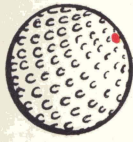


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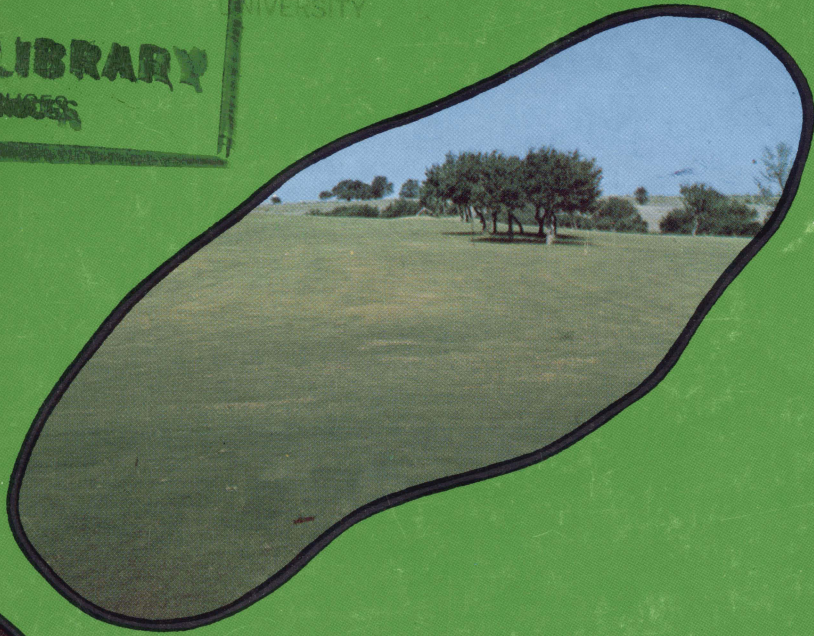


Bermudagrass Management on Golf Courses in Texas



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Cover photos
Courtesy John M. Griffith, Jr., Tolar, Texas

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SUMMARY

Bermudagrass tolerates a wide range of environmental conditions including drouth, heavy irrigation, heavy fertilization, close and frequent mowing and excessive traffic. Consequently, bermudagrass is widely used for golf turf throughout the South. Special purpose bermudagrasses have been developed for golf greens, tees and fairways. Tifdwarf and Tifgreen bermudagrasses are excellent for putting greens, while Tifway, Tifgreen and common are well suited for golf tees and fairways. U-3 bermudagrass is the most cold-tolerant of the golf turf selections and is used for tees and fairways in the Texas Panhandle. Certified stock of these bermudagrass selections is available in Texas; buyers should specify Texas Certified stock to guarantee source and purity of planting material.

Common bermudagrass is the only turf variety that can be established from seed. All other varieties must be established from vegetative material. If sod is purchased, it must first be shredded into fragments (sprigs) consisting of roots and stems. The sprigs should be uniformly broadcast over the seedbed at a rate of 5 to 10 bushels per 1,000 square feet on greens and 2 to 3 bushels on tees and fairways. Sprigs should be broadcast with a hydromulcher or other equipment, incorporated lightly with a disc or top-dressed with a sterilized soil mixture and watered lightly and frequently until they are rooted. Rolling with a heavy cultipacker or roller will help firm the seedbed and smooth the surface. Subsequent watering, fertilizing and mowing practices are the keys to attaining a fast cover.

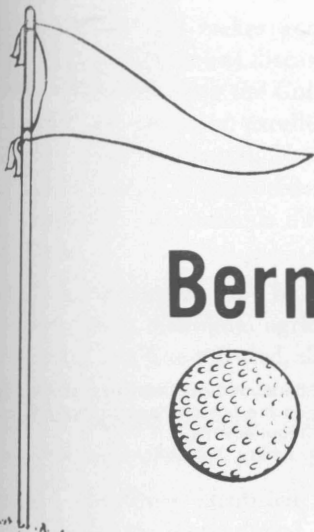
Bermudagrasses require a high level of maintenance to provide desirable and attractive playing surfaces. Irrigation rates and frequencies are dependent on climatic conditions and soil types within a specific area. Generally, an average of one-fourth of an inch of water per day is required to maintain bermudagrass turf during summer months. The frequency of application is determined by the storage capacity of the soil or soil mixture. Bermudagrasses have a high requirement for nitrogen fertilization. Bermudagrass greens and tees require

from 12 to 24 pounds of nitrogen per year to maintain a desirable playing surface, whereas fairway turf requires much less. Nitrogen sources largely determine the rate and frequency of applications. Mowing tolerances of bermudagrass turf range from one-eighth inch to several inches in height and from daily to monthly frequencies depending on the use of the turf.

Putting greens should be mowed daily at $\frac{1}{8}$ to $\frac{1}{4}$ inch to maintain a smooth uniform putting surface. Light, frequent, vertical mowing is required to reduce thatch and eliminate graininess in bermudagrass putting greens. Periodic aerification and top-dressing with a soil mixture are necessary to reduce thatch, alleviate surface compaction and maintain a smooth putting surface. Overseeding bermudagrass greens with a cool-season grass or grass mixture is required to provide a year-round playing surface. Maintenance of golf tees is similar to that of golf greens depending on quality of turf desired.

Maintenance of fairway turf is also similar to that of greens and tees, but the frequency of maintenance operations is reduced considerably. Fairways should be mowed from $\frac{3}{8}$ to $\frac{3}{4}$ inch depending on the grass variety, the frequency of mowing and the quality of turf desired. Irrigation should be sufficient to prevent severe wilting without creating wet playing conditions. Fertilization rates and frequencies should be adequate to maintain a green color and a dense turf without excessive growth. Under special circumstances, aerification and vertical mowing may be necessary to alleviate compaction and remove excess thatch accumulation from fairways.

Weed and other pest control practices should follow label recommendations as stated by the manufacturer of the product. Specific weed, insect and disease control recommendations may be obtained from county agricultural agents, turf extension specialists or others knowledgeable in the diagnosis of pest problems. Positive identification of the specific pest is the first step to its effective control.



Bermudagrass Management on Golf Courses in Texas

R. L. Duple, W. G. Menn and A. C. Novosad*

IN 1971 THERE WERE 540 GOLF COURSES IN Texas with a total of more than 7,000 golf holes according to the National Golf Foundation. The amount of money spent for turf maintenance on golf courses in Texas has risen dramatically in the past 20 years. The estimated cost of turf maintenance per hole for 1952, 1962 and 1970 was \$2,278, \$3,307 and \$4,577, respectively. Presently, \$35 million are spent annually for maintenance of golf course turf in Texas. This may be contrasted to only \$15 million in 1961, or more than a 100-percent increase in 10 years. Construction costs for golf holes have demonstrated even greater increases. These rising costs of construction and maintenance necessitate efficient and effective management practices. Current ideas and practices relating to the management of bermudagrass turf on Texas golf courses are summarized in this report. The information and management practices presented are based on research conducted at Texas A&M University from 1957 through 1972 and are intended for use in producing higher quality golf turf in Texas.

BERMUDAGRASS VARIETIES

Bermudagrass is a warm-season, sod-forming perennial that spreads by stolons and rhizomes. It is widely distributed throughout the southern part of the United States and widely used for lawns, golf courses, athletic fields and other turfgrass areas (Table 1). Common bermudagrass, *Cynodon dactylon* (L.) Pers., was introduced from Africa and is well adapted to the South where rainfall is sufficient and to the Southwest under irrigation. It is best adapted where the average daily temperature is above 75° F. Bermudagrass turns off-color

in cool weather and brown after frost. It does not tolerate dense shade or poor drainage and produces good-quality turf only on liberally fertilized soil. It is relatively drought resistant, but responds well to irrigation. Bermudagrass is fairly resistant to diseases and insects and rather tolerant to selective herbicides.

