D. A. Farmers' Bul. 1426.
Farmstead Water Supply. U. S. D. A. Farmers' Bul. 1448.
Tests of Spray Irrigation Equipment. U. S. D. A. Cir. 195.
The Bulletin of the United States Golf Association Green Section. Vol. 8, No. 7; Vol. 11, No. 8.
Watering Turf, and Soil Requisites of Putting Greens. The Bulletin, U. S. G. A. Green Section. Vol. 12, No. 2.
Effect of Watering Putting Greens on Occurrence of Brownpatch. The Bulletin, U. S. G. A. Green Section. Vol. 13, No. 3.

### Weeds

A Manual of Weeds. Georgia. The Macmillan Co. 1914.
Insecticides, Fungicides, and Weed Killers. Bourcart. D. Van Nostrand Co. 1925.
Weeds of Farm and Garden. Pammel. Orange, Judd & Company. 1911.
Dodder. U. S. D. A. Farmers' Bul. 1161.
Weeds—How to Control Them. U. S. D. A. Farmers' Bul. 660.
Poison Ivy, Poison Sumac and Their Control. U. S. D. A. Farmers' Bul. 1166.
Quack Grass. U. S. D. A. Farmers' Bul. 1307.
The Seeds of Quack Grass and Certain Wheat Grasses Compared. U. S. D. A. Reprint from Jour. of Agr. Res. Vol. 35, No. 6.
Wild Garlic and Its Control. U. S. D. A. Bul. 43.
Buckhorn. Penn. Agr. Exp. Sta. Ext. Leaflet No. 1. State College.
Colorado Weed Seeds. Col. Exp. Sta. Bul. 260. Fort Collins.
Common Weeds of Colorado. Col. Exp. Sta. Bul. 310. Fort Collins.
Farm Weeds of Canada. Ottawa Ministry of Agr. Ottawa.
Fifty Important Weeds of Montana. Mont. Exp. Sta. Bul. 45. Bozeman.
Idaho Weeds. Idaho Agr. Exp. Sta. Ext. Bul. 56. Moscow.
Illinois Seed and Weed Control Laws. Ill. Exp. Sta. Bul. 330. Urbana.
Manual of Ohio Weeds. Ohio Agr. Exp. Sta. Bul. 475. Wooster.
Michigan Weeds. Mich. Agr. Exp. Sta. Bul. 267. East Lansing.
Minnesota Weeds. Univ. of Minn. Agr. Exp. Sta. Buls. 129, 139, 176. St. Paul.
Nebraska Weeds. State Dept. Agr. Bul. Lincoln.
Orange Hawkweed. Penn. Agr. Exp. Sta. Ext. Leaflet No. 7. State College.
Orange Hawkweed. Cornell Cir. No. 9. Ithaca.
Pennsylvania Weeds. Penn. Dept. of Agr. Gen. Bul. Harrisburg.
Spraying to Kill Weeds. Ohio Agr. Exp. Sta. Bul. 102. Wooster.
Some Farm Weeds: How to Know and Control Them. Univ. of Wis. Ext. Service Cir. 171. Madison.
The Control of Weeds. Calif. Agr. Ext. Service Cir. 54. Berkeley.
Weed Flora of Iowa. Iowa State Geol. Survey. Des Moines.
Weeds and Methods of Eradication. N. Dak. Exp. Sta. Bul. 80. Fargo.
Weeds of Manitoba. Man. Dept. of Agr. Winnipeg, Canada.
Weeds of New Jersey. N. J. Agr. Exp. Sta. Cir. 219. New Brunswick.
Weeds; Losses, Agencies in Distribution and Control. Utah Agr. Exp. Sta. Cir. 71. Logan.
Weeds and Their Control. S. Dak. State College Bul. 21. Brookings.
West Virginia Weeds. W. Va. Exp. Sta. Cir. 59. Morgantown.
Controlling Weeds in Putting Greens. The Bulletin, U. S. G. A. Green Section. Vol. 10, Nos. 8 and 9.

# Drift and Speed of Putted Ball on Bents as Determined by Mechanical Putter

By Fred V. Grau

During the many years that have elapsed since bent grasses were first planted on putting greens by the stolon method there has been constant argument as to the merits of the different types of bents for producing good putting surfaces. Many good players have maintained that good putting surfaces can not be obtained from bent planted with stolons. Equally good players, on the other hand, have contended, and have fully demonstrated in play, that bents planted with stolons can provide good putting turf. Those who have judged the grasses in an impartial way have called attention to the fact that neither the critics nor the supporters of stolon-planted greens have been able to observe any noticeable difference in the scoring of a large group of good players in important tournaments when the putting greens had been planted either with seed or with stolons. It is argued that if either the seeded or the stolon-planted greens were as unsatisfactory as their respective enemies claim them to be, it would be only reasonable to expect that scoring would be generally higher in tournaments held on courses with such faulty putting greens.

The arguments concerning the newer type of bent putting greens soon brought forth some interesting theories and many definite claims based wholly on guesswork. As an example, it has been claimed that stolons should not be planted on any slopes with more than a 2-per-cent grade, for the reason that a ball could not be stopped on a stolon-planted turf when the grade exceeded 2 per cent. This claim was rather widely accepted without making a test to determine whether such was the case.

