SEPTEMBER 1975

USGA GREEN SECTION RECORD

A Publication on Turf Management
by the United States Golf Association

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Cover photo: Proper components and proper mixing are most important to the success of any green.

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TOP-DRESSING FOR TURF

by HOLMAN M. GRIFFIN
Mid-Atlantic Director
U.S.G.A. Green Section

Any serious discussion of "Principles of Turf Management" would be most incomplete without giving consideration to such a basic principle as topdressing. With the lack of manpower during World War II, we found we could get along without it. Improperly done, it can add to our problems and essentially destroy a well-constructed green of otherwise excellent quality. Apply too much and we smother the grass. If we fail to sterilize topdressing components, we plant weeds and very likely encourage disease.

There are other potential disadvantages too numerous to mention, so why don't we just close the book on topdressing and forget it? We don't because ever since man began managing turf and improving it for sports use, the many advantages have been obvious, although not often understood. Topdressing is the turf industry's castor oil. It is a bitter medicine to take, but it certainly does a lot of good things for turf.

Many of the advantages of topdressing are spelled out in an article by W.H. Bengeyfield, entitled "Top-Dress Greens and See the Difference," published in the GREEN SECTION RECORD in January, 1969.

Bengeyfield lists the advantages as (1) smoother putting surfaces, (2) tighter and finer textured turf, (3) reduced grain, (4) an aid to thatch decomposition, (5) reduced disease, (6) better water and fertilizer infiltration, (7) alleviation of compaction, and (8) protection against cold weather injury. In addition to these advantages, we might suggest at least two beneficial uses of topdressing as (1) soil modification, and (2) as a seedbed for winter grasses on bermudagrass greens.

These beneficial aspects of topdressing place the subject in an entirely different light. Still, there are a great many valid questions left unanswered about the materials to use and how best to apply them in addition to the basic question about the need for topdressing at all. At this point, I can only rely on the preponderance of research information which favors topdressing and my own practical experience and observations which also favor the practice.

One reference published in 1970 said topdressing is usually not necessary. Suitable turf grasses will thrive without it. However, there are a few special situations where topdressing may be warranted (because of the labor and expense involved, topdressing should be limited to the most important turf areas). This isn't a complete shutout because the door is left open to some topdressing in special

The sod job pictured was a poor one but top-dressing is certainly in order with this or any other sod job.

situations and, besides, it refers more to parks, lawns, and athletic fields than to putting greens. On the other hand, the entire reference tends more to downgrade the benefits of topdressing than to promote them. Perhaps this particular reference is a little too far removed from our real subject to be applicable, however, we can start there and move on to a reference published in 1973 which says, "Topdressing should not be used as a routine practice in the cultural system but only as needed to control thatch or to improve the smoothness of a green surface. The frequency of topdressing varies from none to as frequently as every 3 to 4 weeks. Quality bentgrass greens have been maintained for years without topdressing, while topdressing may be a necessary cultural practice on other greens."

The most recent reference is an article in the May, 1974, issue of the GREEN SECTION RECORD by Madison, Paul, and Davis, of the University of California. The article is entitled, "Consider a New Management Program for Greens." This article outlines some advantages of and procedures for light, frequent topdressings. Basically, they are talking about topdressing 15 or 20 times a year, depending on such variables as the section of the country, the management the turf receives, and the type of grass being grown.

Now, who are you going to believe and which practice should you follow? All of these references are correct if taken in their proper context and if followed advisedly. What a turf manager must do is learn the basic principles behind topdressing, use these with a definite purpose in mind, and adjust the topdressing schedule according to the needs of his individual situation.

Now, let us go into some basic facts about topdressing and its use:

1. Topdressing Material and Layering

The material used as a topdressing must be a properly analyzed product which would be suitable for use in green construction. Specifications for such a material are clearly and definitely outlined in the USGA "Green Section Specifications for Putting Green Construction," and in the recently published article, "Sand for Golf Courses." There is no way to achieve the best result from topdressing greens with a material of lesser quality.

A good topdressing material (properly analyzed) can eventually modify or replace the poor soil to a depth which is adequate to give your green a new lease on life and provide a manageable situation.

Although we would prefer to have the entire topsoil on a green uniform in depth, this is seldom possible unless the right soil was used in construction and its use was continued as topdressing.

Dr. Marvin Ferguson has said that, "Much of the controlability of traffic on putting greens is either built in at the time of construction or it is left out." The same goes for manageability. We may be able to improve a poor soil with topdressing to the point where we can live with it, but we can never make it as good as it would have been if properly constructed in the first place.

A compaction resistant soil with adequate drainage as well as adequate moisture retention, such as would be the product of a proper physical analysis according to USGA specifications, when placed as topdressing over a tight clay, typical of most older greens, would make an almost immediate improvement in the growth of the turf. Of course, the deeper the layer of good soil the better, but in numerous situations like this (a loose soil on top and a clay underneath) we have seen bentgrass roots strong and healthy below 12 inches. The tops were good, too. In this special case, layering has distinct advantages.

2. How Much Topdressing and Why?

The amount of topdressing required will vary with each situation; soil modification taking the most and normal topdressing for thatch and grain control tak-

Vandalism is an increasing problem which necessitates costly repair. New soil (topdressing) will have to be used to fill up the ruts.

Soil needs proper pore space for both air and water.

ing the least.

In my opinion, topdressing should always be done so that it is incorporated with or naturally blends with the thatch. Simply covering a layer of thatch, especially a heavy layer of more than ½ inch, would have about the same effect as installing one of those bad layers we are all so afraid of.

To properly mix the topdressing with the thatch, we must either topdress frequently enough to keep the thatch from getting ahead of us, as Madison suggests, or we must mechanically remove the thatch by aeration, filling the holes with good topdressing material; or remove the thatch by slicing and filling the grooves with topdressing.

Mixing the thatch with topsoil encourages microbiological activity which in turn breaks down thatch and converts it into valuable soil humus. In addition, new soil around the grass plant will cover stems causing them to take root and send out new shoots thereby producing a tighter, finer-textured turf with less grain. Last but not least, repeated topdressing will smooth and true the putting surface—ball marks, footprints, damaged areas and all—and help to keep it putting better.

