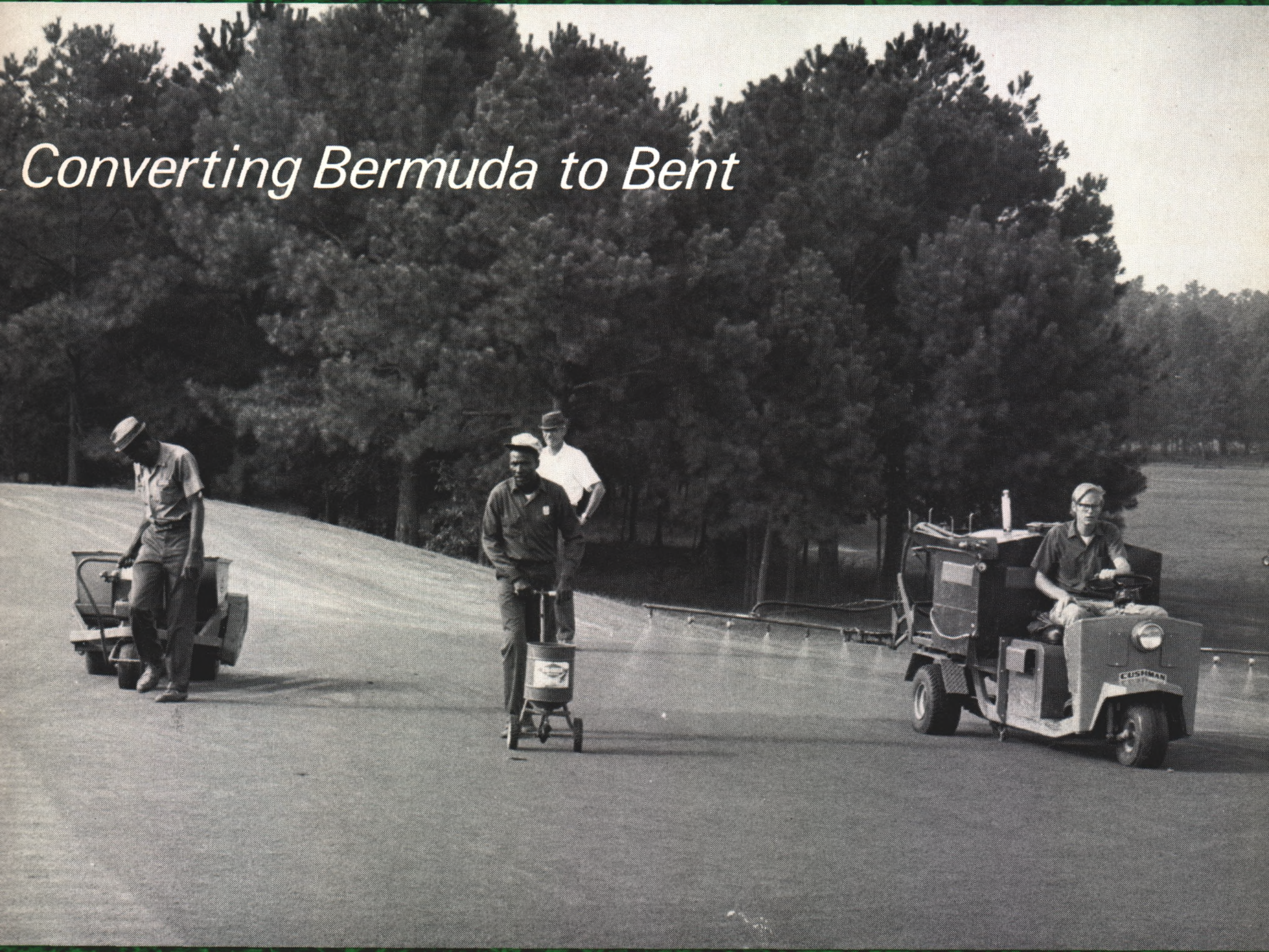
NOVEMBER 1971

USGA GREEN SECTION RECORD

A Publication on Turf Management
by the United States Golf Association



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Calloway Gardens Golf Club, Pine Mountain, Ga., converting 18 bermuda greens to bentgrass. Applying Siduron, bentgrass seed and topdressing.

Instant Bentgrass Greens

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

In this age of instant foods, instant hotel and airline reservations and — for some — instant credit, isn't it time for "instant bentgrass greens?" That day may not be as far off as some think, thanks to the efforts of Charlie Danner, superintendent of Capital City Club, Atlanta, Ga. His members may believe such a day is already here.

In 1969, Danner was first to try an innovative technique in converting bermudagrass greens to bentgrass. There was a short period of inconvenience at seeding time, but this was minimized with proper handling during conversion. The method has since been successful at Charlotte Country Club and Quail Hollow Country Club in Charlotte, N.C., where each club converted 18 greens to bentgrass.

Other clubs started similar conversion programs in September, 1971. These include 18 holes at Calloway Gardens, Pine Mountain, Ga., and Chattahoochee Country Club, Gainesville, Ga. Changing from bermudagrass to bentgrass greens at these clubs was suggested only because greens were originally built with good surface, internal, and sub-drainage.

Many pre-emergent chemicals today seem to affect some grasses more than others. One such chemical is called Siduron, and it has been found quite effective on bermudagrasses. Bermudas vary in tolerance to Siduron, but, due to its general toxicity, it is not suggested for use in the South. It has had limited sale value there.