A number of improved varieties have been developed for turf usage through extensive hybridization and selection. Most improved varieties are sterile, or nearly so, and must be propagated vegetatively. Improved bermudagrass varieties released by the State Agricultural Experiment Stations, the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture (USDA), the U. S. Golf Association Green Section (USGA) and other organizations are subject to *certification* in Texas. The purchase of *certified* turfgrass sod or sprigs guarantees the buyer a pure source of planting material. In the case of common bermudagrass, the buyer is encouraged to purchase *certified* seed.

Common bermudagrass is the most widely used grass for golf course turf in Texas. It is a relatively coarse-textured grass but is well suited for tees and fairways. Common bermudagrass putting greens require frequent top-dressings and vertical mowing to provide

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Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by The Texas Agricultural Experiment Station and does not imply its approval to the exclusion of other products that also may be suitable.



Bermudagrass varieties should be selected on the basis of appearance and maintenance requirements.

an acceptable putting surface. Common can be established from seed or vegetative material. Common bermudagrass is rapidly being replaced by the finer-textured varieties on golf greens.

Tifgreen bermudagrass, released in 1956 at Tifton, is a fine-textured, vigorous hybrid that makes a dense, weed-resistant turf. Tifgreen (Tifton 328) is the South's most widely used putting green grass. It produces an excellent quality putting green which tolerates overseeding with cool-season grasses better than most bermudagrasses. Tifgreen bermudagrass must be established from vegetative material. Certified planting sprigs of Tifgreen are available through certified producers in Texas.

Tifdwarf bermudagrass, released in 1965 by the Georgia Coastal Plain Experiment Station at Tifton, is a superior grass for golf greens. Glenn W. Burton, who helped develop the grass, said, "Its tiny leaves hug the ground so closely that a number of them are never cut by the greensmower. This characteristic helps it to tolerate a 3/16-inch cutting height better than Tifgreen. Its softer leaves and fewer seed heads also contribute to its superior putting quality. Tifdwarf has a darker green color than Tifgreen. Its basic purple plant color, which helps to keep it looking dark green in the summertime,

becomes very noticeable when temperatures drop in the fall. As a consequence, Tifdwarf takes on a purplish cast that may prove objectionable to some." Tifdwarf has proved to be winter hardy in areas of Texas where Tifgreen has been successfully grown. At Texas A&M University's turf research laboratory, Tifdwarf has produced a darker green and denser turf than Tifgreen. It also has about the same nutrient requirements as Tifgreen but appears to be more susceptible to sod webworm and bermudagrass mite damage. Tifdwarf requires less top-dressing material than Tifgreen to produce a smooth putting surface. Certified planting sprigs of Tifdwarf are available through certified producers in Texas.

Tifway bermudagrass, selected as Tifton 419, was released in 1960 by the Georgia Agricultural Experiment Station for use on fairways and tees. Tifway has an upright growth habit, stiff leaves and a dark green color. These characteristics make it superior for fairway use. Tifway does not recover from injury as fast as Tifgreen or common bermudagrass. Certified planting sprigs of Tifway are available through certified producers in Texas.

Texturf 1F, selected as T35A, was released by The Texas Agricultural Experiment Station at College Station in 1957. Texturf 1F is a fine-textured, light green grass that produces a dense turf. It is relatively free of

TABLE 1. CHARACTERISTICS OF BERMUDAGRASS VARIETIES USED FOR PUTTING GREEN TURF IN TEXAS

Variety	Texture	Color	Seed head production	Thatch accumulation	Disease resistance	Quality ¹
Sunturf	Medium	Very dark	Few	Light	Poor	Good
Tiffine	Fine	Light	Abundant	Heavy	Fair	Fair
Tifgreen	Fine	Dark	Few	Medium	Fair	Excellent
Gene Tift	Fine	Light	Abundant	Medium heavy	Fair	Fair
Texturf 1F	Medium	Light	Few	Medium	Poor	Good
Tifdwarf	Fine	Very dark	Very few	Medium	Fair	Excellent
Common	Very coarse	Medium	Abundant	Light	Poor	Poor

¹An overall evaluation of bermudagrass varieties based on general appearance, density, spring recovery, putting quality and maintenance requirements.

unsightly seed heads and makes good spring recovery. Texturf 1F is susceptible to leaf diseases and, consequently, is not recommended along the Gulf Coast and in East Texas. Texturf 1F produces excellent quality turf on golf courses in areas of Central, North and West Texas where frequent watering is practiced. Certified planting sprigs of Texturf 1F are available through certified producers in Texas.

Sunturf was released in 1956 by Alabama, Arkansas, Oklahoma and South Carolina agricultural experiment stations. Sunturf is a fine-textured, dark green, turf-type bermudagrass. It is susceptible to leaf diseases, but they do not cause permanent damage. Sunturf is sufficiently fine to be used as a putting green grass.

Bayshore, sometimes identified as Gene Tift, was released by the Florida Agricultural Experiment Station at Gainesville. It was selected at the Bayshore Golf Club, Miami Beach, in 1945 and is believed to be a natural hybrid between common bermudagrass and an introduced species from South Africa. It is light green in color and fine-textured. It has been used as a fairway and putting green grass but now is being replaced with superior selections. Numerous variations have appeared in Bayshore greens. Bayshore also produces abundant seed heads under conditions of drouth and unbalanced nutrients.

Tiffine bermudagrass was released by the Georgia Agricultural Experiment Station in 1953. It is light green in color, fine textured and more disease resistant than common bermudagrass. Tiffine, like Bayshore, produces abundant seed heads under stress conditions. Tiffine is no longer being planted on new greens; both established Tiffine and Bayshore greens are being replaced by newer selections.

U-3 bermudagrass was released in 1947 by the USGA Green Section and the USDA. It is a moderately fine textured, cold tolerant and fast spreading grass that is adapted for use on tees and fairways in the Texas Panhandle.

BERMUDAGRASS ESTABLISHMENT

With the exception of common bermudagrass, the bermudas used on golf courses must be established from vegetative material. Common can be established either vegetatively or with seed. Seed or vegetative material to be used should be of known varietal purity and free from troublesome weeds. State certified planting material and seed should be used to assure genetic purity and minimum weeds. The use of noncertified planting material from unknown sources may result in the wrong variety or mixture and the introduction of troublesome weeds such as purple nutsedge and others.

Seed are available from two general types of bermudagrass—common bermudagrass and giant bermuda-

grass. Both are grown in western states where most of the common bermudagrass seed are produced. Giant bermudagrass is a coarse, vigorous growing, open, upright type adapted for pasture and hay use. It is frequently a weed in seed fields of common bermudagrass. As a result some lots of common bermudagrass seed sold for turf purposes also have giant mixed with them. Buying and using only certified common bermudagrass seed will prevent this possibility.

U-3 bermudagrass produces seed sometimes offered for sale. This seed should be avoided; establishment should be with vegetative material from a certified source. Seed from U-3 do not produce plants like U-3.

Greens

Proper green construction and soil preparation are necessary prior to grass establishment. Properly built greens will help insure good grass growth and minimize maintenance. Many problems associated with soil compaction, water infiltration, poor drainage and poor playing conditions usually can be avoided by proper green construction.

Some specifications for putting-green construction follow:¹

1. Locate the greens in full sunlight where there is good air movement.

2. Provide good soil drainage. This usually will necessitate the use of tile below the surface overlaid with crushed rock or pea gravel followed with coarse sand and with 12 inches of suitable soil mixture in which the grass is to grow. The top soil mixture, such as washed and screened sand, soil and peat in an 8-1-1 ratio or other materials should be properly proportioned and mixed in accordance with test results from a competent laboratory such as the USGA Soil Testing Service, Box 5248, State College, Mississippi 39762. Samples of materials available for use are subjected to tests, and recommendations of a suitable mixture are made for a nominal fee.

3. Contour the green to drain the water from its surface away from the paths of heavy traffic.

4. After applying the topsoil mixture, uniformly incorporate fertilizer and/or lime requirements according to a soil test recommendation. Usually, a complete fertilizer, such as 12-12-12, applied at a rate of 15 to 20 pounds per 1,000 square feet will be adequate. After the soil has been leveled and smoothed, it should be compacted or firmed. Firming will eliminate soft spots and result in having the stolon bed uniformly firm. Use of water is helpful in settling and firming the surface and

¹Detailed specifications for putting-green construction are available from the U.S. Golf Association Green Section, 40 East 38th Street, New York, New York 10016 for a nominal fee.

also will reveal any water-holding depressions which might interfere with surface drainage.