Exactly how much topdressing to use should be redetermined for each application and will vary with such things as type of grass, temperature, purpose of the topdressing, and condition of the grass on the putting surface. A handy figure to remember is that it takes 1.54 (roughly one and one-half) cubic yards of topsoil to cover 1,000 square feet ½ inch deep. To figure other depths or volumes required, simply multiply for greater depths and divide for less.

In most cases, ⅕ (.2) of a cubic yard per 1,000 square feet is considered a very light topdressing. This is one cubic yard on an average 5,000 square foot green. This would figure out to about 1/16-inch of topdressing over the entire green. When using a heavier topdressing, possibly before overseeding bermudagrass, two to three cubic yards per 5,000 square foot green might be used to prepare a good seedbed and to aid in protecting the bermuda stolons and rhyzomes through the coming winter.

3. Preparation, Handling and Application of Materials

The final step in preparation is sterilization, which can be done in many ways, such as composting or with chemicals such as methyl bromide or Vapam. However you do it, this is an important step that should never be omitted.

Proper handling of topdressing materials means that they will be stored in a place that will keep them uncontaminated and dry; ready for use at any time. Polyethylene covers are sometimes used, but they are a poor choice over permanent storage facilities.

The advantages of a good topdressing are many, and where the finest quality putting greens are desired, this practice is a must. In my opinion, the merits of topdressing have been adequately proven although there are still a great many unanswered questions about when, how, and why we should do it; what it does for the turf, and especially what constitutes a good material. We certainly hope that current soil studies being carried on at several research stations can help supply some of these answers.

A GREEN SECTION SUPPORTED RESEARCH PROJECT

Mechanizing Trash Removal from Sand Bunkers

by DENNY C. DAVIS*

Poor maintenance of sand bunkers can sorely degrade the appearance and playing condition of a golf course. Efforts to minimize cost and labor requirements while maintaining good quality trap conditions have resulted in sand bunker modifications making them suitable for mechanical raking. Some golf course superintendents, however, continue to face trashy trap conditions that are not remedied by mechanical raking.

Wind blown debris, player-dropped trash, and gravel rising from beneath the sand pose trash problems in bunkers. To-date methods and machines for mechanically gathering trash from bunkers have not been available to golf course superintendents. A research project at the Georgia Experiment Station (of the University of Georgia College of Agriculture), funded in part by the U.S.G.A. Green Section Research & Education Fund, Inc., is partially directed toward providing a machine that will rid sand bunkers of the undesirable trash. The objective of this research is to develop a machine that will remove trash 1/4 inch in diameter or larger from surface layers of sand and leave a surface that is pleasing in appearance and conducive to play.

CLEANING PRINCIPLE

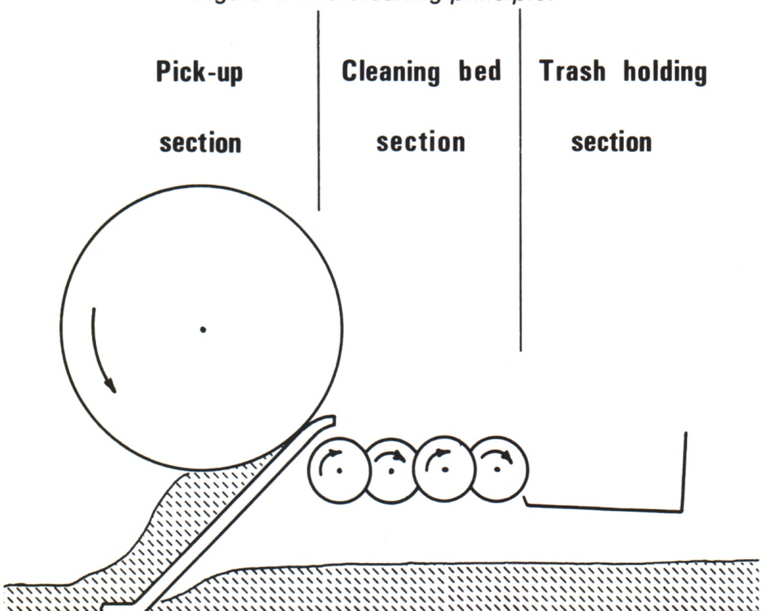
Trash that hinders play or degrades the appearance of bunkers can be on the sand surface or either partially or entirely buried in the surface layer of sand. Therefore, the cleaning unit must collect not only that trash at the sand surface but also that within the surface layer.

The principle selected for use in the cleaning unit includes elevation of the surface sand layer, removing the trash, and returning the sand to the bunker. The basic cleaning principle is illustrated in Figure 1. As the cleaning unit moves forward (to the left in the figure), the sand layer is elevated and passed over the cleaning bed where trash separation occurs. Trash is then conveyed to the holding section while the sand falls back onto the surface below.

The pick-up section of the cleaning unit serves to penetrate the surface layer of sand and transport the sand and trash mixture to the cleaning bed. The pick-up section, when using spaced tines to penetrate the sand, provides some trash separation by allowing sand to pass between the tines and fall to the sand surface below. Rotating brushes above the tines assist the movement of the sand-trash mixture (that which accumulates at the tines) back to the cleaning bed section.

The cleaning bed section is the primary mechanism for separating trash from the sand. The cleaning bed is composed of parallel shafts rotating opposite to ground wheel rotation during forward travel.

Figure 1. The cleaning principle.