During the mid and late '60s, much interest

A test plot area showing control of bermudagrass in bent.

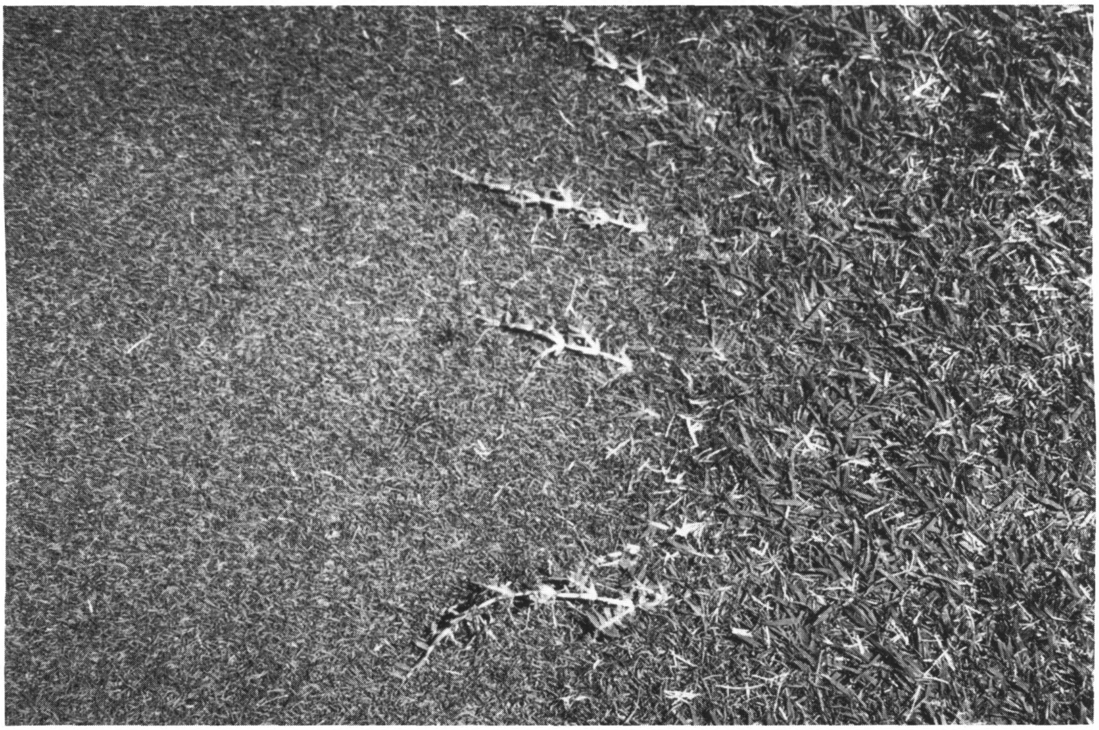
was shown in Siduron as a chemical means of keeping bermudagrass out of bentgrass greens. At this time, several clubs in the South, where Seaside and Penncross bent is used, began to retard encroachment of bermudagrass into bent greens with Siduron. Since some bents are susceptible to this chemical, tests should be made before applying it to greens if you are trying to eliminate bermudagrass.

THE CAPITAL CITY STORY

Danner is believed to be the first superintendent to convert bermuda greens to bentgrass with Siduron. Danner presented the following report at the Georgia Superintendent meeting in January, 1971, and was printed in the *Georgia Turfgrass News.*[1]

> In 1968 my club made the decision to convert from bermudagrass to bentgrass greens, and to convert six of them in the fall of 1968. We installed six temporary greens and these were ready for play when we started the conversion work on September 10, 1968.
>
> We approached this job in what we thought was the best and most foolproof way. First, we mixed soil, sand, and peat at a central mixing site. Second, we removed one inch of sod from the greens. Third, we hauled in soil from the mixing site to compensate for the sod removed. Fourth, we rototilled and then rough-smoothed the greens. Fifth, we sterilized the soil using methyl bromide and the greens were smoothed and made ready for seeding. Finally, the six greens were seeded to two pounds of Penncross bentgrass seed to each 1,000 square feet.
>
> We were washed out twice and had to reseed. The third seeding was made by mixing the seed with Hydro-mulch, which finally held.
>
> The six greens were out of play from September 10, 1968, to April 29, 1969. All this time we were using temporary greens, much to the distress of our golfing members, and the cost ran up to $7,792.40.
>
> Back in the winter, I wondered if there was some easier and better way to convert the greens from bermuda to bent, and then I remembered Tupersan (the

[1] *The Georgia Turfgrass News*, 1971, Vol. 1, p.3.



Bermudagrass encroachment into a bentgrass green.

trade name for Siduron)! Some years ago the DuPont Company sent one of their field men to Capital City to put in some experimental plots of pre-emergence weed control materials. We gave him three tees and he put in a number of 5 x 10-foot plots. In one of the plots the bermudagrass was killed! When the man returned to evaluate his plots, I asked him what he used on the plot that killed the bermudagrass. He answered that it was an experimental chemical to be named Tupersan. I gave this no more thought until I began to read the magazine ads which said that Tupersan could be used on areas to be seeded to bluegrass or bentgrass. They said the chemical could be applied one day and seeding could be done the next. "I talked to Bob Miller, from DuPont, during the winter. He encouraged me to try Tupersan, but he could not advise me of the rate to use. The Company had been testing three rates; 4½ ounces, 9 ounces, and 13 ounces per 1,000 square feet, but I had to find the best rate myself. I also contacted James B. Moncrief and Holman Griffin, with the USGA Green Section. Griffin told me about a club in Arlington, Va., that had some success in converting from bermudagrass to bentgrass using Tupersan. With this encouragement, I determined to try this method.

