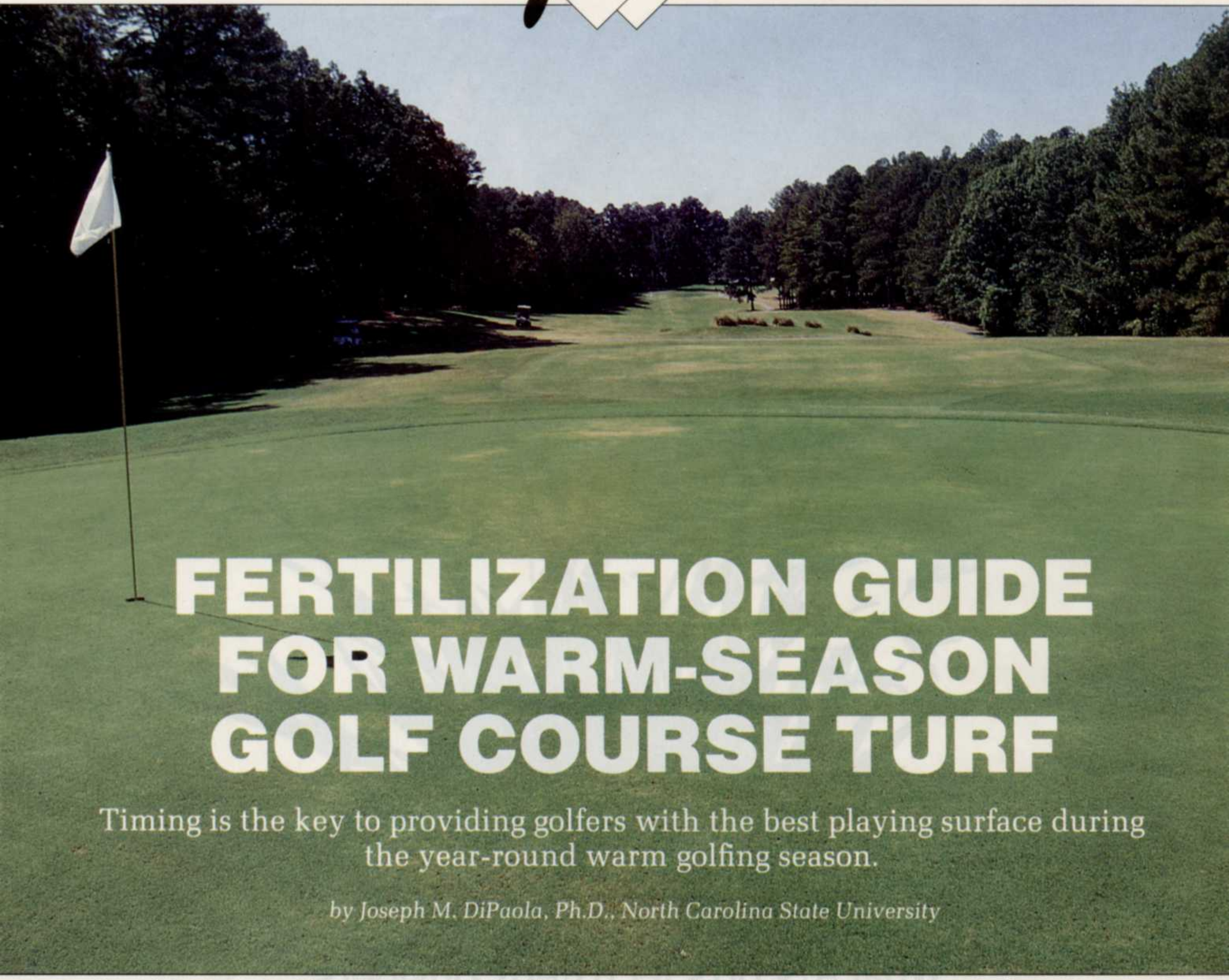

FERTILIZATION GUIDE FOR WARM-SEASON GOLF COURSE TURF

Timing is the key to providing golfers with the best playing surface during the year-round warm golfing season.

by Joseph M. DiPaola, Ph.D., North Carolina State University

Superintendents should implement a solid fertilization program in order to maintain good green color on the course.

As summer draws to a close and the cooler weather of fall approaches, golf course superintendents look forward to some annual activities like aerification, winter overseeding, lime applications, renovation and fertilization.