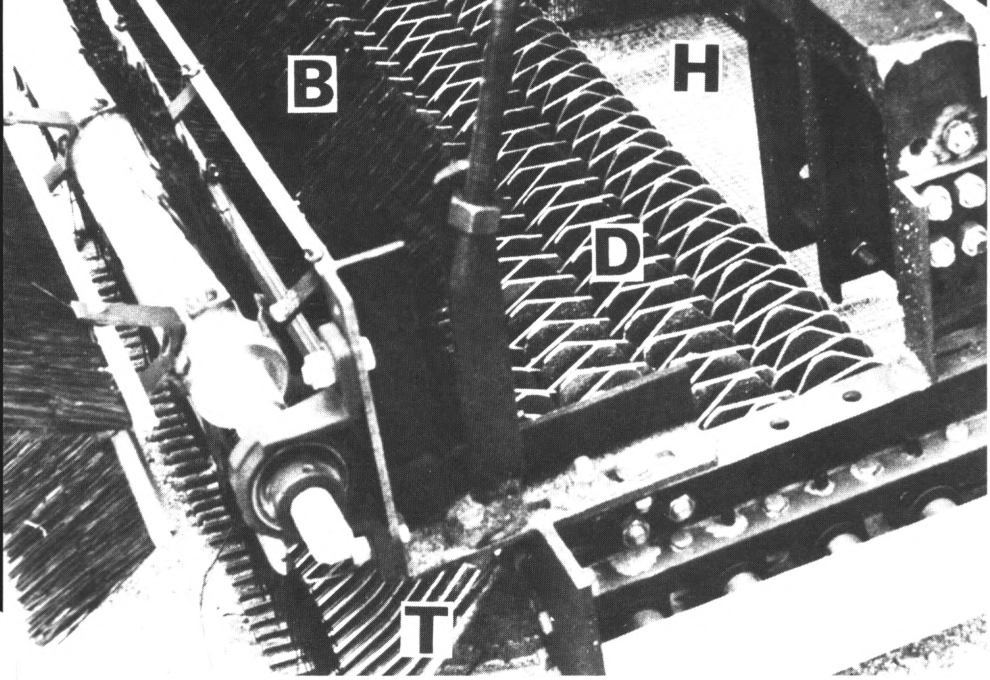


Figure 2. The cleaning unit showing brush (B), discs (D), trash holding basket (H), and the tines (T).

Fastened to and equally spaced on each shaft are thin discs that overlap with those on adjacent shafts. Separation of trash from the sand-trash mixture reaching the cleaning bed occurs as the sand falls through the discs to the exposed sand surface below and the trash having dimensions greater than the disc clearance is carried over successive rows of the rotating discs to the trash holding section.

The trash holding section serves as a collection point for all trash passing through the pick-up section and over the cleaning bed. A removable basket, one that allows small quantities of retained sand to sift out, is used to hold the trash until a sufficient quantity has been collected to require emptying. Alternatively, a conveyance device replacing the basket could carry trash away from the cleaning bed.

MACHINE DEVELOPMENT

Development of the sand cleaning unit has progressed through three stages:

1. Construction of a cleaning unit for laboratory evaluation of the cleaning principle.
2. Construction of a portable power unit and modification of the cleaning unit for use in a sand bunker and
3. Evaluation and refinement of the cleaning unit for improved performance.

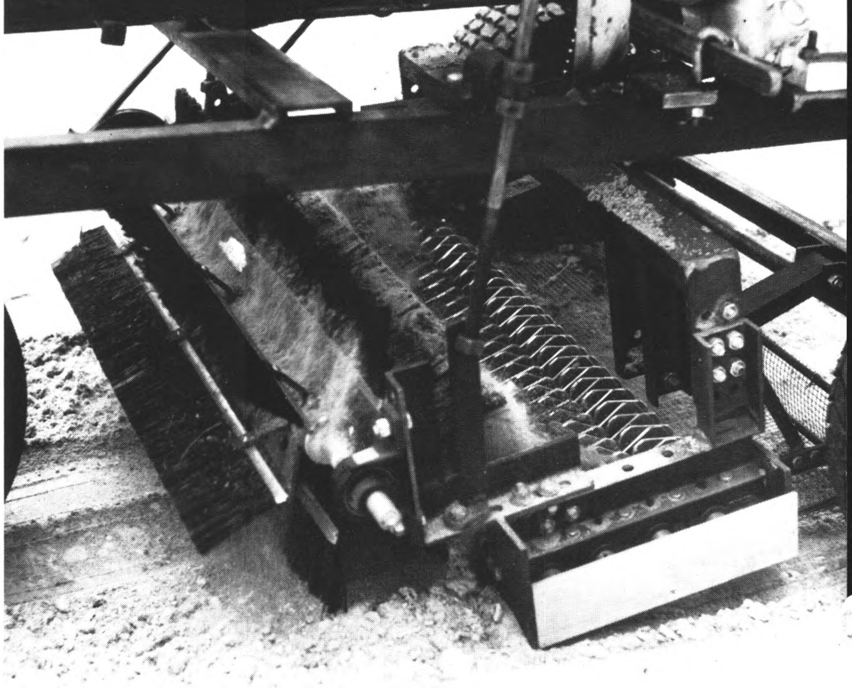
The first cleaning unit was constructed to clean a 12-inch wide strip of sand for laboratory evaluation of the cleaning principle. The cleaning unit was placed in a test apparatus that could provide to the pick-up section a 2-inch deep layer of sand at various travel speeds. As trash (1/4 to 1-inch maximum diameter wood, rock, and paper pieces) was randomly introduced into the moving sand layer, that quantity of trash elevated, passed over the cleaning bed, and collected in the basket was compared to that escaping through the cleaning unit. The cleaning efficiency (number of pieces collected/total number introduced) was used to evaluate the performance of the cleaning unit.

Six different test conditions using travel speeds ranging from 0.1 to 0.6 mph and three brush speeds were repeated three times each to evaluate the cleaning efficiencies. Resulting cleaning efficiencies ranged from 87 to 100 percent with an average of 95 per cent. Cleaning efficiency was not significantly affected by ground speed but was improved by increased brush speeds.

A portable power unit and a sand bunker were constructed and the cleaning unit was modified (as suggested by laboratory test results) for testing the machine under field conditions. Square discs were used in the cleaning bed (replacing circular discs used previously) to provide more aggressive cleaning and trash conveyance actions expected to be necessary under uneven terrain conditions. Qualitative evaluation of the cleaning unit performance revealed that trash could be removed effectively from the sand with this unit. Under relatively wet sand conditions, however, significant quantities of sand were carried with the trash to the trash holding basket.