We had a 5,000-square foot nursery of Tifton 328 bermudagrass, and we started our experimental work here on March 28, 1969. The bermudagrass was just starting to green. We split the nursery into four sections. One section was for the 4½ ounce rate, one for the 9 ounce rate, one for the 13 ounce rate, and the last as a check with no Tupersan applied. First, we used a verti-cut and a greens mower, both machines set down to the ground. We verticut and mowed in two different directions. This removed all bermudagrass down to the ground. Second, we spiked the area in six different directions to get good penetration of the Tupersan into the soil and to make a better seed bed. Third, we applied the Tupersan to each section as outlined above. The Tupersan was washed into the soil thoroughly with about one half inch of water. Lastly, seeding was done the next day at two pounds of Penncross bentgrass seed to each 1,000 square feet. Seed germination was good and the nursery was maintained as a green from then on.

By May 15, 1969, we could evaluate the results. Bermudagrass was present in all the plots, but in the 13-ounce plot it looked very unhealthy. We had nothing to lose so I decided to apply another application of Tupersan at 13 ounces to 1,000 square feet over all four plots to see what would happen. This was done on May 29, 1969, and the temperature was 96 degrees. By the end of summer we could find very little bermudagrass in the nursery and no living bermudagrass was left in the plot that had a total of 26 ounces applied.

I showed the results of my experimental work to my Green Chairman, and we decided to use this method to convert the remaining greens to bentgrass.

Work on the remaining 13 greens commenced on September 15, 1969. We did not want temporary greens, so we decided to work the back two-thirds of each green and to leave the front one-third for the golfers to play on. We followed the same procedure used on the nursery; verti-cut, mow, spike, apply Tupersan, and seed. On October 15, 1969 the back two-thirds of each green far exceeded our expectations and by this time was in real good shape. We then worked the front one-third, but the weather had turned cooler. The bentgrass germinated but did not thicken until the following spring. If we had to do this over again, we would do the whole green at one time and let the golfers putt on the seed and top-dressing. We think seeding no later than September 15 to be the best time. It is best to have the newly seeded grass well established before cold weather sets in.

Seeding was performed with small cyclone spreaders. We applied one half pound of seed in one direction and cross-seeded with one half pound in the opposite direction. We top-dressed with one eighth inch of top-dressing. On top of the top-dressing we again applied one half pound of seed in one direction, and another one half pound in the opposite direction. We then power dragged in two different directions.

Common is one of the most difficult bermudas to kill.

Another application of Tupersan at 13 ounces per 1,000 square feet was made on March 23, 1970, which made a total of 26 ounces of Tupersan applied over six months.

Of course, we anxiously watched the greens to see if the bermudagrass came back. We found that on the Tifdwarf greens we obtained 100 per cent control. On the Tifton 328 greens we had a few small patches (not over 1 per cent) which did not overly concern us since we figured another application of Tupersan in October, and another in March would take care of this and also prevent encroachment into the greens. We made one application on October 19, 1970 and another in March, 1971, at 13 ounces per 1,000 square feet.

The cost of converting the 13 greens amounted to $2,735.00. This included seed, Tupersan, and top-dressing. We estimated that we spent about $700 more for the Tupersan and seed, primarily because of the higher cost of Penncross bentgrass seed. The big bonus was that we had no temporary greens to manage. Another bonus was that Tupersan is a real good pre-emergence chemical for crabgrass and crowfoot grass. We were not bothered by these weeds the past year.

We were pleased that we were able to convert 13 greens while keeping them in play. Also, the greens far exceeded our expectations and pleased our golfing members, which is what our job is all about.

We feel that any club with bermudagrass greens can convert to bentgrass, provided that good drainage (sub-surface, surface, and air) exists and one uses a good soil mix. This can be done at very little cost and without temporary greens, which should please the golfing members.

OTHER CASES

Quail Hollow Country Club, Charlotte, N.C., is the host to the Kemper Open, and the tournament was played on overseeded bermuda greens until 1970. In September, 1970, Superintendent Bob Mashburn vertical mowed the greens three ways and denuded them of bermudagrass as much as possible. After the debris was removed, he applied 13 ounces of Tupersan per 1,000 square feet. The chemical was watered in with a minimum of one-half-inch water. On September 29, he seeded with Penncross bentgrass seed. It took about one week before there was a noticeable effect on the bermudagrass. The chemical reacts by causing retardation of the root system. Top-dressing made a smooth enough putting surface and the bent began to sprout and grow within a week and the putting began to improve. Play was at a minimum due to the beginning of the football season.

In April, 1971, nine ounces of Siduron per 1,000 square feet was applied and 13 ounces applied in May and again in June. During the late summer there was an occasional bermuda sprout, but the greens were free of goosegrass and crabgrass. *Poa annua* has not been a problem. The bent was mowed at one-quarter-inch after the tournament, and it has been maintained at this height throughout the summer. Pythium has been a problem, but use of a fungicide has kept it to a minimum.