While fulfilling these management procedures, superintendents must also contend with the usual increase in the play of the course, including tournament events. Keys to playable turf are:

- balancing a fertility program to ensure adequate growth to withstand the wear of increased play;
- minimizing the very real risk of winter injury from excess fertilization of warm-season turf; and
- encouraging the germination and development of winter overseeded grasses with fertilization, which can also increase Bermudagrass growth and thus its competition with cool-season overseedings.

The difference between success and failure often depends on a superintendent's timing of agronomic practices, particularly in relation to environmental conditions.

A good beginning point for planning a late-summer and fall fertility program is to review nutrient and soil pH status record. It is also advisable to double-check the area of the greens, tees and fairways. Inaccurate judge of their size, which has a tendency to change over time, can result in significant over- or under-applications of nutrients. Soil sample collection at this time also avoids delays in receiving laboratory results typically experienced in the spring.

After adequate soil phosphorus, potassium and pH levels have been attained, greens should be sampled annually, tees every one to two years and fairways every two to three years.

Minimizing winter injury

Centipedegrass, bahiagrass and St.

Augustinegrass have only poor to moderate resistance to cold damage; Bermudagrass has intermediate cold tolerance; zoysiagrass is the most low-temperature hardy of the warm-season turfgrasses. Advantageously, Bermudagrass and zoysiagrass have deep rhizomes which typically avoid exposure to low temperature because of their below-ground location. Warm-season turfgrasses without these underground lateral stems cannot fully benefit from protective insulation offered by the soil.

A healthy turf tolerates more types of stresses. Fertilizing under-nourished turf before stress exposure will typically enhance performance. However, once an adequate nitrogen level has been established, undesirable turf responses to additional fertilization are likely. Nitrogen, phosphorus and potassium fertility ratios of 3-1-2 or 4-1-2 should be sought; however, a specific application may need to vary, to compensate for actual soil nutrient levels.

Unlike cool-season grasses, increasing nitrogen fertilization during the fall increases the risk of winter injury to warm-season turf. Nitrogen applications to warm-season turfgrasses at or above 1 lb. N/1000 sq. ft. after October promote leaf development from the crown when the metabolism of this structure should be hardening.

FALL NITROGEN GUIDE FOR WARM-SEASON GOLF TURF

	August	September	October	November	December
	- - - - - - - - - - -	lbs nitrogen/1000 sq. ft.	- - - - - - - - - - -		
Greens	0.75-1.5	0.25-0.5	—	—	—
Hybrid Bermudagrass	0.75-1.25	0.25-0.5	0.25-0.5	0.25-0.5	0.25-0.5
Overseeded Bermuda					
Tees	0.75-1.25	0.25-0.5	—	—	—
Hybrid Bermudagrass	0.5-1.0	0-0.5	—	—	—
Common Bermudagrass	0.5-1.0	0-0.5	—	—	—
Vamont Bermudagrass	0.75-1.0	0.25-0.5	0.25-0.5	0.25-0.5	0.25-0.5
Overseeded Bermuda					
Fairways	0.3-0.5	0-0.3	—	—	—
Hybrid Bermudagrass	0.25-0.3	0-0.25	—	—	—
Common Bermudagrass	0.25-0.3	0-0.25	—	—	—
Vamont Bermudagrass	0.3-0.5	0.25-0.3	0.25-0.3	0.25-0.3	0.25-0.3
Overseeded Bermuda					
Roughs	0-0.3	—	—	—	—
Common Bermudagrass	0-0.25	—	—	—	—
Bahiagrass	0-0.1	—	—	—	—
Centipedegrass					

The higher application rates are suggested for irrigated areas that have clippings removed, particularly for turf on sandy soils. These suggestions are only offered as a guide. Courses located where the first normal frost occurs before or after the first week in October should shift the calendar to the left or right, respectively.

This new flush of growth has resulted in turf winter injury by increasing the temperature at which the turf is injured during the winter. However, like cool-season grasses, fall nitrogen applications will prolong the fall color retention and speed the turf's spring greenup.

Many fertilizer sources including sulfur-coated ureas, ureaformaldehyde reaction products, IBDU, etc., have yet to be evaluated for their impact on winter injury of warm-season turf following fall applications.

Potassium deficiency can result in a weak stand of turf because this nutrient is critical for maximization of cold hardiness, disease resistance and drought tolerance of the turf. Adequate levels of potassium encourage the development of a deep and extensive root system.

Winter injury is a problem for all warm-season turfgrasses, but is of particular concern for northern regions of the transition zone of turf adaptation. Maximizing winter survival will minimize weed infestation and reduce the turf's spring renovation requirements. Potassium applications at 1-2 lbs./1000 sq. ft. have enhanced cold hardiness, but do not alter fall color retention. Late summer potassium applications will increase the availability of this nutrient at the beginning of the hardening process.