A third generation cleaning unit, constructed to clean a 25-inch wide strip of sand, is shown in Figure 2. This unit contains four rows of rotating discs (D) spaced with 3/8-inch clearance between discs on each shaft and a rotating brush (B) composed of six bristled paddles. The discs, 2 1/4-inch-square pieces with corners rounded to a 23/4-inch diameter, are increased in size from those of the earlier cleaning unit models to provide a greater cleaning bed length and, therefore, allow more time for sand to fall back to the trap surface. Sharp edges occurring with square discs are avoided by the "rounded-square" shape. The tines (T), constructed from 1/4-inch diameter

Figure 3. The cleaning unit operating in the sand bunker.



rods, are separated by 1/4-inch clearance to retain the trash but allow some sand to pass through. The 1/4-inch square holes in hardware cloth used in constructing the trash holding basket (H) allow retained sand to fall back to the sand trap surface.

The cleaning unit performance was evaluated by subjecting it to two 25-inch by 19-foot test strips in the bunker. One strip (for Test 1) had been hand raked five hours prior to the test, but the second (for Test 2) had not been altered since a 1-inch rain had fallen four days before. Fifty pieces of trash (wood and rock pieces approximately 1/4-inch in diameter) were scattered randomly over each test strip. The tines of the pick-up section were set to penetrate approximately 3/4-inch below the sand surface in both tests. Figure 3 shows the cleaning unit during the performance tests.

In each test the cleaning efficiency was evaluated by the ratio of the number of trash pieces collected to the total number that were within the cleaning width of the machine. Because a noticeable amount of trash was missed in Test 1, a second pass was made over that test strip in pursuit of a greater cleaning efficiency. The test results are summarized in Table 1.

Performance of the cleaning unit varied between 74 and 93 per cent efficient for the two tests. The pre-loosened and drier sand conditions of Test 1 resulted in greatest return of both sand and trash to the sand trap surface. The compacted sand surface of Test 2 encouraged mass movement of the sand-trash mixture and resulted in increased amounts of both sand and trash at the holding basket. Improved performance of the cleaning unit probably would result as greater experience with the unit is gained and better control is utilized to offset the effects of sand moisture and compaction on the cleaning unit performance.

The cleaning principle reported here does separate trash from sand as desired. As experimentation continues to determine optimum design and operating conditions for the unit, increased efficiencies and rates of cleaning can be expected. Development may be only a stone's throw from a cleaning unit that can be attached to available power units and can aid in overcoming trash problems in the sand bunker.

Table 1. Performance of the Cleaning Unit

	Number Collected	Number Not Within Reach	Cleaning Efficiency Ratio	Cleaning Efficiency Percentage
Test 1				
1 pass	34	4	34/46	74
2 passes	41	0	41/50	82
Test 2	43	4	43/46	93

*Assistant Professor of Agricultural Engineering, University of Georgia, Georgia Experiment Station, Experiment, Georgia 30212

A GREEN SECTION SUPPORTED RESEARCH PROJECT

Velvet Bentgrass Putting Greens—

Fertilizer and Topdressing Management

by **DR. C.R. SKOGLEY** University of Rhode Island

Velvet bentgrass (*Agrostis canina* L.) has not been used widely in modern times for putting greens. This is the case even though greens on some of the most prestigious golf clubs of the Northeast consist primarily of velvet bentgrass. The Newport and Misquamicut Golf Clubs in Rhode Island are good examples.

In the early days of golf course construction in the United States, and perhaps into the 1930s, the most common grass seed utilized on golf greens was South German mixed bent. The seed was a mixture of velvet, creeping (*A. Palustris* L.) and colonial (*A. tenuis* L.) bentgrass. Over the years when superintendents had very little fertilizer for their courses, velvet bentgrass often predominated and provided very excellent putting surfaces. During the past 20 to 30 years the intensity of management, including fertilizer useage, has increased dramatically. It appears that this has favored the more aggressive creeping bents at the expense of velvet bent.

Very little management research has been done with velvet bentgrass in recent years except at the Rhode Island Agricultural Experiment Station. Aside from displeasure with this grass on the part of many superintendents as they increased fertilizer rates, pure seed of velvet bentgrass was not available until the mid 1960s. There may have seemed little use in researching a grass species that was not available except in a vegetative form.

Turfgrass researchers at the University of Rhode Island released "Kingstown" velvet bentgrass in 1962 and seed reached the market a few years later. It seemed desirable to initiate further management studies with the species since seed was now available and the grass still had many admirers.

During 1967, 6,000 square feet of ground was seeded to Kingstown velvet bentgrass at the recommended rate of one pound of seed per 1,000 square feet. The soil in the test area was Bridgehampton fine sandy loam—a friable, well-drained soil. An establishment fertilizer with a 1-2-1 ratio was incorporated into the seedbed prior to seeding to supply two pounds of nitrogen. The soil pH at seeding was about 5.5 No limestone was added.

The entire area was maintained uniformly through 1968 until the green was well developed. Treatments were commenced in April of 1969. A split plot experimental design was utilized with 13 x 36 foot main plots as topdressing treatments and 12 x 13 foot subplots as fertilizer treatments. The treatments included were:

Topdressing applied:

1. April and September
2. April, June and September
3. April, June, Sept., and Oct.
4. Once each month April through Oct.

Nitrogen rates and timing:

a. 3 lbs.—1 lb. Apr. and Sept. 1/2 lb. June and August
b. 5 lbs.—1 lb. Apr., Sept., Oct., 1/2 lb. May, June, July, Aug.
c. 7 lbs.—1 lb. each month from Apr. through October

A topdressing made from locally composted soil mixed with equal parts sand was used. Topdressing was blended, sterilized and stored for six to 12 months prior to use. It was applied with a mechanical spreader at a rate that readily brushed into the turf.