The conflicting claims and evidence as to the relative merits of the different types of grasses for putting greens naturally led to the important question as to how much of the criticism directed toward the various grasses should actually be charged against the grasses and how much against the methods used in their maintenance. If a club makes the mistake of planting an undesirable type of grass on all of its putting greens, it will find that the correction of this mistake is a slow and expensive procedure. On the other hand, mistakes in maintenance can often be completely corrected in a short period of time and at little expense. It is therefore evident that it is of much importance to clubs to determine how much of the members' objections to its putting greens are due to a poor type of grass and how much to the maintenance methods in use.

It is well known that the putting qualities of a green can be decidedly altered by changes in mowing, fertilizing, watering, or other routine maintenance practices. Therefore in determining as a wholly separate question the influence of the type of grass on putting qualities, it is important to make due allowance for differences in maintenance methods. This allowance can not easily be made in comparing putting greens on different golf courses receiving entirely different care.

In order to give a fair test of the influence of the type of grass on the putting qualities of turf, a series of large plots of representative putting green grasses were planted on the Arlington turf garden, at Washington, D. C., and the Mid-West turf garden, at Everett, Ill. In the latter garden there is a uniform slope to all plots. In the Arlington turf garden, however, each of the plots is divided into three equal strips; the lower third of each having a grade of 1 per cent, the middle third a grade of 3 per cent, and the upper third a grade of 6 per cent. In preparing these plots for planting and in topdressing them later they were all checked with a surveyor's transit to assure the correct grades.

**Johnny Farrell, of the Quaker Ridge Golf Club, Mamaroneck, N. Y., National Open Champion in 1928, tests the putting qualities of one of the grasses at the Arlington turf garden, Arlington, Va. The mechanical putter used to eliminate the personal factors in making the tests of drift and speed of the grasses is also shown.**

The grasses in this series of plots are kept in as good condition as modern cultural methods will permit. They are all cut at the same time with the mower set to cut at 3/16 of an inch. A large number of good players have putted on these plots within the past few years and have expressed decided preferences for some grasses. Recently it was decided to ask players to definitely rate the grasses on the plots at the Arlington turf garden, and the first summary of such ratings was published on page 224 of the December, 1932, number of the Bulletin.

In order to determine accurately and impartially the relative putting speed of the different grasses, the plots at Arlington were tested at intervals during the season with the Arnott mechanical putter. This device will be found described in the article on page 3 of the Bulletin for January, 1929. By the use of the mechanical putter in tests such as these there are eliminated the variable factors which necessarily attend the human putter, such as distraction of attention, fatigue, lapse of control, and prejudice.

In the course of the season the plots were tested 13 different times in order to compare the grasses under different seasonal conditions, since the response of the different grasses to different seasonal conditions varies markedly. All readings in each test were made on the same day in order to give comparable figures. The tests were made immediately after mowing, except in the case where the influence of grasses on putting was to be compared before and after mowing. All the tests were made on a 6-per-cent slope. In setting the putter for the tests great care was taken to have it set exactly the same for all plots so that the results would be strictly comparable on the basis of the entire season's results. A description of the method follows.

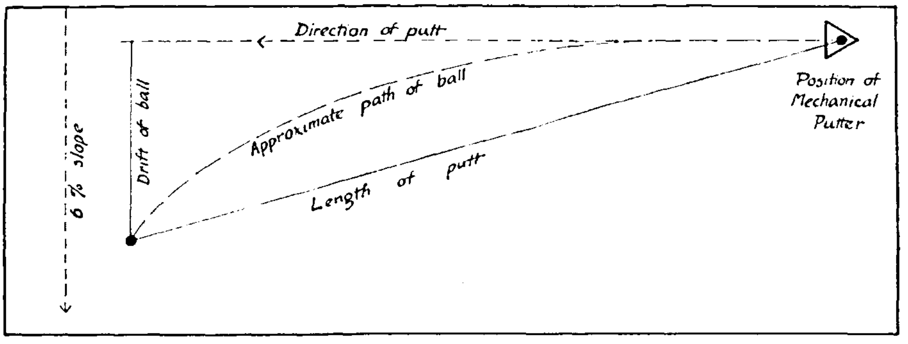


**Diagram 1—Plan adopted for measuring the drift of a putted ball and the length of putt across a known slope.**

A string was stretched across the upper side of the plot at right angles to the direction of the slope (see Diagram 1). The putter was set securely in position and so placed that a putted ball began its course along the stretched string on a dead level. Since the putt was across a 6-per-cent slope, however, the ball began to drift away from the direction of the putt and came to rest at a point below the stretched string and at a distance from the point where it was struck. Five balls were putted from the same point and an average reading taken of the five.

The location of the point where a ball came to rest was determined by two measurements—(1) in a direct line from the point of impact (giving the length of putt), and (2) in a direct line from and at right angles to the stretched string (giving the drift of the ball). In this way it was possible to evaluate the relative "speed" of the putting surface and the resistance of the grass to the roll of the ball. Inasmuch as the slope on each grass was determined at intervals by a surveyor's transit to be true to grade within 1/100 of a foot, the data obtained have been treated as strictly comparable. Each grass was treated throughout the season according to its requirements in order to maintain it in the best possible putting condition.