5. Before planting, fumigate the soil with 1.5 to 2 pounds of methylbromide per 100 square feet applied under air tight covers for 24 to 48 hours to kill weed seeds, nematodes and other soil-borne pests. For effective results, soil temperatures must be above 50° F. Wait 48 hours after removing covers before planting the grass.

The vegetative planting material should be freshly harvested, kept moist and protected from desiccation by the wind and the sun. It likewise should not have been exposed to undue heating, which can occur when moist material is allowed to remain packed for extended periods of time, especially when temperatures are high. Exposure to freezing temperatures, of course, should also be avoided. The soil should be moist when material is planted.

There are several methods of planting, such as setting sprigs at intervals of 6 to 12 inches or broadcasting sprigs and stolons. For a quick cover and minimal weed problems, broadcasting 5 to 10 bushels of shredded sprigs or stolons per 1,000 square feet is suggested. The heavier rates permit earlier play. Most greens today are established by a method known as "stolonizing." This refers to the planting of shredded stolons or fragments of bermudagrass roots and stems resulting when the grass sod is chopped into fine pieces. This shredded material is spread over the area with mechanized equipment and then lightly incorporated into the existing soil or covered lightly with sterilized topsoil mix. About one-fourth inch of soil is usually adequate; this is approximately three-fourths cubic yards per 1,000 square feet. The soil should be the same as that used in the topsoil mixture for the green. After the soil is added, the area should be rolled lightly. If coarser planting material is used, then it should be incorporated deeper into the soil, or topsoil should be added to cover the sprigs adequately. Rolling should follow to smooth the surface and to firm the soil around the sprigs.

The sprigs should be watered immediately after planting and the soil kept moist by frequent light waterings. This may require two to three waterings daily, especially under conditions of high temperatures and low humidity. The frequent watering schedule should be continued until the grass is well rooted and growing. The schedule then should be adjusted to apply more water each time, but less frequently, in order to encourage a deeper root development.

As the grass starts to grow, additional nitrogen fertilizer will be needed. At the initiation of grass growth, approximately 1.5 pounds of N per 1,000 square feet should be applied and this application repeated every 2 weeks until a good cover is attained. Nitrogen fertilizer, along with optimum moisture conditions, is the key to attaining a quick cover.

Mowing should begin as soon as some of the grass reaches a height of approximately 1 inch. While the turf is becoming established, the cutting height should probably be at least one-half inch, or high enough to prevent scalping of high spots. As the green settles and low areas are filled by topdressing, the cutting height should gradually be lowered as the smoothness of the surface permits. When the turf is fully established, the cutting height should be at the desired height for play.

The same topsoil mixture used in construction should be added to fill low spots and to smooth rough areas. This operation should begin as soon as the turf is well enough established to permit this being done without damage. Approximately one-fourth cubic yard of topdressing per 1,000 square feet may be applied in a single operation without damage to the turf. The turf should be permitted to recover between topdressing operations.

Tees and Fairways

The tee surface often is only fill-soil. The most desirable loam or sandy loam soil should be reserved for the tee surface. Site conditions generally do not justify elaborate seedbed building or the installation of subsurface drain lines, but some modification of the topsoil is often desirable. This is especially true where tee areas are small and subjected to heavy use. Tees should be constructed to allow good surface drainage, with gentle slopes which are machine-mowable.

Since considerable acreage is involved in fairways, grass is usually established in the existing soil without modification. If areas are to be cut during construction, the topsoil should be set aside and spread back over when the cuts are completed. The soil should not be worked while it is excessively wet. The fairway area should be thoroughly cultivated in order to form a seedbed that is firm and free of weeds and undecayed plant parts or other organic materials. Provision for adequate surface water drainage should be considered in the construction phase.

When vegetatively propagated bermudagrass is to be used on fairways and tees, the planting procedure is similar to that for greens. A lower planting rate is often used on fairways because quick establishment is usually not so critical; thus, costs can be reduced. A minimum rate should be 2 or 3 bushels per 1,000 square feet or 100 bushels per acre. The sprigs should be broadcast on a clean seedbed and incorporated into moist soil by disking or otherwise. Rolling should follow immediately. Covering with topsoil is generally not practical on extensive areas such as fairways. Good moisture conditions must be maintained to assure a good cover.

Common bermudagrass is often seeded on fairways and tees. The seeding rate should be 20 to 40 pounds

of hulled common bermudagrass seed per acre. The higher rate will give a quicker cover with fewer weed problems. Seeding can be accomplished by disking the prepared seedbed lightly and following with a drag or light roller to smooth and firm the soil. The seed should then be broadcast evenly over the area and rolled again. A corrugated-type roller usually works best for this operation. Special seeders are available which will do the rolling and seeding in one operation. Regardless of the planting method, the seed should only be pressed into the moist soil and not covered deeply.

Moisture is critical in bermudagrass establishment from seed. The top inch of soil must remain moist for 15 to 20 days after planting for new bermudagrass seedlings to establish sufficient root systems to survive. Thus, rapid drying of the top inch of soil after the seeds germinate and before the roots have penetrated below this depth results in high seedling mortality.

Mulching of newly planted areas is sometimes beneficial. This may be helpful especially when establishing grass on slopes or when water evaporation rates are high. Natural mulches such as straw or hay may be used as well as manufactured mulches, such as cellulose. Special hydroplanting equipment is available to apply seed or shredded stolons along with a special mulch, mixed with water. Fertilizer also can be applied in the same operation.

Fertilizer and/or lime needs, determined by a soil test, should be incorporated into the soil during seedbed preparation just prior to planting, either vegetatively or with seed. The nitrogen fertilizer can be withheld in the initial soil application to reduce the encouragement of early weed growth ahead of the grass. In this event, approximately two pounds of N per 1,000 square feet, or 80 pounds per acre, should be applied immediately as the grass starts growth, with additional applications of approximately 60 pounds per acre at monthly intervals until a good cover is attained.

Mowing should begin as soon as there is sufficient grass and/or weed growth. Most weeds in bermudagrass can be controlled through the use of selective herbicides, such as the organic arsenicals and 2,4-D. Mixtures of these herbicides which will control both grassy and broadleaved weeds in one application are available. The elimination of competitive weeds will greatly enhance bermudagrass growth and coverage.

Roughs

A common practice in the past was to permit roughs to be occupied by naturally occurring vegetation which is mowed occasionally. The trend today is to plant roughs as well as fairways. Acceptable cover and playing conditions are obtained by adjusting height and frequency

of cut and by controlling fertilizer application. Bermudagrasses such as common or Tifway produce tough roughs but can be used if there is not too much shade. To help establish fairness in penalties, the grass can be mowed at an intermediate height adjacent to the fairways and maintained at increasing height as distance away from the fairways increases.

BERMUDAGRASS MAINTENANCE

Bermudagrasses in general are drouth tolerant; that is, they will survive dry soil conditions longer than most turfgrasses. However, the drouth tolerance of bermudagrass is based on the ability of this plant to become semi-dormant and to resume growth when moisture is adequate. The grass does not provide a desirable turf under drouth conditions but responds readily to irrigation. On the other hand, bermudagrass will not tolerate poorly drained soils. Thus, irrigation practices are critical for the maintenance of fine bermudagrass turf. On poorly drained soils overwatering can result in the loss of turf.

In general, the water requirements for bermudagrass turf, for a particular area of the State, are dependent upon the water-holding capacity of the soil and the evapotranspiration rate of the site. The water-holding capacity of a clay soil (heavy soil) is greater than that of a sandy soil. Thus, a clay soil will require less frequent watering than a sandy soil. The evapotranspiration rate changes from day to day but is primarily dependent upon temperature and, consequently, will vary considerably between seasons and between areas of the state. It may range from less than one one-hundredth inch of water per day during the winter to greater than one-third inch of water per day during the summer. Thus, under extreme conditions one-third inch of water per day might be required to maintain adequate soil moisture. Watering systems for golf courses must be designed to meet the requirements for bermudagrass turf during stress periods.