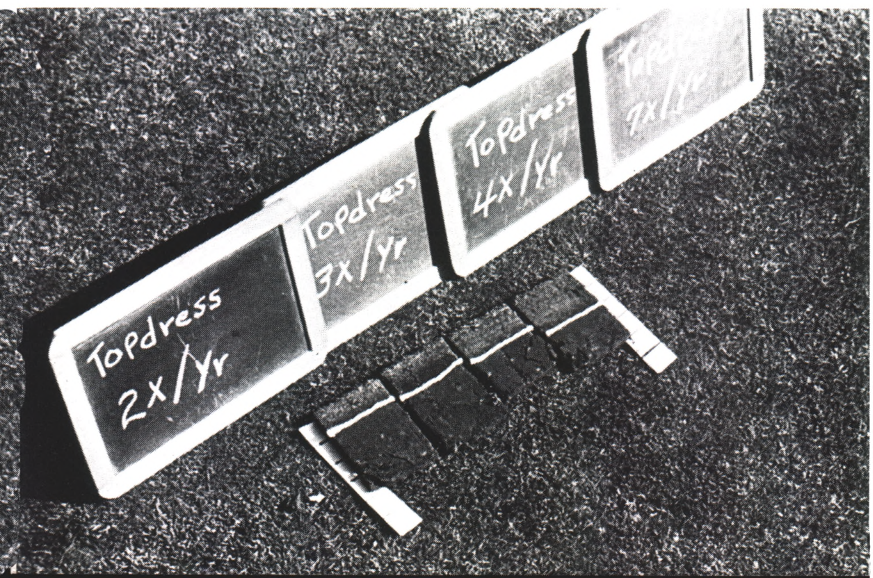


Figure 1.

Table I. Seasonal average turf scores of Kingstown velvet bentgrass as influenced by topdressing and fertilizer treatment.

Topdressing frequency	1970	1971	Year 1972 Score[1]	1973	1974
2 times	6.5	7.3	7.0b*	6.6b	5.4
3 times	6.5	7.3	7.2b	7.0ab	5.4
4 times	6.6	7.4	7.3ab	7.0ab	5.3
7 times	6.5	7.4	7.6a	7.4a	5.1
Fertilizer rate					
3 lbs.	5.8c	6.9b	6.7c	6.8b	6.1a
5 lbs.	6.7b	7.6a	7.4b	7.3a	5.1b
7 lbs.	7.1a	7.6a	7.7a	6.9ab	4.8b

[1] Seasonal average, 7 monthly scores, April through October.9 would represent perfect quality turf and 1 would represent completely brown or dead turf.

* Values followed by the same letter(s) are not significantly different at the 5% level using Duncans New Multiple Range Test.

The green was aerified with a plug or slicing-type aerifier prior to the April and September applications.

A 10-6-4 grade fertilizer was used for April, September and October treatments. Activated sewage sludge was used at all other times.

The cutting height was maintained at 1/4 inch and mowing was done on Monday, Wednesday and Friday. Pesticides were applied as required to prevent or control disease, insects and weeds. Eighteen practice-green putting cups were installed fairly uniformly throughout the test area and were changed at frequent intervals. Members of the university golf team, students in physical education classes, members of the University staff as well as the general public were encouraged to, and did, use the green throughout the entire test period.

The full schedule of treatments was not completed until October, 1969. Data were collected on a monthly basis starting in April, 1970, and this has been continued since that time. A scoring system was used in which 9 was considered perfect turf and 1 was completely brown or dead turf. In early spring and late fall even the best scores may not exceed 4 or 5. The figures presented in the tables are averages of three replications and include all months from April through October of each year. Average seasonal turf scores for the years 1970 through 1974 for both topdressing and fertilizer treatments are presented in Table I.

During the early years of study it is obvious that little difference resulted from frequency of topdressing application but that major differences occurred in relation to fertilizer rate. The fertilizer influence on color may markedly affect the visual quality scores. Color, however, may not be important. It is an esthetic value but may not necessarily influence putting quality.

Through the five years of the study, topdressing treatments resulted in significant differences in quality in 1972 and 1973, but the differences were not large. In late 1973 replicated two-inch plugs were taken from each plot, to the original soil level, and the organic matter content of the thatch and mat layer was determined. The information is presented in Table II.

Although the effect of topdressing frequency was minor on surface appearance, as indicated by quality scores, a large difference in organic matter content occurred. This could well be significant and important over the years in maintaining healthy greens. The influence of fertilizer rate on organic matter content was apparent but not significant. Topdressing has greater influence on this factor than does fertilizer. See Figure I.

Turfgrass response to fertilization, as shown in Table I, was most interesting During the first three years visual quality increased with the rate. This was particularly apparant when the rate increased from three to five pounds and, to a lesser extent,

Table II. Organic matter content of thatch and mat layer under Kingstown velvet bentgrass as influenced by seasonal topdressing frequency and fertilizer rate.

Topdressing frequency	% Organic matter	Fertilizer rate	% Organic matter
2 times	12.9b*	3 lbs.	11.6
3 times	12.6b	5 lbs.	11.4
4 times	12.0b	7 lbs.	12.5
7 times	9.8a		

* Values followed by the same letter(s) are not significantly different at the 5% level using Duncans New Multiple Range Test.

when the rate increased from five to seven pounds. In 1971 the quality of turf on the seven-pounds plots was no better than on those receiving five pounds of fertilizer. By 1973 a reverse trend was noted, and by 1974 the quality had completely reversed, with the quality of turf on the three-pound plots significantly better than that on the five- or seven-pound plots.

There are two primary factors that contributed to this reversal in response to fertilization. First, it was noted during the first years of the study that copper spot *(Gloeocercospora sorgi)* incidence was positively correlated with nitroten rates increased. Injury resulting opened the turf to *Poa annua* invasion. Second, during the summer of 1973 extremely hot, humid weather occurred for a prolonged period. Turf on the plots receiving higher levels of nitrogen were actually scorched. This did not occur at the three-pound nitrogen rate. Again, *Poa annua* invasion was accelerated as a result. Photos taken in the spring of 1975 clearly illustrated the increase in *Poa annua* with increasing fertilizer rates. The percent of *Poa* present in December, 1974, as influenced by topdressing frequency and the amount of fertilizer used is shown in Table III.

For those who understand the management requirements of velvet bentgrass, these results might be predictable. The results also apply, however, to creeping bentgrasses. Although the fertility level might be at a higher level for creeping bentgrasses, probably fewer problems will occur if seasonal fertilizer rates are at lower levels than frequently used. Golfers may need to be reeducated to differentiate putting quality from color. It would be worth all the effort if a quality surface could be assured with the use of less fertilizer.