TABLE 1.—AVERAGE DRIFT OF BALL AND LENGTH OF PUTT ACROSS A 6-PER-CENT SLOPE FOR EIGHT BENT GRASSES DURING THE SEASON OF 1932 AT THE ARLINGTON TURF GARDEN

| | Average drift from line of putt | Average length of putt |
|---|---|---|
| | *Feet* | *Feet* |
| Seaside creeping (seeded) | 3.9 | 13.8 |
| Velvet (stolons) | 4.0 | 13.6 |
| Colonial (seeded) | 4.2 | 13.9 |
| German mixed (seeded) | 4.4 | 14.6 |
| Washington creeping (stolons) | 4.7 | 14.8 |
| Metropolitan creeping (stolons) | 5.0 | 15.2 |
| Virginia creeping (stolons) | 5.7 | 15.6 |
| Columbia creeping (stolons) | 6.0 | 16.5 |
| Average | 4.73 | 14.75 |

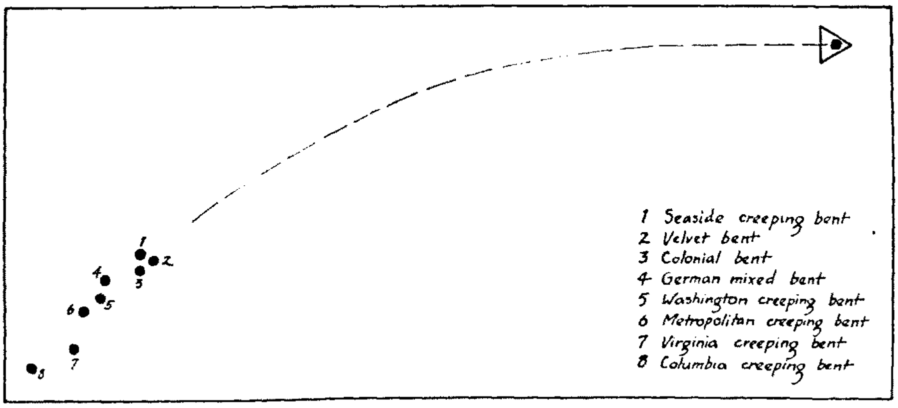


**Diagram 2—Pictorial representation, drawn to scale, of comparative drift of ball and length of putt for eight different bent grasses, putted over a 6-per-cent slope with a mechanical putter. The drawing is prepared from the data in Table 1.**

An additional precaution in placing the putter so that comparable data would be obtained was to establish a uniform distance, by measurement, from the point where the putter arm was held by the hook preparatory to being released, to the point where the ball rested on the turf before being struck. This distance was held constant throughout the tests, with the result that a uniform impulse was imparted to each ball upon the release of the putting arm. Furthermore, several tests were made upon turf which presented no slope, to check upon the accuracy of the method of setting the putter so that a uniform direction might be given to each ball. The results of all these precautions showed that the method was reasonably accurate and justified a comparison of the data upon the proposed basis.

Plots were prepared for testing eight bent grasses as well as fescue and annual bluegrass. Due to summer injuries to the fescue and annual bluegrass plots, however, it was found that their condition would not justify their inclusion in tests on a comparable basis with the bent grasses. The data here presented, therefore, include only figures pertaining to the eight bent grasses, five planted with stolons (velvet, Washington creeping, Metropolitan creeping, Columbia creeping, and Virginia creeping), and three planted with seed (seaside creeping, German mixed, and colonial).

Averaged figures on the extent of drift and length of putt obtained with the mechanical putter on the eight bent grasses at the Arlington turf garden in 1932 across a 6-per-cent slope are presented in the accompanying tables. The length of the putts were longer or shorter than 15 feet, as seen from the actual readings averaged in Table 1, but by calculation the amount of drift was made to correspond to a 15-foot putt. This was found to be permissible since by so doing the relative ratings of the grasses remained unchanged and it has been possible to make a more direct comparison among the grasses on this basis. A pictorial representation of the comparative drift and length of putt given in Table 1 is presented in Diagram 2. While the largest extent of drift in a 15-foot putt, as occurred on stolon-planted Columbia creeping bent, was 5.48 feet, as will be seen from Table 2, due recognition must be given to the fact that a putted ball will, in fact, come to a stop on stolon-planted turf across a 6-per-cent slope, despite the claim that has been made that stolons should not be used on any slope exceeding 2 per cent. The figures in this table show that this extreme drift for Columbia creeping bent in a 15-foot putt on a 6-per-cent slope is 15.0 inches in excess of the minimum drift obtained—namely, that for seaside creeping bent.