While phosphorus applications have not been found to influence the cold hardiness of warm-season turfgrasses, a high P-to-K ratio has been observed to increase the winterkill of centipedegrass. This response demonstrates that the balance between nitrogen, phosphorus and potassium is important for turf quality and winter survival.

Cold hardiness following fall nitrogen fertilization can be enhanced by including phosphorus and potassium.

Foliar application of iron has been used to improve turf color without the shoot growth stimulation that follows nitrogen fertilization. This color enhancement can occur even in the absence of iron deficiency symptoms (eg. interveinally chlorotic younger leaves). Iron salts (eg. ferrous sulfate) and chelated sources (eg. Agri-Plex, Extra-Iron, Ferriplex 138, Rayplex, Sequestrene 330) are typically applied at 2-8 lbs. of elemental iron per acre (0.75 to 2 oz. of iron per 1000 sq. ft.).

Iron salts are usually a less expensive treatment. Exercise care however, when applying iron near sidewalks, cartpaths, markers or other objects to avoid staining. Washing immediately after application will minimize staining.

Nitrogen fertilizer applications to warm-season greens, tees and fairways should be gradually diminished at about 60 days prior to the first normal frost. The fertilization requirement of greens exceeds that of tees and that of tees exceeds that of fairways, largely because of the increased demand for greater recuperative rate, clipping removal, more intensive irrigation and sandy soil profiles.

Overseeded turf requires fertilizer applications from fall through spring if optimum turf quality and color is to be maintained. Fertilization rates generally should not exceed 0.5 lb. N/1000 sq. ft. and be repeated every four weeks. Applications should be delayed until the overseeded cool-season grasses have germinated and have been clipped in order to minimize Bermudagrass competition.

Turfgrass fertilization remains as much an art as a science. Decisions on application rates and sources of nutrient carriers are made based on subjective color assessments by the superintendent, budgets and the club schedule as much as they are on the turf's agronomic requirements. However, the many nitrogen fertilizer carriers now available, particularly slow-release sources, have enhanced program flexibility. Fall fertilization programs are largely driven by the need to prepare the warm-season turf for overseeding or for maximum winter survival while dormant.

Southern bentgrass

The growing season for bentgrass greens in the South is shorter than the time between killing frosts. Bentgrass golf greens grow very little during the hot, humid summer months typical of the southern United States. The bentgrass root system will usually become increasingly shallow throughout the summer, so it is critical that root system development be maximized by late-spring.

Supplemental spring applications of potassium at 1 lb. K/1000 sq. ft. can substantially improve bentgrass rooting.

During the course of a year, bentgrass greens may receive between 5-10 lbs. of nitrogen per 1000 sq. ft. depending upon many factors. Newly-constructed greens typically need nitrogen applications at the upper end of this range. Slow-release fertilizers used during the late-summer and fall should not exclusively contain nitrogen sources that need microbial activity for nutrient release (eg. ureaformaldehyde, activated sewage sludge). Declining soil temperatures during the fall and winter will limit nutrient availability from these sources. Also, nutrient release may occur the following summer when the superintendent wishes to minimize nitrogen levels for reason of heat stress and disease.

Late summer and early fall in much of the southern United States can include many very warm days interspersed with cool spells. Superintendents should resist the urge to quickly aerate, top-dress and fertilize bentgrass greens until cool weather is assured. Waiting until soil temperatures have dropped to near 70 degrees F. is a more reliable guide than air temperatures.

Aerating the greens accelerates soil drying which can increase the water stress experienced by bentgrass during late summer.

Fertilizer applications should not accompany top dressing and drag matting at this time of the year. Placing fertilizer salts on bentgrass leaves during late summer—while this turf's root system is most shallow—will further aggravate water stress should warm weather return. So, if tournament schedules and other factors necessitate an earlier-than-desirable aerfication, fertilizer applications should be conducted in a separate operation.

LANDSCAPE *Guide* MANAGEMENT

FERTILIZATION GUIDE FOR COOL-SEASON GOLF COURSE TURF

Golf course superintendents must rely on their powers of observation, and experiment with different fertilization practices.

by David Wehner, Ph.D., University of Illinois

Turfed areas are unique. They must withstand traffic, repeated mowing, attack by disease and insect pests and, at the same time, provide a dense, dark-green covering of the soil surface. One of the most important management practices that helps ensure that the turfgrass plant is able to do its job is proper fertilization.

Because each turfgrass area is different, and each turfgrass manager has a different idea of what is considered acceptable, a single program cannot be written for all areas.