The frequency of application and quantity of fertilizer required for bermudagrass turf depend on the length of the growing season, the soil type, the variety, the desired appearance and growth rate and the source of nitrogen used. In Texas, the length of the growing season for bermudagrass varies considerably from north to south. In general, South Texas has a 9- to 12-month growing season for bermudagrass, whereas North Texas has a 6- to 8-month growing season. The quantity of fertilizer required increases with the length of the growing season.

Soil type also influences the frequency and quantity of fertilizer required. Some soils are inherently low in one or more plant nutrients. Soil tests² provide one

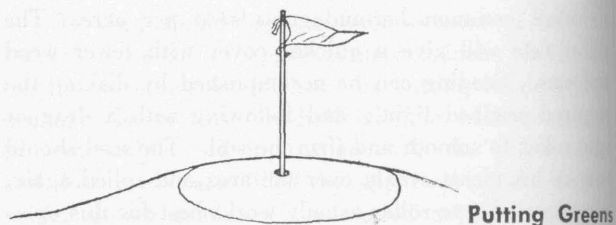
²Soil samples may be sent to the Soil Testing Laboratory, Texas A&M University, College Station, Texas 77843.

means of detecting nutrient deficiencies. Efficient fertilizer practices can be made only on the basis of soil tests. The frequency of application of fertilizer also depends on the soil type. Sandy soils are generally more subject than clay soils to leaching of fertilizer nutrients. Thus, nitrogen fertilizers need to be applied in smaller and more frequent applications on sandy soils than on clay soils.

Bermudagrass varieties differ in nitrogen requirements. In general, the fine-textured varieties need to be maintained at a higher level of nitrogen than common bermudagrass. The desired color, density and growth rate of bermudagrass largely determine the amount of fertilizer required. The dense, dark green turf demanded for putting greens requires higher levels of fertilizer than fairway turf where the same color and density are not essential. Likewise, tees require a higher level of fertilizer than fairways because of the heavier traffic and greater injury from clubs on golf tees. The rate of recovery of bermudagrass turf on golf tees is directly related to the level of nitrogen fertilizer applied.

The source of nitrogen used largely determines the frequency and quantity of fertilizer applications required to produce a uniform appearance. Nitrogen from inorganic sources such as ammonium nitrate and ammonium sulfate is readily available to the grass. Thus, inorganic nitrogen sources produce a rapid growth stimulation followed by a sharp decline in growth rate and color. Therefore, it is necessary to apply inorganic nitrogen sources in small, frequent amounts. Nitrogen from organic sources such as sewage sludge and ureaformaldehyde is not as readily available as nitrogen from inorganic sources. Consequently, larger and less frequent applications can be made. Organic nitrogen sources are often used on putting greens where a uniform growth rate is important. Frequently, a combination of organic and inorganic nitrogen sources is used to obtain the advantages of both materials.

Mowing requirements for bermudagrass turf are dictated by variety, usage and maintenance intensity. In general, fine-textured bermudagrasses require closer and more frequent mowing than common bermudagrass. Turf usage largely determines the mowing height and frequency required to maintain desirable characteristics. Putting green turf is mowed at a height of $\frac{1}{8}$ to $\frac{1}{4}$ inch and from four to seven times each week. Fairways and tees are mowed at a height of $\frac{3}{8}$ to $\frac{5}{8}$ inch from two to three times each week. In general, the shorter the mowing height, the more frequently the grass should be mowed. Mowing requirements are dependent upon the maintenance level imposed on the turf. Nitrogen fertilization and watering practices largely determine the required frequency of mowing for avoiding excessive accumulation and injury to turf.



Golf course putting greens constitute the most intensively managed areas in Texas agriculture. The improved varieties of bermudagrass, materials and equipment make possible the putting green quality afforded golfers today.

Mowing

Bermudagrass putting greens should be mowed at $\frac{1}{8}$ to $\frac{1}{4}$ inch depending on the variety of grass and the putting speed desired. Tifdwarf mowed at $\frac{1}{8}$ inch will produce a very fast putting surface, while Tifgreen or Texturf 1F mowed at $\frac{1}{4}$ inch will produce a slower putting surface. The height of cut is determined by setting the greens mower but is influenced by the amount of mat or thatch present. A putting green with very little thatch will provide a faster and smoother putting surface than a green with a heavy thatch when mowed at the same height. When a heavy thatch is present, the height of cut is greater than the mower setting indicates. Tifdwarf should be mowed daily at a height of $\frac{1}{8}$ to $\frac{3}{16}$ inch. Tifgreen and other varieties should be mowed daily at a height of $\frac{3}{16}$ to $\frac{1}{4}$ inch. Less frequent mowing favors the accumulation of thatch which leads to dry spots, scalping and sponginess.

Fertilization

Bermudagrass has a high nitrogen requirement for maintenance of high quality putting greens. Depending on the length of the growing season, 8 to 20 pounds of nitrogen per 1,000 square feet may be required each year. The ratio of nitrogen, phosphorus and potassium removed from bermudagrass putting greens is approximately 4-1-2. The nitrogen requirement can be met from inorganic nitrogen sources such as ammonium nitrate and ammonium sulfate, but a uniform growth rate is difficult to maintain. Nitrogen should be applied at 1 to 2 pounds of actual N per 1,000 square feet at two- to three-week intervals during the growing season if these materials are used (Table 2). Because the nitrogen from these inorganic sources is completely water soluble and is readily available to the plant, a rapid response can be expected. The material must be watered into the soil so that the grass is not burned. Organic nitrogen sources such as sewage sludge, ureaformaldehyde and IBDU can be used alone or in combinations with inorganic sources to meet nitrogen requirements. The nitrogen from the organic sources is not readily available

TABLE 2. SUGGESTED FREQUENCY AND RATE OF APPLICATION FOR VARIOUS NITROGEN SOURCES FOR PUTTING GREEN TURF

Source	Rate	Frequency
	Lb. N/1,000 sq ft	Weeks
Inorganic		
Ammonium sulfate	1 to 2	2 to 3
Ammonium nitrate	1 to 2	2 to 3
Other soluble sources	1 to 2	2 to 3
Synthetic organic		
Urea	1/2	1
Ureaformaldehyde	4	6
IBDU	4	6
Natural organic		
Sewage sludge	1 to 1 1/2	3 to 4
Combinations of inorganic and organic sources	2 to 3	4 to 5

to the plant, but is released slowly over a period of several months. Sewage sludge at 1 to 1 1/2 pounds N per 1,000 square feet at 3- to 4-week intervals or ureaformaldehyde or IBDU at 4 pounds N per 1,000 square feet at 6-week intervals will meet the nitrogen requirements for bermudagrass putting greens during the growing season (Table 2).

Phosphorus and potassium requirements can be met from various complete fertilizers such as 12-12-12 and 16-4-8 or from fertilizer materials such as super phosphate, 0-20-0, and muriate of potash, 0-0-60. In the fertilizer analysis such as 16-4-8, the first number (16) represents the percent elemental nitrogen, the second number (4) represents the percent P₂O₅ and the third number (8) represents the percent K₂O. Applications of these materials should be based on "soil test" recommendations, and materials should be applied in the fall and spring at recommended rates. Unnecessary applications of these materials are expensive and may lead to problems associated with an imbalance of plant nutrients.

Watering

Bermudagrass requires abundant water during the growing season to maintain a high quality putting surface. In some circumstances greens may require water at a rate of one-half or more inches per day during stress periods. The water requirement depends on the evapotranspiration rate and the soil mixture used in the putting green. During hot, dry, windy weather, greens will dry out rapidly, and daily watering may be required to prevent severe wilting. If greens are properly constructed, the putting surface and aprons will not become water logged following daily watering at heavy rates. On poorly constructed greens, heavy, frequent watering will result in saturated soil conditions with oxygen being excluded from the soil. If the oxygen supply in the root zone is depleted, bermudagrass cannot utilize the water even though the soil may be saturated. Thus, where water infiltration rates are less than one-half inch per hour, the soil should be allowed to dry to the point

where the grass begins to wilt before being watered. After greens are observed for a time, a watering schedule can be established that will meet the water requirements of bermudagrass without excluding oxygen from the root zone.