From September, 1970, through May, 1971, about 12 pounds of nitrogen per 1,000 square feet in a 4-1-2 ratio has been available to the grass, and very little if any nitrogen was added during the summer. When nitrogen is applied, one or two ounces of water soluble material per 1,000 square feet is sprayed on the greens with the fungicide application.

Mashburn stated that if he had to convert his greens again, he would use this method rather than soil sterilization, requiring tedious gassing and tents. Golfers are inconvenienced very little with this method, and they are happy with the results.

Johnny Burns, Superintendent of the Charlotte Country Club, began converting his greens about the same time as Quail Hollow, and he has essentially used the same method as both Capital City and Quail Hollow. Burns has observed that Tiffine or 127 bermudagrass is quite tolerant of Tupersan, and it does not go off-color when it is applied. This emphasizes that chemicals should be checked on your grass under your conditions if there is any doubt.

TEST PLOTS ESSENTIAL

We would like to reiterate that it is advisable to put out test plots if bermuda is invading bentgrass greens to see if your strain of bent is sensitive to Tupersan. For the past three years, Tupersan has been used for retarding bermudagrass, and many greens have been rid of bermudagrass by its use. This chemical shortens the root system of bent, so caution should be used. This method is not suggested unless you have properly constructed greens for maintaining bent.

This is another case history where the turf manager has worked out techniques that have saved him time and money. There has been minimum inconvenience to members since greens have remained in play almost all the time.

Trackster raking traps.

Research and Innovation Means Economy

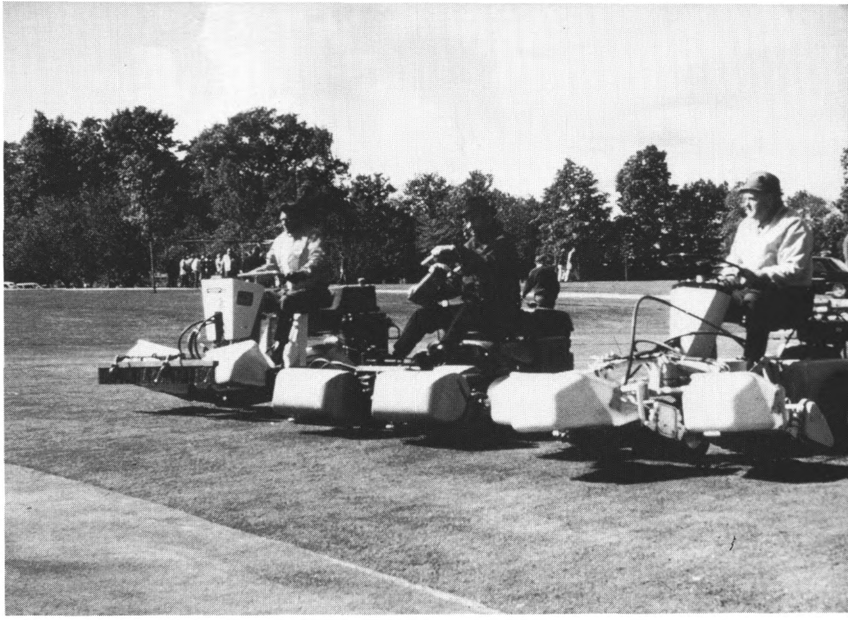
by **WILLIAM G. BUCHANAN,** Agronomist, USGA Green Section

Research and innovations are constantly changing our way of life. New machines are being developed so that one central unit can handle all banking statements for several large cities. Medicine is using research to cure previously "incurable" diseases. People today are living longer because modern sciences have discovered ways to transfer organs from one human to another. Research and innovations are making it possible for employers to use available manhours to a much greater degree of efficiency. The computer can do more jobs more economically than man. Paints are being developed that will withstand weather longer, hold colors better and give better protection to the surfaces to which they are applied.

Initial investments in materials and machines are normally greater than those of yesterday. However, many of the machines are multi-purpose. Many of the materials have been developed to such a degree that it is not necessary to use the quantities or number of applications to obtain the same or even better results.

Golf courses are the same as other businesses. Courses must operate on some type of budget. Wherever budgets are concerned, labor costs play a substantial role in how effective the budget is in achieving the desired results.

New nozzles add speed and accuracy to spraying operations.



Three different triplex putting green mowers.

Manpower is a main concern to golf courses. Good crews are hard to find since golf courses must compete with labor unions' pay scales to retain good, reliable help. Since manpower is more costly, machinery and chemicals must be developed to cope with the situation. Machinery has been developed to reduce the time needed to perform certain operations. They not only save time, but also reduce the number of men needed to do a specific job. This is not to advocate smaller crews, but with the machinery on the market today, a crew of from eight to 10 men can accomplish more work. New machinery makes it possible for one man to mow greens while men who had been used for greens mowing can now be assigned to trim trap edges, repair ball marks on greens, trim around tree trunks and better manicure the course in general.

Triplex mowers are becoming more and more popular. These mowers have made a big impact on golf course maintenance; time and labor saved by their use is considerable. Now one man can mow 18 greens on Saturday and Sunday or holidays and be finished by the time early golfers arrive. However, there are some drawbacks to the mowers, such as mechanical damage to weak fringes from constant turning of the mower, and the increased grain buildup on greens. Triplex units, as with many new products, were designed to be multipurpose. In addition to mowing greens, vertical mowing and spiking can be done with equal time saving compared to single units.