TABLE 2.—DRIFT OF BALL IN A 15-FOOT PUTT ACROSS A 6-PER-CENT SLOPE FOR EIGHT BENT GRASSES (AVERAGE OF ALL PUTTS DURING THE SEASON OF 1932 AT THE ARLINGTON TURF GARDEN)

| | Average drift from line of putt | Excess of drift over that of seaside creeping as zero |
|---|---|---|
| | *Feet* | *Inches* |
| Seaside creeping (seeded) | 4.23 | 0 |
| Velvet (stolons) | 4.41 | 2.16 |
| Colonial (seeded) | 4.52 | 3.48 |
| German mixed (seeded) | 4.53 | 3.60 |
| Washington creeping (stolons) | 4.76 | 6.36 |
| Metropolitan creeping (stolons) | 5.00 | 9.24 |
| Virginia creeping (stolons) | 5.45 | 14.64 |
| Columbia creeping (stolons) | 5.48 | 15.0 |

As regards ratings of the speed of the various bents, as presented in Table 2, these ratings have been compared in several different ways, and have been found in each case to be practically identical. The close agreement of the speed ratings, within the limits of experimental error, indicates that the specific nature of the turf itself has caused the differences. This can be stated with certainty, since every reasonable precaution had been taken to permit no variations in the method of experimental procedure.

The results of these tests clearly indicate that the variety and type of grass exert no such influence on the speed of turf as they are popularly supposed to have. In these tests were included all the popular types of bent grass that are used on American golf courses. It is not uncommon to hear a golfer remark that a certain grass is twice as fast as another. The putting tests reported in Table 1 show a difference of only 2.9 feet between the shortest and the longest putt. This distance represents only 20 per cent of the average length of the putts. Therefore it is apparent that the extreme differences reported by golfers are due either to overestimation or to variation in cultural practices more than to the inherent nature of the grass.

Since Virginia creeping bent and Columbia creeping bent are not recommended by the Green Section as putting green grasses, a comparison of the six remaining grasses should be made on the same basis as reported in Table 1. On the basis of the eight grasses the average falls near the position held by Washington creeping bent; on the basis of the six grasses the average for both drift and speed falls midway between the positions held by colonial bent and German mixed bent, thus presenting an entirely different conception of the average grass as regards drift and speed. Likewise, when the two grasses which are not recommended are disregarded, Metropolitan creeping bent is found to be the fastest grass of the remaining group of six.

TABLE 3.—DRIFT OF BALL AND LENGTH OF PUTT (AVERAGE OF TWO READINGS) ACROSS A 6-PER-CENT SLOPE FOR EIGHT BENT GRASSES AT THE ARLINGTON TURF GARDEN ON OCTOBER 31, 1932, AS AFFECTED BY MOWING. TESTS WERE MADE THE SAME DAY FOR EACH GRASS UNDER TWO DIFFERENT CONDITIONS—(1) NOT MOWED FOR TWO DAYS, AND (2) IMMEDIATELY AFTER MOWING

| | Average drift from line of putt | | Average length of putt | |
|---|---|---|---|---|
| | Before mowing | After mowing | Before mowing | After mowing |
| | *Feet* | *Feet* | *Feet* | *Feet* |
| Seaside creeping (seeded) | 3.83 | 5.0 | 13.75 | 15.0 |
| Velvet (stolons) | 3.38 | 4.75 | 11.91 | 13.95 |
| Colonial (seeded) | 3.75 | 5.0 | 13.04 | 14.75 |
| German mixed (seeded) | 3.46 | 5.21 | 12.12 | 14.37 |
| Washington creeping (stolons) | 4.25 | 5.21 | 13.04 | 14.41 |
| Metropolitan creeping (stolons) | 4.25 | 5.42 | 13.75 | 15.59 |
| Virginia creeping (stolons) | 5.0 | 6.42 | 13.84 | 16.2 |
| Columbia creeping (stolons) | 5.5 | 6.25 | 16.0 | 17.0 |
| Average | 4.17 | 5.41 | 13.43 | 15.16 |

It is well known that cultural practices decidedly modify the putting speed of any grass. Table 3 shows the effect of mowing on the drift of the ball and the length of putts with the same stroke. A pictorial representation of the comparative drift and length of putt for the various bents, before and after mowing, based on the figures in Table 3, is presented in Diagram 3. In this case the grass had not been cut for two days; but since the season of year involved was the end of October, there was much less growth of grass within the interval following the mowing than is usual at other seasons between daily mowings. Neglect of mowing for a longer period would have yielded greater differences in the relative speed of the grasses before and after mowing than are shown in this table. Changes in the height at which the mower is set, and changes in topdressing, watering, raking or brushing, and fertilizing, and changes in other maintenance practices largely determine the speed of the putting surface. It is clearly recognized that some grasses, particularly some of the creeping bents planted with stolons, are much more likely to become troublesome if neglected than are some of the other grasses, such as colonial bent. Likewise colonial bent itself is more likely to be injured by brownpatch, resulting in thinner and faster turf, than are such creeping bents as the Washington strain. The ease or difficulty of maintaining different grasses is often the determining factor in deciding which are the most suitable for putting greens regardless of the speed indicated in these tests. The tests clearly show, however, that if grasses are properly cared for they do not present as much variation in speed of putting as is so commonly attributed to them.