Water infiltration rate is important when establishing a watering schedule. Water should never be applied faster than the soil can absorb it because much of it will be lost through runoff, and very little will penetrate the root zone of bermudagrass. Putting greens constructed according to USGA Green Section specifications will have an adequate infiltration rate to meet watering requirements. Light, frequent application of water discourages deep rooting in bermudagrass and encourages disease and weed development. Thus, water should be withheld until the grass begins to show stress; then water should be applied until the root zone is thoroughly wet. Putting greens should never be watered to hold a golf shot. This must be accomplished through aerification and top-dressing practices.

Hard, compacted greens that have a very low infiltration rate can be improved by aerifying and top-dressing with a coarse-textured material. Preferably, an aerifier with 1/2-inch hollow tines that remove 3-inch cores on 2-inch centers should be used for this operation. The soil cores should be removed and replaced by top-dressing of a washed sand or a mixture of sand and calcined clay. The coarse-textured material should be worked into the holes by being dragged in several directions with a heavy, steel mat. This material will help to keep the holes open for the infiltration of air and water.

The presence of a heavy thatch layer will also interfere with the movement of air and water into the soil. Thatch can be removed by aerification and vertical mowing. The residue must be removed by a brush or vacuum sweeper. Top-dressing the green will also encourage thatch reduction and improve water movement.

Verticutting

Bermudagrass, like creeping bentgrass, spreads by stolons and becomes quite grainy during the growing season. Vertical mowing on a regular schedule will prevent graininess and provide an excellent putting surface. Vertical mowing in two directions at 2-week intervals with the blades set to cut only the grass runners will not noticeably discolor the turf and will help produce a true putting surface. The same practice on a weekly schedule will eliminate graininess and reduce thatch accumulation and produce a fast, smooth putting surface. The vertical mower may also be used following aerification to break up and scatter the soil cores. The vertical mower should be used routinely as a management tool and not on an emergency basis as a renovator.



Vertical mowing is required to reduce grain and thatch in bermudagrass turf.

Aerification

The need for aerification of putting greens must be determined on an individual basis. Again the green construction and soil mixture should determine aerification practices. Greens constructed according to USGA Green Section specifications will have adequate aeration for deep root growth. However, it will be necessary to aerify greens to encourage bermudagrass transition in the spring, to reduce thatch accumulation during the summer and to alleviate compaction resulting from heavy traffic. A minimum of two aerifications each year is essential to good bermudagrass putting greens. Aerification should be accomplished with $\frac{1}{4}$ - to $\frac{1}{2}$ -inch hollow tines that remove a 2- or 3-inch soil core at relatively close intervals. One-half inch tines may be used during

the spring and fall to remove maximum soil and thatch accumulation. Smaller tines should be used during the summer months.

Soil cores may be shredded with a vertical mower and dragged with a steel mat to provide top-dressing, or they may be removed from the green. If removal of thatch or elimination of compaction is the purpose of the aerification, the cores should be removed from the green and replaced by a good top-dressing mixture. If the aerification is to encourage bermudagrass transition in the spring or to destroy surface crusts, the soil cores may be shredded and dragged.

Putting greens constructed of material with a rather large percentage of fine sand, silt and clay tend to be hard and compacted when subjected to heavy traffic. These greens will require more frequent aerification than properly built greens to overcome compaction and to hold a golf shot. Putting greens constructed with a mixture of sand, organic matter and soil (8-1-1 ratio) will not require frequent aerification.

Top-dressing

Three practices prevent accumulation of organic residues and compacted soil conditions—vertical mowing, aerification and top-dressing. All are essential to the maintenance of fine bermudagrass turf. Top-dressing is an expensive and arduous task and requires advanced planning and organization. Equipment to shred, blend and screen the top-dressing material is essential, as is an automatic top-dressing machine. This equipment is expensive, but saves labor and does a better job than hand mixing and spreading. The success of the top-dressing operation depends largely on the choice of material for use in the mixture. If the soil in the greens provides good drainage, water and nutrient retention and



Golf greens need aerification to reduce thatch accumulation and to alleviate surface compaction from heavy traffic.

aeration, the top-dressing material should be of the same general nature. If the soil or soil mixture has not performed satisfactorily, a more desirable mixture should be used for top-dressing. In this case a physical analysis of the materials available for use should be made by the USGA Soil Testing Service³ or another competent soil testing laboratory. The service will include a recommendation for a suitable mixture for top-dressing or green construction. This mixture should become the permanent top-dressing material.

After the proper top-dressing material is shredded, blended and screened, it should be sterilized with methyl bromide or another sterilant and composted for 8 to 10 months prior to use. Top-dressing should be stored in a dry place to insure free flow at the time of application.

Light, frequent applications of top-dressing are more beneficial than heavy, infrequent applications. Tifdwarf bermudagrass, in particular, will not tolerate heavy top-dressing. The application of $\frac{1}{2}$ to $\frac{3}{4}$ cubic yards per 5,000 square feet of putting surface at least four times during the growing season is recommended. A top-dressing should never be so heavy as to cover the grass.

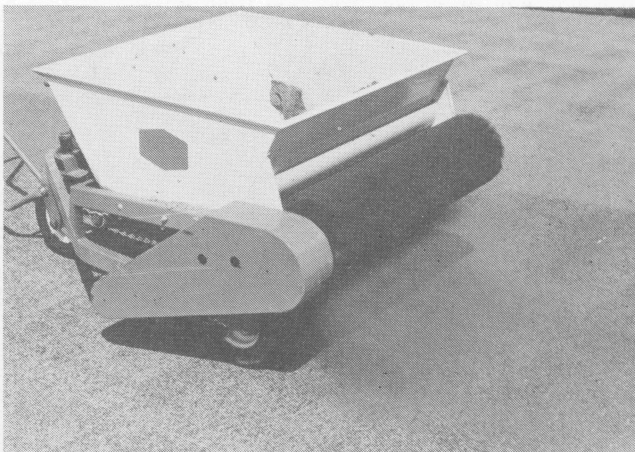
The benefits of top-dressing are pointed out by William Bengueyfield:⁴ "Top-dressing does more than smooth the putting surface. It encourages new growth, resulting in dense, upright and fine-bladed turf. Top-dressing helps prevent thatch accumulation by encouraging organic matter decomposition. It also increases water and nutrient retention in the soil profile; thus, localized dry spots are reduced. Top-dressing adds resilience to the surface; thus, top-dressed greens 'hold' a golf shot better. On heavily played greens, this point is of particular importance. Greens top-dressed just prior to the winter also have fewer problems from desiccation and winter injury."

³Send samples of material to Agronomy Department, USGA Soil Testing Lab, Box 5248, State College, Mississippi 39762.

⁴Bengueyfield, William. 1969. Top-Dress Greens and See the Difference. USGA Green Section Record. 1:1-4.



Top-dressing material is composted several months before being applied to golf greens.



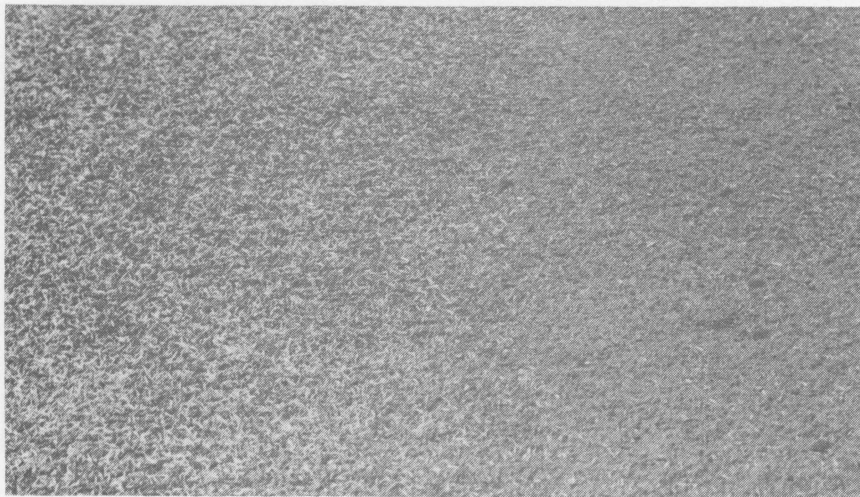
Top-dressing golf greens helps to smooth the putting surface, to reduce thatch and to improve the resilience of the turf.