As noted, the constant use of triplex greens units has a tendency to encourage grain buildup. The speed and accuracy with which the vertical mowing operation can be completed with the triplex units makes it possible for superintendents to better control grain buildup. Increased vertical mowing also helps reduce the incidence of disease by removing the leaf that has a horizontal growth and allowing fungicides to better come in contact with the disease.

Bunkers on many courses are costly to maintain, and until recently all the work was done by hand. With the cost of labor and chemicals needed to maintain a well-groomed, weed-free bunker, the expense is surprising. Recently, power rakes have been developed that offer a tremendous saving in manhours. While visiting one course this summer, we observed a power rake in use. The operation was timed in five minutes; according to the superintendent, it took one man 30 minutes to do the job manually. Therefore he saves 25 minutes in labor on that one bunker every time it is raked. Power rakes are not only a great saving in labor, they also are capable of raking to a depth of three inches, which makes it possible for all bunkers on the courses to play uniformly. The three-inch raking depth will be of great assistance in weed control.

Research is also paying dividends in areas other than machinery. Better fungicides are being developed to give the superintendent better control of diseases for longer periods of time.

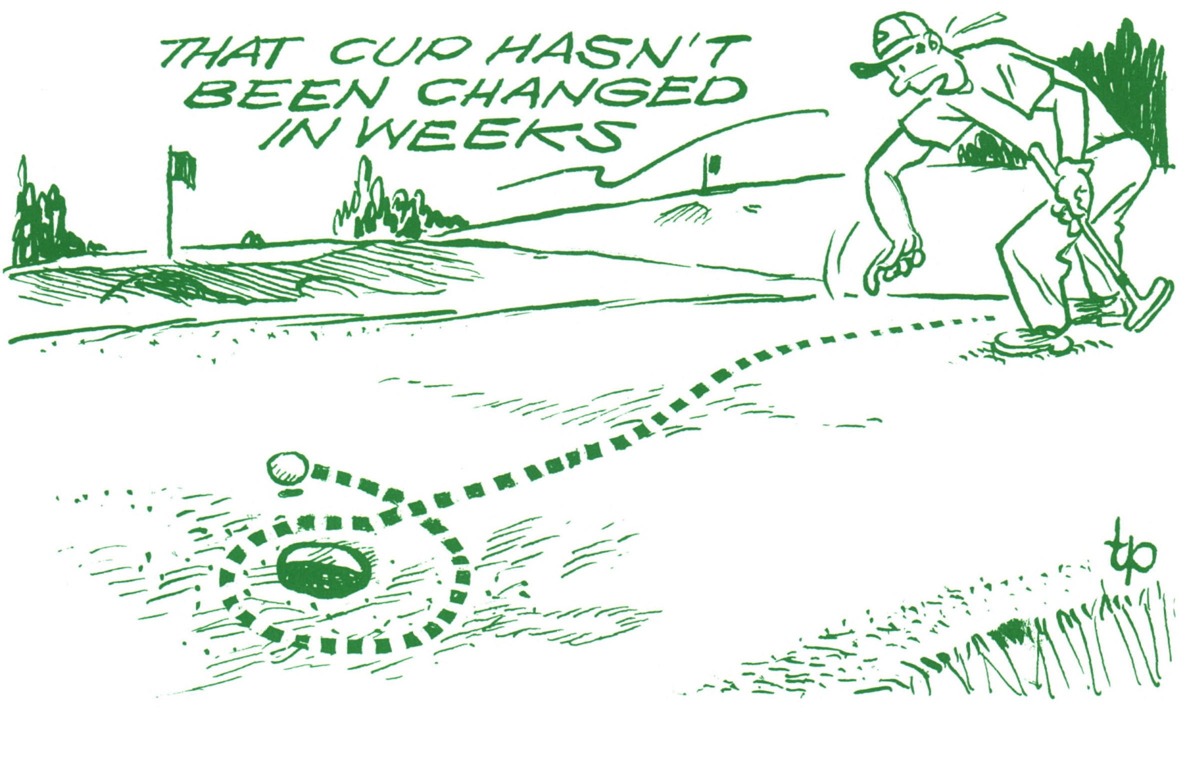
Systemic fungicides have been developed recently that are reported to give excellent controls over dollar spot and the snow mold diseases. Systemic fungicides also have the added benefit that normal rains following application will not wash the chemicals away. In fact, unlike the use of other fungicides, watering helps get the systemic fungicides into the plant. Systemics are not the cure-all by any means, but using them in conjunction with other fungicides can provide a very strong disease prevention program.

Strong chemical programs have been encouraged by improved equipment, which has reduced the time required for spraying. New sprayers with 20- to 30-foot booms, tee jet nozzles, mist blowers and even helicopters are being used to increase efficiency and reduce time needed to apply spray chemicals. More and more golf courses are spraying fairways because of the desire of members to have near perfect turf. Now, because of the improvement in spraying equipment, fairway fungicide treatments are the rule rather than the exception.

Records of time spent on jobs of every description should be kept by the superintendent. Good records can provide time and motion study information that will be invaluable when trying to sell the green committee on the newer and more sophisticated machinery. Many superintendents have been heard to say, "The only way I can buy anything is to convince the Board that the item will save the club dollars." A very fine article for assistance in establishing a good record keeping program is one by Alphonsas A. Barauskas in the March, 1971, issue of the *USGA Green Section Record,* entitled "You Can Do Something About the Whether."