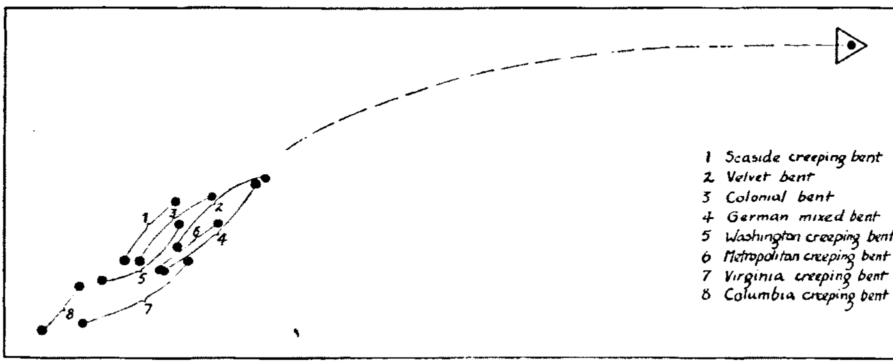


**Diagram 3—Pictorial representation, drawn to scale, of comparative drift of ball and length of putt for eight different bent grasses, putted over a 6-per-cent slope with a mechanical putter, both before and after mowing of the turf. The positions for each grass before and after mowing are connected by lines. The greatest drift and length of putt in each case is after the turf is mowed. The drawing is prepared from the data in Table 3.**

It would appear from the tests also that velvet bent planted with stolons possesses much the same putting qualities as a seeded bent, a fact which doubtless explains many of the erroneous conceptions regarding velvet bent and also its selection as first choice as regards putting qualities in the test by professionals described in the article on page 224 of the Bulletin for December, 1932. In our tests with the mechanical putter, however, while the differences are but slight, velvet bent has not been shown to have less drift than seaside creeping bent. What apparently won it first place in the estimation of the professionals was its general condition and appearance. Seaside creeping bent offered more resistance to the ball, and the two other seeded bents almost as much, yet they were rated far lower by the professionals because they did not have the perfect, velvety, smooth appearance of the velvet bent. The mechanical putter did not "see" the qualities of the velvet bent which have so captivated the imagination of so many who follow the game. As an inanimate machine it faithfully performed what was required of it and no more. The putter arm was propelled by a definite force, which was held constant. The direction of the putt was held constant on a definite slope. The point at which the putted balls came to rest was dependent upon all these factors. But, since these forces or factors were held constant for each plot, it is plain that the differences in the putting qualities of the grasses, on a comparative basis, are contributed by forces or factors outside the mechanical ones contained in the putter. The element of error arising from the human factor, since some one was essential to operate it, may be disregarded, since that error may, for all practical purposes, be considered to be compensating among the different grasses. Since the operator had no preference among the grasses, and since the same operator conducted each and every test, we are further justified in ignoring the personal error.

That differences in the drift of a putted ball on bent grasses are due in larger measure to differences in cultural practices than to whether the turf is stolon-planted or seeded is apparent from a comparative study of figures presented in Tables 2 and 3. The average drift for the five stolon-planted bents in Table 2 is 5.02 feet and for the three seeded bents 4.42 feet, which gives an excess of average drift for the stolon-planted over the seeded amounting to .6 foot. The average drift for the eight bents in Table 3 is 4.17 feet before mowing and 5.41 feet after mowing, which gives an excess of average drift for the bents after mowing over the bents before mowing amounting to 1.24 feet. There is found therefore practically twice as much variation in drift occasioned by variation in height of cut as by difference in method of producing the turf.

The results of the tests made by the professionals, reported in the December, 1932, number of the Bulletin, were obtained ten days after the tests reported in Table 3. The grasses on these two dates were comparable in every respect, yet there was little if any correlation between the choice of the professionals and the speed of the grasses. The second slowest of eight grasses received first place, while the next two places were given to grasses which rated among the four fastest, indicating that the putting qualities alone were not the deciding factors in the choice of the professionals.

In presenting these comparisons it has not been the purpose of the Green Section to attempt to influence the preferences of any set of golfers or of any club for any kind of grass for use for putting purposes. The purpose has been merely to assist golf clubs, confronted with a difference of opinion as to the putting qualities of various kinds of bent turf, in reaching a conclusion based on tests in which personal opinion or prejudice may be considered to have been eliminated by the use of a mechanical putter.

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Strange is the manner in which insects are sometimes killed by poison. The striped blister beetle, which destroys soy-bean fields, particularly in Louisiana, will not eat foliage treated with insecticidal dusts. However, when the beetles crawl over foliage on which fluosilicate of soda has been dusted, this chemical seems to irritate their feet, with the result that they draw their feet through the mouth evidently to allay the irritation. In this way they get the poison, and are thus effectively controlled when that particular chemical is used. They also have the habit of swarming on only a small area of a field at a time, which peculiarity also aids greatly in their control.