Table III. Percentage of *Poa annua* comprising turf cover, in December, 1974, as influenced by topdressing frequency and level of fertilization.

Topdressing frequency	% Poa annua	Fertilizer rate	% Poa annua
2 times	13.4	3 lbs.	2.7c*
3 times	15.7	5 lbs.	15.3b
4 times	15.4	7 lbs.	27.2a
7 times	15.8		

* Values followed by the same letter(s) are not significantly different at the 5% level using Duncans New Multiple Range Test.

A GREEN SECTION SUPPORTED RESEARCH PROJECT

Sulfur and Bentgrass Putting Green Turf

by DR. ROY L. GOSS,
Washington State University

Adequate soil fertility is of great importance to the growth and development of turfgrasses. The major plant food elements nitrogen, phosphorous and potassium have received most of the attention in turfgrass fertility research and practice; however, lack of any one of the essential plant nutrients, N, P, K, Ca, Fe, S, Mn, B, Mg, Cu, Zn, Mo, and Cl will result in unsatisfactory growth. The information presented in this paper will deal mainly with sulfur, but will attempt to bring out the influence of N, P, and S on various factors related to putting green turfgrass quality.

THE SULFUR PICTURE HAS CHANGED

A number of factors are responsible for increased sulfur needs of turfgrasses. Coleman (2) indicated that the use of high-analysis fertilizers that contain little or no sulfur, increased growth, and decreased gain of atmospheric sulfur by soils and plants as a result of decreased combustion of coal and other high sulfur fuels are some of these factors.

It is common knowledge that nutrients leach from sand at a faster rate than from heavier textured soils. Due to current emphasis on the use of sand for building putting greens and tees, we should be aware of the continual need to regularly supply all nutrients including sulfur in a reasonable ratio. In general, the higher the application of nitrogren, the greater the stress for sulfur and other nutrients due to increased growth. Nitrogen applications for greens vary from less than five to over 20 pounds per 1,000 square feet per year with eight to 12 pounds being very normal for many areas in the U.S.

Volk and Horn (5) reported that yields and sulfur content of Tifway bermudagrass clippings from ammonium sulfate vs. ammonium nitrate treatments superimposed on various potassium sources was significantly higher from the ammonium sulfate treated plots grown on a loamy fine sand soil. Woodhouse (6) has reported increased yields seven out of eight years on Coastal bermudagrass fertilized with 62 to 123 pounds of sulfur and 0 to 1,478 pounds of N per acre when grown on a Eustis sand. These citations support the writer's belief that sulfur has often been neglected on turfgrasses growing on sand.

ROLE OF SULFUR AND DEFICIENCY SYMPTOMS

Sulfur deficiencies seriously retard the growth of turfgrasses because the element is needed for:

1. Synthesis of the amino acids cystine, cysteine, and methionine, all required for protein synthesis.
2. Synthesis of some vitamins (biotin and thiamin, glutathione, and coensyme A).
3. The formation of certain disulfide linkages which are associated with the structural characteristics of protoplasm. This is also associated with cold resistance.
4. The formation of ATP sulphurylase, an enzyme concerned with the metabolism of sulfur.

There are several other cited needs for sulfur including its effect on chlorophyll content which affects photosynthesis.

SULFUR REQUIREMENTS FOR TURFGRASSES

There is little information available regarding the requirements and tissue sulfur levels for turfgrasses. Martin *et al* (4) stated that many field fertilizer experiments with S have been carried out, but only in a few has plant content of S been determined over a range of S rates or for an entire season. Love (3) reported higher levels of S in seaside bentgrass tissue than in Merion bluegrass or Pennlawn red fescue. He showed levels of 0.19, 0.15, and 0.12 per cent, respectively for the three grasses when receiving adequate fertilizer; and levels of 0.08, 0.06, and 0.04 per cent, respectively when deficient. Beaton (1) has stated that about 0.20 per cent S in turfgrass tissue would seemingly be about normal for good growth. Data presented by Love (3) also showed that tissue phosphorus levels were lower than tissue sulfur. It can be assumed from the little data available that S and P levels should be approximately equal.

SULFUR RESEARCH AT WASHINGTON STATE

The research reported in this paper was conducted at the Western Washington Research and Extension Center at Puyallup, Washington. Sulfur applications were started in 1967 on Astoria bentgrass putting green turf that was established in 1959 on a sandy loam soil. Fertilizer treatments from 1959 through 1967 were made up of all combinations of 20, 12 and 6 pounds of N, O and 4 pounds P_2O_5 phosphorus, and 0, 4 and 8 pounds of K_2O potassium per 1,000 square feet per year. In 1967, sulfur was applied to all plots that previously received potassium at rates of 0, 1.15, and 3.45 pounds of elemental wettable S per 1,000 square feet. Subsequently all potash was applied uniformly to all plots except the check at 8 pounds K_2O per 1,000 square feet per year. All sulfur was applied in March and April of each year in three equal applications.

EFFECTS OF S ON COLOR AND YIELD

All plots receiving 20 or 12 pounds N appeared significantly darker green when treated with 1.15 or 3.45 pounds S, regardless of P or K levels. The same treatments without S were pale, showing little response to N and had less turf density. Only slight color differences were observed at the 6 pound N level with any S treatment, but were slightly favored by 1.15 pounds S.

Although yield is not considered a highly desirable feature on putting greens, it still is a measure of vigor. Plots receiving 20 pounds N, 4 pounds P_2O_5 and 8 pounds K_2O per 1,000 square feet at both S levels produced 71 per cent more clippings than plots receiving N only. S applied at 1.15 pounds produced slightly more clippings than 3.45 pounds S. This indicates that 1.15 pounds S is adequate for good growth and color response and 3.45 pounds may be slightly above optimum.