The superintendent's job today is more demanding than ever. Not only must he possess the technical knowledge to grow fine turf, but he must also keep accurate records of the time spent on each phase of the maintenance program. He must consolidate technical as well as practical knowledge and produce an economic and agronomically sound maintenance program.

SUPER SAM by Paprocki



Better Bermudagrasses to Meet Golf's Demands

by GLENN W. BURTON and JERREL B. POWELL

"Cowpasture pool," a name frequently given to golf 50 years ago, was not chosen by accident. Many golf courses were located in cow pastures and the grass was what was there. Sand greens frequently offered a better putting surface than the mixture of weeds and grasses that covered the greens. Even today several grass species and weeds like yarrow occupy the greens on some of the world's oldest courses.

Golf can be played in a cow pasture, but few golfers in 1971 are willing to do so. One prominent golf course was recently criticized because in the off-season several different strains of bermudagrass could be outlined on the same green. Someone has facetiously observed: "Golf greens today must be as smooth and fast as a billiard table. They must be covered with one grass and not a single weed will be tolerated."

Certainly the grass is one of the most important components of the living green carpet that we call "turf." The other two components that determine turf quality are the environment and management. The grass variety interacts with an environment that is generally altered by management to make turf. For top quality turf, the grass, environment and management must be compatible.

If we are to develop better grasses for golf, we must know the demands of the game. Here they are as we see them:

Golf Demands

For top-quality golf greens, a grass must be able to withstand daily defoliation to a height of 3/16 inch and maintain a smooth, uniform surface that will keep the ball on a true course. Its leaves must be fine, soft, and closely spaced to meet this requirement. It must also have a uniform dark green color. For tees, a variety must be tough to stand the punishment doled out by the golfer and his clubs. It must have dense, stiff leaves to hold the ball well above the soil, and it must heal rapidly to fill in divot holes left by the players. For fairways, a variety must make an attractive, uniform carpet, dense enough to give a good lie to the ball. It must be able to heal divots rapidly and must tolerate considerable traffic. It must do all of this over a great variety of microenvironments with less water and care than greens and tees.

In addition to these specific demands, there are a number of general characteristics that we would like to incorporate into new golf course varieties for the South. First and most important is dependability. These varieties (except for overseeded winter grasses) should be perennial regardless of the weather. They should maintain a green color throughout their growing period (hopefully to be extended by increasing frost resistance). Low maintenance costs and, of lesser importance, low establishment costs should receive major attention in the development of every new variety. Wear resistance, shade tolerance and low weed potential are other important traits that should be added.

Figure 1. Potted plants of Tifgreen on the left and a very small dwarf mutant induced by exposing dormant sprigs of Tifgreen to gamma rays.

Figure 2. Close up of stolons of the two grasses shown in Figure 1.

Last year, $7,750,000 was spent in Georgia on maintaining golf courses. We can lower maintenance costs materially as we add resistance to drought, disease, insects, nematodes and weeds. Adding dark green color and dense growth habit, as we have done in Tifway bermudagrass, can reduce fertilizer needs but it may increase thatch problems, particularly if fertilizer applications are not reduced to match the needs of such new varieties. The dense growth required to give a good lie to the ball adds wear resistance and materially reduces weed problems. Sod density can be increased genetically or by adding more fertilizer. It is much cheaper to do it genetically, but management must match the variety. Too much fertilizer, as it makes too much grass, will increase mowing costs, disease and insect-control problems, and will add to the difficult job of removing thatch. Finally, developing small or dwarf varieties that rarely produce seedheads can reduce mowing frequency and lower maintenance costs. Such savings may be offset, in part, by expenditures for herbicides to control the weeds that are usually more prevalent in areas planted to these less-vigorous grasses.

Having outlined the requirements for these new varieties, we have only to find or create them, prove their worth, learn how to manage them, and put them to work. To do this sounds easy, but it will require a much greater investment in time and money than has been made to date.

Bermudagrass is the species that best satisfies the demands of golf in the South. Since it is a highly variable species, one might expect to find superior types on old golf courses. Such was the history of U-3. Discovered on a Georgia golf course and tested at Beltsville, Md., U-3 bermudagrass was released by the USGA Green Section and the Crops Research Division, ARS, USDA in 1947.

Hybridization

When we began our turf research at the Georgia Coastal Plain Experiment Station with the help of a USGA Green Section grant in 1946 (support that has been continuous to date), we collected superior bermudagrasses from a number of golf courses in the South. Most of these were superior to bermudagrass established from seed, but none of it was equal to an experimental hybrid that we had made. This hybrid, named Tifton 57 (later Tiflawn), was released in 1952. Experience soon proved that Tiflawn grew too fast for golf. (It is still tops for football fields and similar heavy duty use.)

Hybridization, the technique that gave us Tiflawn, was used to create Tiffine, Tifgreen and Tifway. To produce these varieties, the tetraploid *Cynodon Dactylon* was crossed with the tiny fine leafed diploid *Cynodon transvaalensis* to combine the desired turf qualities of both species. Like their parents, these hybrids were variable and only the best selected

THE AUTHORS

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after much testing, were named and released. Although these triploids are sterile, vegetative propagation has permitted their widespread use in the South.