Instead, turfgrass managers should rely on their powers of observation to determine the desired results and experiment with modifications to discover better ways of producing those results.

Nitrogen fertilization

Turfgrasses require 16 elements for adequate plant growth. Of these, nitrogen (N) is supplied by fertilization in the largest quantities, followed by potassium and phosphorus. Nitrogen sources are characterized by their rate of nutrient release.

Water soluble N sources such as urea, ammonium nitrate and ammonium sulfate provide a short, quick response. Slow-release N sources such as ureaformaldehyde, sulfur-coated urea, IBDU and Milorganite will last longer because they are re-

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NITROGEN GUIDE FOR COOL-SEASON GOLF TURF

	Aug.	Sept.	Oct.	Nov.	Apr.	May	June	July
				lbs nitrogen/1000 ft²				
Greens								
Creeping bent		1.0	0-1.0	1.0	0-0.5	0.5-1.0	0.5-1.0	0-0.5
Fairways								
Creeping bent		1.0		1.0		0.5-1.0	0.5-1.0	
Kentucky blue		1.0		1.0		0.5-1.0	0.5-1.0	
Perennial rye		1.0		1.0		0.5-1.0	0.5-1.0	
Tees								
Creeping bent	0.5	1.0		1.0		0.5-1.0	0.5-1.0	0.5
Kentucky blue	0.5	1.0		1.0		0.5-1.0	0.5-1.0	0.5
Perennial rye	0.5	1.0		1.0		0.5-1.0	0.5-1.0	0.5

Use low end of ranges for courses with moderate play, high end for courses with heavy play. Use higher N on Penneagle greens. Use low end of range if fairway clippings are returned or to combat annual bluegrass. Maintain good fertility on perennial ryegrass fairways to help reduce the severity of red thread. Tee program should be adjusted based on number of rounds and size of tees.

leased at a slower rate. Slow-release N sources are more expensive even though quick-release sources may be applied more frequently.

The turfgrass manager should evaluate several sources to determine what type of results fit the budget. Almost any fertilizer, used properly, can provide good results. More expensive fertilizers do not necessarily provide better results.

Cool-season turfgrasses exhibit their maximum growth rate in the spring and fall. Growth slows over the summer because of higher air and soil temperatures. The typical fertilization program on lawns, parks and other turf areas is adjusted to provide more nutrients in the fall and spring than in the summer. A complicating factor on the golf course is that more rounds of golf are played during the summer than in any other season. The superintendent must watch his greens and tees to make sure that there is some turfgrass growth over the summer to ensure recovery from wear.

Fairways are less critical because the traffic is spread out more. Summer fertilization can be done by either applying small amounts of a soluble fertilizer on a frequent basis or by using a slow-release fertilizer. The total amount of nitrogen applied to the putting greens will partially depend on the number of rounds played and the emphasis on putting green speed.

As rounds increase, the amount of nitrogen applied must be increased. Where putting green speed is important, use frequent applications of top dressing along with a moderate N level, moderate mowing height and moderate irrigation practices to increase speed. Fast greens are difficult to maintain where the amount of play is heavy and the N level has been reduced.

Superintendents in the Chicago area have observed that Penneagle creeping bentgrass greens require a higher level of nitrogen than Penncross or Toronto greens to provide good quality. They are going in the opposite direction with their Penneagle bentgrass fairways. Good results, that is less competition from annual bluegrass, have been observed on these fairways using lower levels of nitrogen.

Some golf course superintendents apply a small amount of urea to the greens when they apply a fungicide. If the urea is being applied with a contact fungicide, and irrigation is withheld to allow the fungicide to work, then some of the N will be lost by ammonia volatilization resulting in an inefficient application.

Apply the urea when a systemic fungicide is being applied and watered in or apply the urea by itself and water it in. Many superintendents are reluctant to use a liquid fertilizer on their putting greens.

Several liquid fertilizer products being used by the lawn care industry have a place on the golf course. They can be applied with a sprayer at a higher N rate than urea without fear of burning the turf. Fall fertilization, both in the early fall to speed recovery of the turf from summer stress and in the late fall to promote color retention into the winter and early spring greenup, is extremely important on all turfgrass areas. Research conducted at Ohio State University has shown that late fall fertilization promotes root growth in an indirect way.

Turf fertilized in the late fall has a reduced need for early spring nitrogen fertilization. Nitrogen fertilization in the early spring can decrease root growth. Also, because there is generally a flush of growth during the spring due to increased moisture, the first fertilization should occur in late spring.