Top-dressing is expensive but essential to maintaining fine bermudagrass putting greens. Although it does not produce immediate miracles, its long-range benefits are undeniable. Together vertical mowing, aerifying and top-dressing can do much for the maintenance of fine bermudagrass putting greens.

Overseeding

To protect dormant bermudagrass from traffic and to provide a green, uniform putting surface during the winter, cool-season grasses or grass mixtures are seeded each fall. The alternatives to overseeding—spraying colorants on dormant turf, playing temporary greens or playing dormant greens—are generally unacceptable to the golfer. The success of the overseeding depends largely on the preparation of the greens prior to planting. Bermudagrass will survive the winter and recover earlier in the spring if it is healthy and relatively free of thatch going into the dormant period. Aerification, vertical mowing and top-dressing four to six weeks prior to the overseeding date will help alleviate soil compaction, reduce thatch accumulation and encourage bermudagrass root development. Aerifying with $\frac{3}{8}$ - to $\frac{1}{2}$ -inch hollow tines and light vertical mowing in several directions will remove much of the organic residue and grass runners that contribute to thatch. Top-dressing with one-eighth inch of material and fertilizing with nitrogen will encourage organic matter decomposition and stimulate bermudagrass regrowth.

At the time of overseeding, light vertical mowing in two directions will thin bermudagrass and reduce competition with overseeded grasses. "Soil test" recommendations with respect to P, K and lime should be followed. Excessive phosphorus may encourage *Poa annua*, whereas phosphorus or potassium deficiencies will retard overseeded grasses. Nitrogen fertilization should not be excessive and may be delayed until seedlings have emerged. Selection of grass or grass mixtures and seeding rates depend somewhat on results desired. For



Overseeding bermudagrass greens is necessary to provide an acceptable putting surface throughout the winter. The photograph shows the seed before top-dressing (left) and after top-dressing (right).

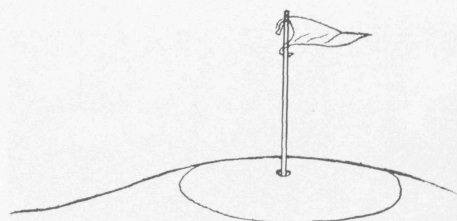
example, perennial ryegrasses seeded at 40 pounds per 1,000 square feet will provide a fine-textured, dense and uniform putting surface that will tolerate heavy traffic. Other desirable qualities of the ryegrasses are their rapid germination and establishment and their excellent competition with annual bluegrass (*Poa annua* L.). *Poa trivialis* at 10 to 12 pounds per 1,000 square feet will provide a fine putting surface but will not tolerate as much traffic or compete with annual bluegrass as well as the perennial ryegrasses. Other cool-season grasses include bluegrasses, fescuegrasses and bentgrasses, most of which are used in mixtures of two or more varieties. The alternatives are numerous, but in Texas the most popular combinations contain various amounts of Sea-side bentgrass, *Poa trivialis* and Kentucky bluegrass or fescue.⁵

Overseeded greens will require light, frequent watering until seedlings are established. It may be necessary to water several times each day during the first 2 weeks after seeding. Putting greens should be mowed at $\frac{1}{4}$ to $\frac{5}{16}$ inch with a freshly sharpened mower during this time. Regular mowing schedules may be maintained. *Pythium*, *Rhizoctonia*, *Helminthosporium* and other seedling diseases should be controlled on a preventative spraying schedule during the establishment period. Frequent changing of pin placements is essential to protect overseeded grasses and dormant bermudagrass from excessive wear. Loss of grass cover or thin areas encourage annual bluegrass and other weeds to invade the putting green turf.

Winter greens require $\frac{3}{4}$ to $1\frac{1}{2}$ pounds of nitrogen per 1,000 square feet per month, depending on grass used, to maintain good color and uniform growth. Soluble and slow-release nitrogen sources may be used to

furnish the required amount. If soluble sources are used, small, frequent applications are necessary. If slow-release sources are used, larger and less frequent applications may be made. Phosphorus and potassium requirements should be met prior to the time of overseeding.

Spring transition from cool-season grasses to bermudagrass can be improved by proper timing of vertical mowing, aerification and fertilization. Light verticutting every week or two when bermudagrass breaks dormancy will thin overseeded grasses and stimulate the recovery of bermudagrass. Whether verticutting is necessary every week or only every 2 weeks depends on how rapidly the bermudagrass grows. Cool night temperatures will retard bermudagrass recovery and result in a thin turf if verticutting has been too severe. On the other hand, failure to thin cool-season grasses may retard bermudagrass recovery. If transition to bermudagrass is proceeding too slowly, aerification with $\frac{3}{8}$ -inch hollow tines will favor bermudagrass. Increasing nitrogen fertilization to 2 pounds per 1,000 square feet from a soluble N source every 3 weeks will also stimulate the bermudagrass.



Fairways

Although putting green maintenance requires much concern and major expenditures, much of the game is played on the fairways. The condition of the fairways will be reflected in the golfer's attitude or opinion of a particular course and most certainly in his game of golf.

⁵Menn, W. G., and G. G. McBee. 1971. An Evaluation of Various Cool Season Grasses and Grass Mixtures in Overseeding a Tifgreen Bermudagrass Golf Green. Texas Agr. Exp. Sta. PR-2878.



Manicured bermudagrass fairways provide a fine playing surface as well as a beautiful appearance.

Even though fairways may not receive the intensive care given the greens and tees, they should not be neglected. The golfer expects a uniform, dense, closely mowed sward of turf from which to hit his next shot toward the green.

The degree of fairway maintenance will vary considerably from course to course depending primarily upon the budget. The following suggestions are offered with this in mind and range from minimal care of fairways to the utmost in fairway maintenance.

Irrigation

Golfers playing on fairways not having watering systems play on poor turf throughout much of the year. No location in Texas has the quantity of evenly distributed rainfall needed to eliminate the requirement of a supplemental irrigation system.

There is no hard and fast rule as to how much or how often all golf fairways should be watered. Two general theories of watering are as follows: (1) Deep soakings several days apart will promote deep rooting and consequently a more drought tolerant grass and (2) frequent watering will maintain a uniform degree of moisture in the upper soil. The first theory of "deep soakings" seems to be more practical; however, with the sophisticated automatic irrigation systems now available, the latter theory may be applicable.

Courses having heavy soils in fairways should not be equipped with high volume sprinkler heads. The low infiltration rate of these soils restricts the movement of water into the soil and much moisture is lost through runoff. The reverse is true for courses built on light, sandy-textured soils. Here the high volume sprinkler would save time in watering. If watered properly, the heavy soils can be watered less frequently than the sandy soils.

Drainage

Surface and internal drainage are a necessity on fairways to insure a playable course after heavy rains or waterings. This may call for filling in low spots or the use of French drains in some areas.

Mowing

Properly mowed fairways not only give the course a neat, uniform appearance but also afford the golfer a good, clean shot to the green. Frequency of mowing may vary from biweekly to three or four times per week depending on acreage to be mowed, equipment available and season of the year. During the active growing season, bermudagrass fairways should be mowed at least weekly and preferably two or three times per week.



A reliable irrigation system is necessary for successful maintenance of bermudagrass turf.