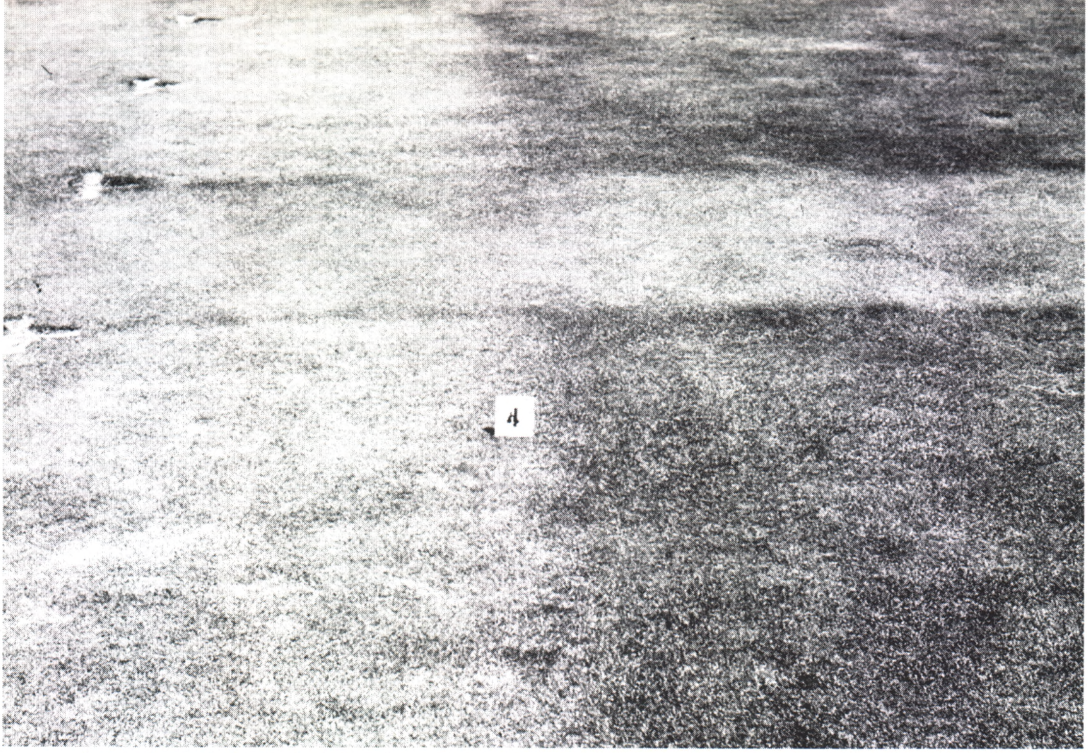
X-ray spectographic analyses have shown significantly higher levels of tissue S from plots receiving S than those without S at the same N-P-K treatment. Tissue S increased also with increasing S levels.

The significance of the above discussion is that continual removal of clippings stimulated by high levels of N can result in S deficiency unless fertilizers contain adequate amounts. These plots received N from urea, P from phosphoric acid, and K from muriate of potash, hence, essentially no S is applied as fertilizer impurity.

EFFECTS OF S ON POA ANNUA

A significant reduction in *Poa annua* populations was observed in all plots that received 3.45 pounds S regardless of N and K levels. The most significant *Poa annua* decrease was noted in plots receiving 6 pounds N as compared to 12 and 20 pounds N.

Phosphorus is an important element for the development of *Poa annua*. All plots receiving P, regardless of N, K and S levels, had higher populations of *Poa annua* than those without P. Plots that received



A section of the turf plots showing no S on the left and application of S on the right.

1.15 pounds S had higher populations of *Poa annua* than those receiving 3.45 pounds at all levels of N, P, and K. It appears that 1.15 pounds S provides the greatest stimulus to growth and color of both bentgrass and *Poa annua.* The highest populations of *Poa annua* were recorded from all N and P treatments. Plots receiving 1.15 pounds S without P at all N levels had less *Poa annua* than those receiving P.

EFFECTS OF S ON DISEASE AND WINTER HARDINESS

All plots receiving S had less *Fusarium* patch caused by *Fusarium nivale* than those without S, regardless of N, P, and K treatment. Plots that received the highest N levels, in general, had more disease than the lowest N plots. The mode of action of S in this case is not well understood, but may be related to a direct effect on the fungus itself or the increased formation of S containing substances which may make the plants more resistant. No *Ophiobolus* patch disease, caused by the fungus *Ophiobolus graminis* var. *avenae,* has been observed in any of the S treated plots, but does occur in some plots without S.

Increased resistance to low temperature injury was noted during one winter. The winters in western Washington are usually wet and mild, but occasionally temperatures fall below 15°F. accompanied with wind and no snow cover. After one such winter, all plots receiving S showed less scorching and greened up much faster than those without S. This is in agreement with statements made by Beaton (1) regarding the effects of S on structural characteristics of protoplasm.

THE EFFECTS OF S ON SOIL PH

Sulfur does increase soil acidity (lower pH) through reactions in the soil. Annual applications of 3.45 pound S per 1,000 square feet lowered the pH in some plots from 5.6 to 4.8 over a period of seven years. There was no noticeable effect from the lowered pH, and as pointed out previously, turfgrass quality was best in all plots receiving S. It should be pointed out that applications of 20 pounds of N per 1,000 square feet from urea without S reduced pH much lower than 12 or 6 pounds of N with the highest S rates. No lime has been applied to any of these plots since the research began; although calcium levels have fallen to as low as 1 meq. per 100 gm. of soil, there is no plant evidence of calcium deficiency.

CONCLUSIONS

Several important conclusions can be drawn with regard to sulfur applications to putting green turf as related to the conditions of this test.

1. Increased color, vigor and nitrogen utilization.
2. Highly reduced populations of *Poa annua* at the highest levels of S without regard to N, P, or K.
3. Low S levels (1.15 pounds per 1,000 square feet) caused an increase in *Poa annua* and general turf vigor.
4. Additions of P in excess of minimum maintenance requirements increased *Poa annua* in all treatments.
5. Decreased incidence of *Fusarium* patch disease and complete elimination of *Ophiobolus* patch disease.

6. Reduced earthworm activity.
7. Elimination of black algae.
8. Increased cold and dessication tolerance.

Sulfur investigations are continuing and it is hoped that more specific reasons for S activity can be clearly defined. Golf course superintendents have been advised to proceed with some caution since variable soil conditions, other chemical programs, and management practices may influence results.