## QUESTIONS AND ANSWERS

**All questions sent to the Green Section will be answered in a letter to the writer as promptly as possible. The more interesting of these questions, with concise answers, will appear in this column. If your experience leads you to disagree with any answer here given it is your privilege and duty to write to the Green Section. While most of the answers are of general application, it must be borne in mind that each recommendation is intended specifically for the locality designated at the end of the question.**

**Establishing Bermuda turf of fine texture.**—Where can we obtain seed of the best kind of Bermuda grass for our putting greens? When we built our course we turfed the greens with Bermuda grass found growing wild on a river bank. Although this has served its purpose very well we feel that a much finer kind of Bermuda grass is available. The general opinion among golfers in Mexico seems to be that Bermuda grass is the only grass that is satisfactory for putting greens under subtropical conditions. As we are about to start a nursery we should like to obtain the most suitable seed. (Mexico)

ANSWER.—Most of the Bermuda grass seed on the market is grown in Arizona. This seed contains fine strains as well as coarse strains. We know of no one who has made selections of the finer strains and propagated them commercially. Such selections as we have made have not proven altogether successful for putting green purposes. We would recommend that you use Arizona seed in reseeding the putting greens, in order to select the finer strains of Bermuda grass which will no doubt appear following the use of this seed. Probably each patch of fine Bermuda which appears will be a distinct strain and will remain true as long as the reproduction is by runners or stolons, and not seed. After these patches have been watched for one or two seasons and are found to come close to the type of grass you desire, sod from one or more of them could be cut out and planted in nursery rows. The growth from this sod will all be of the same type, and you can continue growing this type as long as you wish by planting new nurseries. All further planting on the greens should be done with the strains you select and propagate.

**Improving weedy fairways.**—Our fairways, which are composed of Acapulco grass, carpet grass, Angleton grass, and Bermuda grass are in poor condition, being invaded by weeds of various kinds. We are sending you samples of what we consider our worst weeds. We wish to eradicate these weeds and to improve the turf. The samples of soil which we are forwarding are from the highland, where the soil is red and poor, and from the lowland, where the soil is rich and dark. (Cuba)

ANSWER.—In order to improve your fairways your program would seem to consist of heavy fertilizing and burning the weeds with sulphate of ammonia. The samples of weeds you forward are mostly leguminous plants and hence their control will depend somewhat on the maintenance of an adequate supply of nitrogen in the soil, since leguminous plants generally are subject to control by this method. The sulphate of ammonia can be used as a medium for burning the weeds and hence checking their growth, while the nitrogen from the sulphate of ammonia will remain in the soil for some time and thus increase the growth of the grass. Grasses such as Bermuda, Acapulco, and carpet, which have heavy rootstock growth, will not be badly injured by the burning resulting from the use of the sulphate of ammonia.

The examination of the sample of your black soil from the lower areas indicates that it contains about 75 pounds of phosphoric acid to the acre, and the red soil from the higher areas about 25 pounds to the acre. The black soil has a pH value of 7.5, indicating that it is on the alkaline side, while the red soil runs from 6 to 6.2 in pH value, indicating that it is slightly acid. It appears that there is sufficient potash in both samples, but the black soil contains about twice as much potash as the red soil.

We would recommend, therefore, that your program open each year with the burning of the weeds with sulphate of ammonia. This should be done in April. Powdered sulphate of ammonia should be sprinkled by hand over the solid patches of weeds at the rate of from 10 to 15 pounds to 1,000 square feet. This should be done early in the morning when the dew is on the grass or when the grass is wet so that the chemical will stick to the weeds until its effect is produced. Some dealers sell fine forms of sulphate of ammonia free from lumps. A lumpy form could be used, however, if first powdered by rolling.

Following the burning of the weeds, heavy applications of some complete mixed fertilizer containing about equal amounts of nitrogen, phosphorus, and potash should be made. The turf should be disked at the time of fertilizing with a straight disk to facilitate the entrance of the mineral elements into the soil. The straight disk would not turn over or injure the existing turf. It would be best to apply the fertilizer in two applications, one application immediately after burning the weeds, and followed with another two or three weeks later, or after a rain coming shortly after the first application. This fertilization should induce a heavy growth of grass during the spring and summer months, and if the fairways could be fertilized again in September or October you should have a continued heavy growth of grass well into the winter. The fall application also should be split in half and made in two applications several weeks apart. By splitting the applications there is less likelihood of loss from heavy rains which you sometimes have in Cuba.

After the weedy patches have been burned with sulphate of ammonia, the fairways have been fertilized, and the new growth has begun, if the burned areas are not filling in fast enough, stolons of Acapulco grass or of Bermuda grass should be chopped or disked into these areas in order that they may fill in with grass before the weeds get a chance to become reestablished. In some cases it will be necessary to burn the same patches of weeds several times before the weed is killed out. Burning weedy patches with sulphate of ammonia is an effective treatment and one from which little damage can result to the turf.