Recent research conducted at the University of Illinois evaluated late fall applications of IBDU, sulfur-coated urea and urea for their effect on spring color. With sulfur-coated urea and urea, a November application resulted in superior spring color compared to where these same fertilizers were applied in September. With IBDU, a September application resulted in turfgrass color equivalent to where the IBDU was applied in November. Better results for the year were found where IBDU was applied in June and September than in June and November.

Although the greatest plant response is caused by nitrogen fertilization, the other elements are certainly important in the overall health of the plant.

The other elements

A basic recommendation regarding the use of nitrogen, phosphorus (P) and potassium (K) is to apply these elements in a 3:1:2 (N:P:K) ratio. This recommendation is based on the fact that turfgrass tissue contains N, P and K in approximately this same ratio.

However, consider the points listed below when planning the rest of your fertilization program.

1. Potassium fertilization. There is a trend to apply higher levels of potassium to turfgrasses. This means applying an amount of potassium equal to or greater than the amount of nitrogen applied. Research reported by Bob Shearman, Ph.D. and Jim Beard, Ph.D., in 1975 indicated that increased levels of potassium resulted in improved wear tolerance of Toronto creeping bentgrass.

Currently, Shearman is studying the effect of potassium fertilization on both creeping bentgrass and Kentucky bluegrass on both heavy and light textured soils. He recommends a 1:1 ratio between nitrogen and potassium. You may want to try higher levels of potassium on an area that gets a lot of wear to judge the results.

Remember that potassium chloride (muriate of potash) can burn the turf if applied under the right conditions. Potassium sulfate (sulfate of potash) has a lower burn potential than potassium chloride.

2. Phosphorus fertilization. The trend with phosphorus applications on golf turf has been to apply as little as possible. This practice resulted

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from the observation that annual bluegrass encroachment was greater where phosphorus levels were high. Also, the use of tricalcium arsenate to control annual bluegrass dictated that phosporus levels be low since phosphorus counteracted the toxicity of the tricalcium arsenate. Some recent observations have indicated that the turf's stress tolerance is reduced under low levels of phosphorus.

It would be wise to take periodic soil tests to monitor the phosphorus level especially where clippings are being collected. Don't entirely eliminate phosphorus from consideration in your fertility program.

3. Lime. Lime applications are necessary when growing Kentucky bluegrass on acid soils. Maintaining the proper pH in the soil will help ensure the maximum rate of thatch decomposition.

4. Sulfur. Just as lime applications can be used to raise soil pH, sulfur applications can be used to lower the soil pH. The reason for lowering the pH is to provide a better medium for plant growth. Some nutrients are not available to the plant at a high soil pH.

Ideally, sulfur should be incorporated into the seedbed before planting since it reacts slowly. It is important to be careful when using sulfur on established areas. Do not make large applications at any one time. Since the sulfur breaks down slowly and moves slowly, you can end up with an extremely low pH in the thatch layer. Consider applying sulfur after core cultivation.

Use soil tests to determine whether it is feasible to lower the soil pH with sulfur. Sometimes it is difficult to apply enough sulfur to lower the soil pH when the water used for irrigating the turf has a high pH or where free calcium carbonate is present in the soil.

Sulfur has been applied to creeping bentgrass putting greens to discourage the growth of annual bluegrass since the bentgrass can tolerate a low pH but annual bluegrass cannot. Flowable forms of sulfur are preferred to granular forms for applications to greens. Before starting a sulfur program on greens, consult with your state turfgrass extension specialist for information about using sulfur.

5. Iron fertilization. Iron applications may be necessary in parts of the country where soil pH is high and iron in the soil is not available to the plant. Iron can also be used to enhance the color of the turfgrass stand in areas of the country where iron deficiencies are not common. Iron sulfate applied at a rate of 1-2 oz. per 1000 sq.ft. will provide a response for several weeks. The actual length of the response will depend on the growth rate of the turf. Iron is not translocated in the plant. Once the treated tissue is mowed off, the response will fade.

6. Micronutrients. Applications of micronutrients (iron, manganese, zinc, copper, molybdenum, boron and chlorine) may sometimes be necessary on pure sand putting greens because of the low nutrient holding capacity of the sand, but they are rarely if ever needed on turfgrasses growing on pure soil or a mix containing soil.

With careful planning, a good fertility program can be developed for the golf course. It is important to realize that weather conditions can dictate departure from the basic plan. Do not be afraid to experiment with different programs.

Finally, seek help from a fellow superintendent if you are new in an area and unfamiliar with the weather patterns or the history of the golf course. Most superintendents are glad to help someone be successful. **LM**