We acknowledge with gratitude financial assistance provided by the USGA Green Section to aid in this research and advice and observations from Drs. C.J. Gould and S.E. Brauen.

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A GREEN SECTION SUPPORTED RESEARCH PROJECT

"TOUCHDOWN!"
A New Bluegrass for Golf

by ALEXANDER M. RADKO, DR. C. REED FUNK, THOMAS F. REWINSKI and MARTIN C. PICK[1]

The release of a new turfgrass variety is always an exciting event. It is the culmination of years of testing, research, and rigid evaluation pitting the new experimental turfgrass against all others which include experimental as well as standard commercial varieties. When one particular grass stands out in this evaluation procedure, it has to be a plant worthy of note and potential release to the turf industry. Such an exceptional turfgrass is Touchdown, a new Kentucky bluegrass selection released jointly by Rutgers University and the United States Golf Association Green Section.

What sets this grass apart from others? According to Dr. Funk, Touchdown growing in New Jersey exhibits good resistance to the following major diseases that attack bluegrasses:

(1) Leaf spot *(Helminthosporim vagans)*
(2) Leaf rust *(Puccinia poae-nemoralis)*
(3) Powdery mildew *(Erysiphe graminis)*
(4) Stripe smut *(Ustilago striiformis)*

Although Touchdown is not resistant to *Fusarium* blight caused by *Fusarium roseum* and *F. tricinctum* (no bluegrasses are), it does appear to get less of this disease than average.

Touchdown is a medium-low turf-type Kentucky bluegrass having upright leaves. Its leaf width is slightly finer than Merion. Touchdown has a pleasing bright medium dark green, whose color greens-up earlier in the spring and stays longer in the fall than does Merion. Under moderate fertility, this new Kentucky bluegrass variety has excellent density and good aggressiveness.

The story of Touchdown started in 1908 in Southampton, N.Y. on Long Island, when the renown National Golf Links of America, a Charles Blair Macdonald creation, was built and seeded. In those days

Tom Rewinski, Superintendent of the National Golf Links of America, on the 9th fairway where Touchdown was discovered.

The clubs extended from and touching the golf bag indicate the original size of the Touchdown plot when first discovered by Superintendent Rewinski. The clubs laid on the turf to the far right and far left show how big the clone has grown to-date—now measuring approximately 30 feet in diameter.

turfgrass seed production was not as sophisticated as it is today and seed was bulk-harvested from open fields and marketed. Seed lots contained a variety of progeny from whatever was growing in that particular seed field. Perhaps somewhere in this rather heterogenous seed lot that was to produce the fairway turf on the National Golf Links in 1908 was the beginnings of the new elite Kentucky bluegrass now named Touchdown.

Once planted, the fairway turf matured and individual pure clones developed over the years. The clone that was to become Touchdown (Rutgers experimental number P-142) continued to sprout rhizomes and spread, crowding out the other grasses in the fairway until, at the time of its selection in 1969 from the 9th fairway at the National, it covered an area approximately 30 feet across! This development and growth underscores the innate vigor and overall disease resistance of this grass under an intensive, low-cut fairway management program.

Credit for the discovery of this new Kentucky bluegrass variety belongs to Thomas F. Rewinski, superintendent of the National Golf Links of America. Mr. Rewinski has been associated with the club beginning in 1938 as a caddy. After completing a tour of duty in the Navy, he returned to the club in 1951 and became superintendent in 1958. It was under his watchful eye that the overall performance of this promising low-growing fairway-type turfgrass was first judged. It was pointed out to Alexander M. Radko, USGA Green Section Agronomist and National Research Director. After several inspections, Mr. Radko informed Dr. C. Reed Funk and a sample was entered into the Rutgers University turfgrass research and testing facility, in a project which is supported in part by the U.S.G.A. Green Section Research and Education Fund, Inc. Its ratings were continuously high at Rutgers and in other tests at other regional turfgrass experiment stations. As a result of its fine turf performance and potential, Pickseed West Inc. expressed interest and an agreement was entered into for the marketing privileges for this new variety of Kentucky bluegrass which subsequently was named *Touchdown.* Breeder to foundation seed was produced in the Madras area of Oregon. Establishment vigor of P-142-Touchdown was evident when a September seeding produced a subsequent seed crop in excess of 600 pounds per acre. After the 1975 harvest there should be sufficient seed available for limited use by the professional turfgrass industry. We believe it has a place in areas where Kentucky bluegrasses are grown.

[1] National Research Director, USGA Green Section; Research Professor in Turfgrass Breeding, Rutgers University; Superintendent, National Golf Links of America; Director, Pickseed Inc., respectively.

USGA GREEN SECTION RECORD
SEPTEMBER 1975

TURF TWISTERS

IF YOU NEED MAGNESIUM

Question: As a result of my recent soil tests, it is recommended that an application of dolomitic limestone be made. Why should dolomitic limestone be used instead of regular limestone? (Ohio)

Answer: Dolomitic limestone contains magnesium along with calcium. Apparently your soil test results indicated a deficiency in magnesium, hence the reason for the recommendation.

GET A LIFT

Question: In planning our new maintenance building, a question has come up on the possibility of installing a hydraulic lift in the service area. In your travels, have you seen where other golf course superintendents have made use of such a lift? (Mass.)

Answer: We certainly have! An automotive-type hydraulic lift can be a real time, money and labor saver besides being extremely handy for all types of major and minor repairs, including the all-important preventive maintenance work that must be done on the equipment today. We feel certain that a lift in your new (or old) golf course service area would be well worth the expense involved.

FROM A FLAGSTICK

Question: During a recent business-golfing vacation to Southern California, I was intrigued by a yellow, plastic ball (about the size of a Texas grapefruit) positioned on the flagstick of every green on the course I played. What's up? (Florida)

Answer: If the plastic ball is up, the flagstick or cup is located to the rear of the green. If it is in the mid position on the flagstick; the cup is generally in the middle section of the green and if the ball is low on the flagstick, the cup is forward on the green. The main idea, we are told, is to speed play.