Normally, the greater mowing frequency results in a dense, uniform and more beautiful playing surface. Fairway mowing units will vary from 5-gang to 9- or even 11-gang units; the 5- and 7-gang units are more maneuverable. Large, open, relatively flat areas would be suited to the use of the 9- or 11-gang mowing units. With two 5-gang units, a 5- and 7-gang unit or two 7-gang units, the fairways on an average 18-hole golf course can be easily mowed in half a day. A combination of a 5- and a 7-gang unit may be better than two 5- or two 7-gang units. With a mowing schedule so that any given fairway is mowed alternately with a 5-gang unit and a 7-gang unit, the problem of wheel marks will be decreased on courses following a program of two to three mowings per week. If only two 5-gang or two 7-gang units are available, the variable hitch location allows change of the location of the hookup at each mowing, thereby changing the location of the wheels in relation to the mowing unit. Changing the direction of mowing with each cutting will prevent the grass from lying down.

The variety of grass in the fairway will have some bearing upon the type mower that should be used. As a general rule, shifting toward finer textured grasses in the fairway means changing to mowing units containing more blades per cutting reel. For example, in mowing common bermudagrass fairways, the mowing unit should contain 5 or 6 blades per reel, while in mowing Tifway bermudagrass fairways, the reel should contain 6 or 7 blades. On some courses where Tifgreen or one of the other fine-textured bermudagrasses have been used throughout, the mowing units would need 7 to 8 blades per reel.

Cutting height in the fairways can affect the golfer's game. A closely mowed fairway lessens the possibility that the golfer's club will catch the grass before coming in contact with the ball and also decreases the drag on the ball as it hits the ground. Normally, the mowing level for fairways will vary from $\frac{1}{2}$ inch to about $\frac{3}{4}$ inch in height. Several factors will govern mowing height; grass variety is one. For example, Tifgreen bermuda looks good and plays well when mowed at $\frac{1}{2}$ inch, while common bermuda looks better at a $\frac{3}{4}$ -inch cutting height. Frequency of mowing will also influence clipping height. Those fairways mowed only once per week should be clipped at the taller height, while those being clipped three times per week could stand even closer mowing. Seasons of the year affect mowing height. In spring the cut should be lower and should be raised slightly during July and August. A fairway mowed at $\frac{1}{2}$ inch during April, May and June may be mowed at $\frac{2}{3}$ or $\frac{3}{4}$ inch during July and August. However, as the weather becomes cooler in September and October, the cutting height can be gradually lowered to the spring level.

Aerification

The practice of aerification of fairways is increasing each year. This increase is required, in part, to alleviate the compaction problems caused by the increase in traffic on today's golf courses. Also, aerification provides for more efficient use of moisture and nutrients in the fairway and perhaps reduces or helps control thatch buildup.

The need for aerification will vary considerably between different courses and perhaps even between different fairways on the same course. The need for aeration will be influenced largely by the amount of traffic encountered and the soil type on which the fairway was constructed. Some courses "get by" without a fairway aerification program while others must aerify as often as four or five times per year. Many aerify once in the spring and once in late summer or early fall.

Circumstances that may indicate a need for aeration are excessive water run-off, hard-to-wet soils or yellowing grass from lack of oxygen (apparent when moisture and nutrient levels are adequate and yellowing is not a result of disease or insect damage).

Dethatching

Vertical mowing (dethatching) has become a necessary practice on a number of courses throughout the State because thatch prohibits the movement of air, moisture and nutrients into the soil where they are needed. Thus the grass may lose much of its drought tolerance and require excessive fertilization. Thatch accumulation appears to be associated with an increase in disease. Many of the effects of thatch are not yet clearly defined; however, turfgrass researchers at The Texas Agricultural Experiment Station are conducting studies which may shed new light on many problems associated with thatch.

As with aerification, the need for dethatching or vertical mowing must be determined by local circumstances. Vertical mowing needs might be influenced by grass variety, frequency and height of mowing and by the fairway fertilization program. Some courses need no dethatching; others are on a monthly fairway verticutting schedule. Courses that must be verticut once per month during the growing season probably have problems in other areas of their maintenance program that are causing this rapid accumulation of thatch—perhaps overfertilization, improper mowing, et cetera. In most cases, one or two dethatchings on fairways per growing season should be sufficient to keep down heavy thatch accumulation.

Fertilization

Fertilization of a fairway is exacting. Enough fertilizer should be applied to maintain a tight, dense stand of turf and assure its recovery from traffic and divot

injury. Proper fertilization should also lessen the weed problems in a fairway. Even though noticed first, color should not be the prime factor in determining fertilizer needs on the fairway. Although the darker, lush green growth produced by heavy fertilization may be pleasing to the eye, usually it is associated with a heavy thatch accumulation, a need for increased mowing frequency and, quite possibly, an increase in disease incidence.

Rate, frequency and source of fertilizer materials will be governed by factors such as the length of growing season, availability and use of irrigation, amount of annual rainfall, height of cut, budget and the desire of the players for darker color. The rate of fairway fertilization may also vary with the age of the grass. For example, during establishment, the grass will require more fertilizer than when it becomes a mature, established turf.

The growing season for bermudagrasses in Texas will vary from approximately 6 to 8 months in northern areas of the State to 9 to 12 months in the southern region. Courses in the 6- to 8-month growing season belt probably will need 3-5 pounds of actual N per 1,000 square feet during the season. This may be supplied by a late April or early May application of a complete fertilizer, preferably in the ratio range of 4-1-2. This should be applied at a rate of 1.5 pounds of N per 1,000 square feet (or approximately 65 pounds of N per acre). Although distribution of the material at this rate should supply sufficient P and K needed for grass growth, the wide differences of P and K content found in the various soils of Texas suggest soil testing prior to any fertilizer applications. The indication that medium to high P and K exists in a fairway soil should eliminate the need for application of these two elements for that year. However, soil analyses should be run in subsequent years to see whether the P and K supply is being depleted. The remaining 2.5 to 3.5 pounds of N required on fairways in North Texas during the growing season may be applied in several forms. Of the relatively inexpensive inorganic forms of N (ammonium sulfate, ammonium nitrate, urea, et cetera), low rates should be applied at rather frequent intervals ($1\frac{1}{2}$ to 1 pound of N per 1,000 square feet applied at 4- to 6-week intervals). To eliminate the frequent applications, one of the organic slow-release forms of N (ureaform, IBDU, activated sewage sludge, et cetera) may be used. In applying these materials, a rate of approximately 1.0 pound of N per 1,000 square feet should be distributed several times during the growing season (May, July and September).

A combination of both the inorganic and organic forms of N might give more satisfactory results. The grass will respond rapidly to the inorganic N source and will continue to respond to the organic, slow-release form.

In the southern region, with the longer growing season, the nutrient requirements on fairways will increase. In South Texas, 4 to 6 pounds of N per 1,000 square feet per year may be required. It is recommended that a schedule similar to that of North Texas be followed with the exception that applications would begin earlier (late February or early March) and continue later into the fall.

Weed Control

In fairway weed control, weeds can be grouped into cool- and warm-season categories and further subdivided into broadleaf species and weedy grasses. The principal cool-season weed in fairways is annual bluegrass (*Poa annua* L.) which falls into the weedy grass category. Management practices that provide a dense, tight-knit bermudagrass going into the fall will help to fight the invasion of *Poa annua*. On courses where *Poa annua* is already a problem, several preemergence-type herbicides may, if applied properly, eliminate annual bluegrass problems. A few of these materials are DCPA (Dacthal), bensulide (Betasan, Pre-San, et cetera), Kerb, benefin (Balan) and diphenamid (Dymid, Enide, et cetera). Another material used postemergent on *Poa annua* is chlorflurenol (Po-San). This herbicide is sprayed on the actively growing *Poa annua* before seed heads begin to form and should prohibit seed formations, thus reducing next year's stand. The preemergent materials should be applied in the fall prior to the germination of *Poa annua*.