A turf bermudagrass with greater winter hardiness than any now available would have a place in the U.S. We hope to develop such a hybrid using as one parent a very winter-hardy bermuda found in Berlin in 1966.

Attempts in recent years to improve the "Tif-" bermudas by making new hybrids have failed. The best of these (that are nearly as good as the "Tifs-") are being kept in our nursery as insurance against a possible disaster, such as the 1970 corn blight disease which greatly reduced corn yields.

Tifdwarf, our latest development, is a natural dwarf mutant that occurred in Tifgreen. As one might expect, Tifdwarf is very much like Tifgreen except that it is smaller. This makes it better able to withstand daily mowing at a height of 3/16 inch* and gives it better putting qualities. One of the nation's all-time-great golfers said recently, "These Tifdwarf greens and Tifway fairways and tees are the finest turf I've ever played on." Obviously, they were well managed.

Mutation Breeding

Apparently, Tifdwarf and Tifway are close to the ideal for golf. But small changes in their plant color, pest resistance, herbicide tolerance, size and ease of management could make them better. The occurrence of the natural mutant Tifdwarf in Tifgreen and the finding of other probable mutants indicated to us that we might speed up this natural mutation process by treatment with mutagenic agents.

Thus in the winter of 1969-70, we began mutation breeding research designed to produce mutants of Tifdwarf and Tifgreen. Dormant stolons, washed free of soil and cut into one or two node sections were selected because their buds contain few cells. Actively growing buds contain many cells and a one-celled mutant occurring in such buds will usually be obscured by the development of the normal cells around it. Thus the ideal bud for mutation breeding would be one cell in size.

When we treated dormant buds of Tifdwarf and Tifgreen with the chemical mutagen EMS (ethyl methane sulfonate) at rates up to levels that killed many buds, noticeable variants failed to appear. When we exposed dormant sprigs to 5 to 12 kR of gamma irradiation from a Cobalt 60 source, however, a number of distinctly different bud mutations occurred. Isolated from normal tissue and grown in two-inch pots in the greenhouse, these 60 mutants differed in leaf size, hairyness, stem diameter, internode length and basic plant color. In a field planting they showed differences in herbicide sensitivity, frost tolerance and rate of spread.

In the winter of 1970-71 we exposed dormant stolons of Tifgreen and Tifway to gamma rays and planted them in flats of sterile soil in the greenhouse. In April we spaceplanted in the field, the tiny plants that grew from the irradiated buds and isolated 62 mutants from Tifgreen and 36 from Tifway. These mutants were similar to those obtained earlier. Tifway, however, gave a lower mutation frequency and failed to produce as much variation in plant color.

These mutants are yet to be evaluated for pest resistance and all of the important characteristics required by golf. Time (at least three years) and much work will be required to test these mutants. Many will fail to pass the tests, but, hopefully, some of them will be better than the best we have today.

Figure 3. Tifgreen plot in foreground. Other plots are gamma ray–induced mutants of Tifgreen or Tifdwarf.

Fertilization Practices and Quality Turf

Twenty-one day root growth of Kentucky bluegrass sod transplanted in window boxes in April 1 from a late fall-winter nitrogen fertilization experiment. Nitrogen (ammonium nitrate) amounts applied from left to right: 1, none; 2, one pound of N/1000 sq. ft. in October, December, and February; 3, two pounds of N/1000 sq. ft. in October, November, December, January, and February.

by R. E. SCHMIDT and J. E. SHOULDERS
Associate Professor, Agronomy and Turfgrass Extension Specialist
Virginia Polytechnic Institute and State University

Plants need 16 other elements in addition to carbon, hydrogen and oxygen, which are supplied by air and water. The other necessary elements are: nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, manganese, copper, zinc, boron, molybdenum, sodium, chlorine, silica, and vanadium. The first six (nitrogen, phosphorus, potassium, calcium, magnesium and sulphur) are needed by the plant in relatively large amounts and are referred to as macro-nutrients.

Micro-nutrient turfgrass deficiencies (i.e., the last 10 elements mentioned) are not now considered the cause of the majority of nutritional problems. Generally, sufficient micro-nutrients are supplied to the turf from rain, irrigation water, fertilizer carriers, lime and natural weathering of the soil. However, in some areas micro-nutrient deficiencies are being reported, and many fertilizer companies now supply speciality fertilizers containing micro-nutrients.

Since the majority of turf nutritional deficiencies are associated with the major elements, it is wise to insure that adequate and proper major elements are available to the grass plant. The word *proper* should be emphasized here. Although the grasses tolerate "imbalance" of the elements, the grasses function and produce better turf with properly balanced nutrients. Also the nutrition availability and season interaction must be considered for proper fertilization.

Soil Tests

Two methods that aid in determining nutrient status for plant growth are soil tests and tissue analysis. The soil test is most widely used. Generally the soil testing service provides the pH status and calcium, magnesium, phosphorus, and potassium content of the soil. From the information along with the knowledge of the soil type, species of grass and turf usage, a fertilizer recommendation can be made.

Although grass species differ in their tolerance to acidity, all grasses do best at about a pH of 6.5. Soils receiving more than 20 inches annual rainfall generally become acid; therefore, lime is used to correct acidity.