**Yellowing of turf in winter.**—Our turf in winter is affected in a manner not specifically mentioned in your article Turf Diseases and Their Control in the Bulletin for August, 1932. The winter in Japan is not very severe, and it seldom snows, but toward February, the coldest month of the year, the grass becomes frost-bitten and some parts of the green discolored, having a tinge of blackish brown, although as the weather becomes warmer the grass resumes its usual greenish color. The trouble is that there are a lot of "yellow blights" in winter in place of brownpatch in summer. The blade of the grass becomes yellowish in some sections, probably due to overfertilization or underfertilization. Your suggestions will be appreciated. (Japan)

ANSWER.—The general discoloration of grass in the winter months to which you refer and which is common throughout the United States is a natural response of the grass to cold. When warm weather returns the discoloration soon disappears. The yellowing which you mention is however probably something else. If it occurs in definite patches somewhat like the snowmold or brownpatch diseases, it may be caused by the snowmold fungus or a similar fungus active at low temperatures. If it is in more or less indefinite areas it might be caused by poor drainage. In some cases it is found that where there are little depressions in the surface, water may collect, and even though there may be no water covering the grass in these areas the soil may be entirely too wet, resulting in a poor root system, which often leads to the yellowing of grass blades over a large area. In such cases the injury is more or less confined to areas which are lower than others. If the yellowing occurs rather well scattered over the putting green it may be due to a deficiency of iron or some other fertilizing element in the soil. Sometimes a yellowing of grass is found, particularly in the fall, winter, and early spring, where a fertilizer too high in phosphoric acid, as for example bone meal, has been used. This has been explained as due in part at least to a chemical reaction in the soil whereby the phosphoric acid combines with the iron and makes it unavailable to the plant. If this is your difficulty you will find that the grass will quickly regain its color if you apply a little sulphate of iron in solution. It is suggested that you try the iron on a small area of one of your greens badly affected, and if improvement results as evidenced by a marked difference between the treated and untreated areas, the same treatment may well be given to the entire putting green. It is suggested also that you have the affected grass examined by a plant pathologist located at one of your universities with a view to identifying the cause of the yellowing.

**Seeding rate for putting green mixtures.**—We are advised to seed our putting greens with a mixture of colonial bent, velvet bent, and some red fescue. It is suggested that in order to get a quick growth of turf in a year we should sow this mixture at the rate of 3 ounces to a square yard. Is this rate of seeding in accordance with your recommendations? (New Zealand)

ANSWER.—Our experiments as well as results obtained in general practice in the United States and Canada give us data upon which we base our recommendations on rates of seeding. We recommend seeding bent on putting greens at the rate of from 3 to 5 pounds to 1,000 square feet, and fescue at the rate of from 10 to 15 pounds, provided the seed test shows a high percentage of germination. Therefore rates of seeding for mixtures of the two would come between the extremes, depending on the percentage of each kind of seed in the mixture. It would seem that the rate you mention, which is equivalent to over 20 pounds to 1,000 square feet, is considerably more than necessary. In the United States we consider that the addition of fescue to bent for putting greens is wasteful, since bent soon crowds out the fescue under the close cutting demanded for putting greens.

**Sugar-mill filter-press cake as a fertilizer.**—We are sending you a sample of cachaza, which is the filter-press cake we can get from the sugar mills here at no cost other than that of hauling. It is almost pure organic matter and we believe it would be of some value as a base for mixed fertilizer. How could we use it to best advantage? (Cuba)

ANSWER.—Your sample of filter-press cake from the sugar mill contains about 2 per cent of nitrogen, 2.5 per cent of phosphoric acid, 1.13 per cent of potash, and 4 per cent of lime. It could be used to best advantage in combination with inorganic fertilizers. To make 100 pounds of such a combination containing about equal percentages of nitrogen, phosphorus, and potash we would suggest the following mixture: 40 pounds of cachaza, 10 pounds of muriate of potash, 28 pounds of 16-per-cent superphosphate, and 22 pounds of sulphate of ammonia. This will make a fertilizer with a formula of 5-5-5, meaning that it contains 5 per cent each of nitrogen, phosphorus, and potash. By varying the relative proportions, a fertilizer of different formula can be obtained if it seems desirable. You could purchase the muriate of potash, sulphate of ammonia, and superphosphate and have them mixed with the dry cachaza either on your own property or by some fertilizer dealer.

**Benefit of lime to bent greens containing some clover.**—We have some woods loam which we desire to apply to our bent greens, but as it is deficient in calcium we should not care to apply it unmixed with lime. Would the application of lime to our greens in this manner stimulate the growth of clover to a dangerous degree? (Virginia)

ANSWER.—Calcium and magnesium, which are contained in lime, are certain elements which soils require. Some grasses and weeds do decidedly better when ample lime is available in the soil. Usually lime increases the growth of clover. However, we have observed that, under close clipping, certain bent grasses, including Metropolitan bent, do not thrive so well when there is a deficiency of lime in the soil. The mere application of lime in order to give the bent what it requires will not of itself bring in clover. If however lime alone is applied the soil will soon become deficient in other elements, such as nitrogen, required by grass, and the grass will accordingly suffer. Clover, on the other hand, is able to draw upon the nitrogen in the air, a faculty not possessed by grasses; hence when nitrogen becomes deficient in the soil it does not affect the clover materially, and the clover commences to crowd out the grass. Our work has shown that where conditions are made favorable for the growth of grass, the grass will compete favorably with the clover regardless of whether lime is supplied or not; consequently as long as adequate nitrogenous fertilizing is maintained on putting greens there need be no undue worry regarding the use of lime. Since your woods earth is deficient in lime you should by all means mix some with the earth at some time previous to its use.