Several warm-season grasses such as crabgrass, goosegrass and field sandbur (grassbur) may present problems in fairway turf. These are annual weedy grasses that may be controlled with the preemergence herbicides listed when they are applied in early spring. In the North Texas area, application should be made

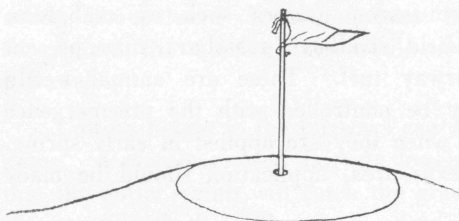


Uniform distribution of herbicides at recommended rates is essential for effective weed control.

April 15-30; in Central Texas, April 1-15; and in South Texas, March 15-31. Dallisgrass, a warm-season perennial, can be very troublesome in fairways but can be controlled by several applications in May and June of one of the organic arsenical herbicides such as DSMA (Ansar 100, Dal-E-Rad, et cetera) or MSMA (Ansar 529).

Some of the broadleaf, cool-season weeds appearing in fairways are clover, chickweed, henbit, oxalis, dichondra, dandelion and carpet burweed. Herbicides showing effectiveness in controlling these weed pests are 2,4-D (amine formulation), dicamba (Banvel), silvex and bromoxynil (Buctril). These chemicals are also recommended for use in controlling many of the warm-season broadleaf weeds such as purslane, pigweed, mat chafflower, matchweed, horse purslane, spurge and evening primrose. In controlling these broadleaf weeds, the herbicides are more effective when applied to young weeds. Application certainly should be made before flowering begins.

It is suggested that all herbicides be applied using calibrated equipment and at the manufacturer's recommended rate. When applied properly, most herbicides will do a good job of weed control without injury to the turf; however, if improperly applied, most of these chemicals will cause serious damage to the desired turf species.



Tees

Golf course tees are probably second only to greens in required management intensity. Tee boxes undergo a tremendous amount of wear throughout the year from traffic and divots. In many instances, tees are so small or narrow that space limitations often hinder their maintenance. A satisfactory tee box should be level and firm for making golf shots and of sufficient size to allow tee markers to be moved regularly. There are no set standards which fix the size of tees on golf courses. Consequently, tee boxes may range from several hundred to several thousand square feet in size. In general, as player traffic increases so should tee size. For instance, one formula suggests that Par 4 or 5 holes need 100 square feet of tee space and Par 3 holes require 200 square feet of tee space for every 1,000 rounds of golf played on that course per year. The formula requires one to project a "rounds-per-year" figure or start



Adequate and well-designed teeing areas simplify the maintenance of golf holes.

with average size tees and increase their size, if necessary, after player traffic has been established. When this formula is applied to courses throughout the State, many tees are greatly undersized.

Irrigation

Irrigation is essential to insure maximum growing conditions under which injured grass may recover more quickly. Again, irrigation frequency will depend largely upon the moisture holding capacity of the material of which the tees are constructed. Tees never should be allowed to dry out to the extent that it is difficult to force the golf tee into the ground. Water should be applied so as to allow maximum time between irrigation and player use. Wet tees under player traffic will increase compaction problems and provide unsure footing for the golfer.

Mowing

Mowing should be scheduled three or four times weekly in order to maintain a smooth, close-knit turf. Mowing height on bermudagrass tees may vary from $\frac{1}{4}$ to $\frac{1}{2}$ inch, depending upon grass variety and frequency of cut. As the texture of the varieties becomes finer and the frequency of cut increases, the mowing height can (and probably should) decrease. Regardless of the height chosen, the grass on tees should always be clipped so that the ball will be above the grass without being teed too high. Mowing should be done with a precision reel-type mower, preferably one of the 3-unit riding models. The 5- and 7-gang fairway units are not normally used for mowing tees.

Aerification

Due to the small size of many tees and the heavy concentration of traffic in this area, the problems of compaction may show up in a relatively short time. Aerification will help to correct many of these problems. Tees should be aerified two or more times during the

year depending upon amount of traffic and the soil type out of which the tees are constructed. Aerification will also enhance moisture penetration if excessive runoff is a problem.

Fertilization

Fertilization of tees may follow the schedule on either greens or fairways depending largely on whether or not clippings are removed. If clippings are removed from tees, a fertilization program similar to the one used on greens should be followed. If the fairway fertilization program is used on tees, the total N applied should be increased by about 2 pounds during the growing season. This would increase the rate of vegetative growth and likewise the recovery of injured grass on tees. If tees are to be overseeded, an additional 5 pounds of actual N should be applied during the winter at a rate of approximately 1 pound per month. Factors which might affect fertilization rates on tees are mowing and irrigation frequency—heavy rates of fertilizer would not be applied to tees mowed only once per week.

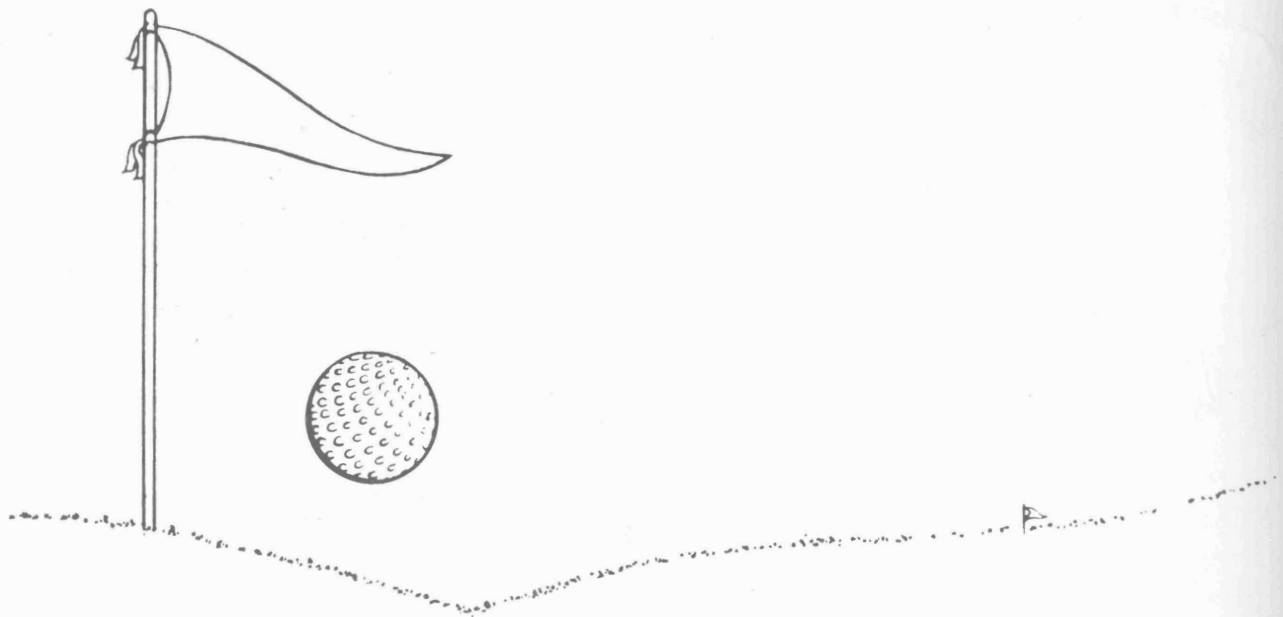
Overseeding

Overseeding tees is a standard practice on many of the courses throughout the State. Aerification of the tee to be overseeded should be scheduled at least 1 month prior to overseeding. Preparation of the tee prior to overseeding ranges from no treatment to the extensive techniques used in overseeding greens. For maximum cover and quality on overseeded winter tees, the tee boxes should be verticut or close mowed, spiked, seeded and topdressed, in that order. Suggested seeding rates for cool-season grasses used on tees are given in Table 3.

TABLE 3. SUGGESTED SEEDING RATES FOR OVERSEEDING TEES

Grass	lb./1,000 ft ²
Ryegrasses ¹	15-25
Kentucky bluegrasses	6-8
Poa trivialis	6-8
Fescues	10-15
Bentgrasses	2-3

¹Ryegrasses are predominantly used for overseeding tees.



The Texas Agricultural Experiment Station, J. E. Miller, Director, College Station, Texas