Liming

Three factors to consider in determining the amount of lime to be applied to turf are: 1) kind of lime to be used; 2) type of soil; and 3) the soil pH. The neutralizing power of lime is based on its calcium or magnesium content. Seventy-five pounds of hydrated lime and 56 pounds of burned lime have the same neutralizing power as 100 pounds of pure limestone. Burned lime is seldom used because of its caustic properties. A dolomitic limestone ground so that at least one-half passes a 100 mesh screen and all pass a 10 mesh screen is preferred because it will provide calcium as well as magnesium.

As a general rule of thumb, it takes about 100 pounds of finely ground limestone per 1,000 square feet to raise one pH unit of a loam soil. Clay soil types will take about one quarter more, and sandy soil one quarter less.

Phosphorus and Potassium

Soil tests show that mature turf soil tends to build up in phosphorus and decline in potassium. The opposite is true of newly established turf. This is because phosphorus is readily fixed in the soil and potassium is soluble and leaches especially in light or sandy soils such as the modified topsoil of greens. A wise turf manager uses a soil test to diagnose and properly supply phosphorus and potash. Medium to high levels of phosphorus and potash should be maintained. Late summer or early fall is the best time to take the soil samples.

Nitrogen

Soil tests for nitrogen are not satisfactory for making turf fertilizer recommendations. Rather, nitrogen recommended fertilization rates and schedules are based on field experiments. Nitrogen recommendations are based on the following:

1. Type of nitrogen source to be used.
2. Type of grass to be used.
3. Anticipated usage of the turf.

Nitrogen sources can be classified into four groups:

1. **The inorganic quickly available.** Usually the least expensive. Soluble but caustic. Must be applied frequently at low rates and often must be watered in to prevent burn.

2. **The organics.** Expensive, but slowly available and not caustic. Higher rates than the quickly available may be applied at one time.

3. **The ureaformaldehydes.** Also expensive, very slowly available, not caustic, but dependent upon microbial activity and warm temperature for the N to become available to the plant. These materials provide only small amounts of nitrogen to the plant during the winter and need to be supplemented on greens.

4. **Synthetics.** Many new types of nitrogen sources are being tested. They have different modes of nitrogen release. Most fall between the availability of the quickly available and the ureaformaldehydes.

No source of nitrogen is better than the other if managed properly. Many turf managers use a combination of several sources.

Recommended yearly rates of nitrogen vary from two pounds for general utility turf to as much as 12 pounds on high quality putting green turf. It is not the intent that fertilizer recommendations for all types of turf be given in this paper. (Consultations with the local agricultural agent, the state agricultural experiment station or USGA Green Section representative are suggested for this information.)

Different Grasses — Different Management

Timing of nitrogen applications vary with the species. Warm and cool season grass species differ in their season growth habits. Therefore, it seems reasonable that growth stimulation due to fertilization should also differ for the two types of grasses.

Cool season grasses naturally increase in food reserves (carbohydrates) during fall and winter. During the flush growth of spring these food reserves are utilized to a large extent. It's not until the next fall that food reserves can be built back up again. Consequently, not much stored energy can produce summer growth.

Root growth follows the food reserve cycle. That is, most root development occurs during the winter and early spring.

Our recent data show that, under Virginia conditions, supplying adequate nitrogen nutrition to the cool season grass during periods of natural carbohydrate build-up enhances the plants' appearance and vigor.

Nitrogen applications made during the fall and winter increase carbohydrates, create green color and produce more roots. This vigor is carried through the summer.

Nitrogen applications made immediately prior to or during the spring flush growth stimulate excess top growth, reduce carbohydrates and root development. If nitrogen is needed, it is best to wait until the spring flush growth has ceased.

Heavy summer applications of nitrogen cause loss of carbohydrates and reduce the turf vigor and should be avoided.

Warm season grasses also benefit when nitrogen fertilization is applied concurrently with the natural carbohydrate development. The warm season grasses differ from the cool season grasses in that they develop their carbohydrates during the summer months. Recent work in North Carolina indicates that relatively high fall nitrogen rates can be beneficial to bermudagrass if phosphorus and potash rates are also high.

Our observations in Virginia show that heavy nitrogen fertilization of overseeded cool season grasses growing on dormant bermudagrass does not reduce the vigor of the bermudagrass the following spring.

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TURF TWISTERS

MILD WINTERS

Question: We have had a very mild winter to date and I've been told if the ground doesn't freeze before the snow flies, snow mold incidence will be more severe than normal. (Massachusetts)

Answer: Very true, so be sure to apply your preventive treatment to minimize damage. Snow mold fungi seem to thrive when snow or ice lays over unfrozen ground. The resultant soil line temperatures seem to be ideal for maximum fungal growth.

ICY WALKS

Question: Around the clubhouse, I have an extensive sidewalk system which is surrounded by bluegrass turf, shrubs, and flower beds. Is there anything I can use to melt the ice on them and not damage the vegetation with salt? (New York)

Answer: Yes! You can sprinkle the sidewalk with a urea-form fertilizer or any dark organic fertilizer. This will melt the ice, plus, it will give your turf, shrubs, and flowers a good start in the spring.

SALTY GRASSES

Question: Do turfgrasses vary in their salt tolerance? (Arizona)

Answer: They certainly do! Work by Dr. V. Youngner at the University of California at Riverside shows the following range of salinity tolerance (from high to low tolerance):

- Improved and common bermudas
- Zoysia
- St. Augustine
- Tall fescue
- Creeping bentgrass
- Perennial ryegrass
- Meadow fescue
- Red fescue
- Kentucky bluegrass
- Colonial bentgrass