**Proprietary remedies for brownpatch.**—The only remedy we have used so far for brownpatch is. . . . We have used it almost exclusively as a curative measure. Hot, still nights constantly bring the threat of a new attack, and while we are now putting extra concentration on the idea of prevention we still had numerous attacks last summer. This year we are giving our bent greens a light spraying every two weeks in the hope that it may ward off the trouble. In the meantime we have noticed extensive advertisements of another remedy, called . . . The dealers make rather extensive claims both as to its curative and preventive properties. Have you tried out this new preparation? (Tennessee)

ANSWER.—We have not tested the preparation which you mention due to the fact that the manufacturers have not furnished us any for the purpose. Our experience has been that companies which have something of merit are anxious to have us make a trial of their product whereas those who have doubts as to its value are hesitant to let us have any for our trials. We have recently obtained a sample for analysis, however, and have been informed by the analyst that the fungicidal ingredient of the preparation is corrosive sublimate. It also has some nitrogen to act as a fertilizer. This of course makes an expensive way to purchase fertilizer and corrosive sublimate.

**Cost of seeded and stolon greens.**—Is there any difference in original cost and maintenance costs between a bent green planted with stolons and one planted with seed? (New York)

ANSWER.—It costs less to plant a bent green with seed than with stolons provided the cost of the seed or the stolons is no greater than the present prevailing market price. Even when the stolons are secured from a nursery on the golf course, their production entails some cost in the preparation and care of the nursery, to which must be added the cost of cutting the stolons, distributing them, and topdressing them when planted. As regards maintenance costs, our observations indicate that turf produced from certain kinds of bent seed, including seaside bent, does not become as thickly matted, even after several years, as the popular strains of creeping bent generally planted from stolons. The reason for this is not altogether clear. For the above reason less topdressing is required as a rule on seaside bent greens planted with seed than, for example, on greens planted with stolons of the Washington or Metropolitan strains of creeping bent.

**Cutting height for fairway turf.**—What is the proper height for cutting fairways in midsummer? At that time of the year our fairways are often badly burned from drought, and the clay loam on which they are built becomes hard and baked. Our practice has been to cut the fairways at ¾ inch in spring and 1 inch in summer. (New York)

ANSWER.—Recent work which we have conducted concerning the best height of cut for fairways, Kentucky bluegrass fairways in particular, has indicated that for the best growth of grass the Kentucky bluegrass should be cut not closer than 1½ inches. This is a little high, no doubt, for fairway purposes unless the fairways can be cut frequently enough to prevent the grass from growing much taller. It would be found that if the grass could be left that long it would be conducive to a much thicker turf, and hence the ball might easily present a better lie than it would on turf cut at 3/4 inch but much thinner. We would suggest that you commence to cut the turf in the early spring at 1½ inches and continue through the summer with the 1-inch cut, and if necessary during the early fall, when bluegrass is growing vigorously. However we would allow the grass to go into the winter on a long cut; in other words, as the end of the fall growing season approaches we would allow the grass to grow to 1½ inches. This gives the grass more of an opportunity to store up plant food to be carried through the winter and to obtain a good start in the early spring.

**How can we control Bermuda grass in putting greens of bent grass?** (Tennessee)

ANSWER.—It is probable that if the Bermuda grass is weeded out of the putting greens by hand as soon as it begins to appear in the spring, and a careful watch is maintained through the spring and summer to keep the greens clean, they may be effectively rid of the Bermuda grass. You will probably find that much of the Bermuda grass has winterkilled and that comparatively little will be left in the putting greens to weed out in the spring. Your conditions in Tennessee are doubtless similar to those in Oklahoma, where there are many beautiful putting greens of seaside creeping bent grass. In those putting greens the Bermuda grass starts out with only a few scattered patches in the spring, but by fall it has sometimes taken over large areas on the putting greens. The putting greens, however, are played on over winter and a great deal of the Bermuda grass winterkills so that by the following spring there are only a few scattered patches left. These patches again increase in the summer until gradually the Bermuda grass takes over more and more of the bent putting greens. The plants should therefore be removed before they have a chance to spread.

**Unnecessary reseeding.**—Our Washington creeping bent greens are in fine condition in spite of the summer drought we have experienced. Would you recommend reseeding these greens in the fall? If so, where can we obtain Washington creeping bent seed? (Ohio)

ANSWER.—Since your greens are in good condition it would be a waste of money to attempt to reseed them in the fall. Moreover, no seed of the Washington strain of creeping bent is available, as this strain must be planted by the stolon method; nor would other bent grasses, if seeded, match your turf of the Washington strain of creeping bent. With putting greens planted some years ago with fescue, redtop, or certain other grasses that are not permanent, it was necessary to reseed many greens in the fall; also the ravages of brownpatch and other diseases often made it necessary to reseed. Clubs now find that it is seldom necessary to reseed putting greens in the fall except when there has been some unusual damage. In spite of these changed conditions a great many individuals still have the reseeding habit and waste a great deal of money as a result. Where greens are planted by the stolon method any scars can be mended by planting stolons or by plugging in pieces of sod from a turf nursery. In your case there would seem to be no need for planting of any kind.

Trouble is an ounce or a ton, depending on how we take it.

Francis Roy Cooper