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PREPARING TURF TO SURVIVE A DROUGHT*

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Many western turfgrass facilities will face a serious water deficit this summer. The extremely dry winter of 1976-77 has resulted in a reduced snow pack, limited reservoir supplies, and an overdraft of groundwater in many western states. Most water districts, agencies, and elected officials today are still only talking about water conservation urging voluntary reductions in water use. However, some water districts already have imposed mandatory water rationing, and in those areas the situation throughout the summer can only worsen. Therefore, it is essential for turf managers in drought-affected locales to know what their water supplies will be for the summer months and to plan accordingly.

Under normal conditions, planning for summer irrigation usually consists of ensuring that the irrigation budget will be adequate, performing preventative maintenance on the irrigation system, and then irrigating "as needed." This vear, planning also must include methods to increase irrigation efficiency by modifying management practices and, in some instances, redesigning the area for selective survival of turf.

Dought Tolerance

One of the first questions that must be answered in an impending dry year is the drought tolerance of the various commonly used grass species. To produce a quality sward, all turfgrasses require applied water or rainfall in amounts equal to or greater than the water they use and lose through evapotranspiration in a given time. When drought conditions exist and total water application is less than evapotranspiration or is eliminated, grasses do differ in their responses to these conditions. Turfgrasses commonly used are ranked according to their drought tolerance in Table 1. In general, warm-season or subtropical grasses are more. drought tolerant than cool-season or temperate grasses. Grasses with deep root systems have better drought tolerance than shallow-rooted grasses. Bermuda and zoysia, for example, frequently have root systems that penetrate 6 to 8 feet deep, providing them with a tremendous soil water reservoir for plant growth and survival. In contrast, well-maintained Kentucky bluegrass has a 6- to 12-inch root system and closely mowed creeping bentgrass a 2- to 6-inch root system.

In a study at the University of California, Davis, Dr. John Madison (3) removed all irrigation from selected turf plots for 120 days. Thereafter, he resumed normal watering and observed the recovery of various turf species. Under his conditions, he found that bermuda, zoysia,

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TABLE 1. The comparative drought tolerance of commonly used turfgrasses (6).

Good Drought Tolerance	**Improved bermuda**
	Zoysia
	Common bermuda
	Tall fescue
	Red fescue
	Kentucky bluegrass
	Meadow fescue
	St. Augustine
	Colonial bent
Poor Drought Tolerance	**Creeping bent**

and tall fescue recovered well in 15 days. "Highland" bent recovered in five months, while Kentucky bluegrass and red fescue showed poor recovery. Note that the deepest rooted species recovered fastest. There are limits to the drought tolerance of each species beyond which the grass sward will not survive, as was evident from the Kentucky bluegrass and red fescue plots.

Madison concluded that there is a "high genetic potential for drought tolerance among turfgrass species but it has not been exploited." Forunately, current research at Colorado State University by Dr. J. Butler is examining the drought tolerance of turfgrass species and varieties as well as the influence of management practices on drought tolerance.

To conclude this discussion, grasses do differ in their drought tolerance, their ability to survive extreme drought conditions is in large part due to their root system depth, and there is a drought limit beyond which sward survival is affected.

Review Management Practices

Mowing fertilization, irrigation, vertical mowing and coring are the five primary management practices regularly used in turf management. During dry periods, these practices should be evaluated and adjusted in terms of maximizing turfgrass drought tolerance.

With respect to mowing height and frequency, the first consideration must be the requirements imposed by the use of the facility. Using a golf course for example, a putting green must be maintained in the 3/16- to 5/16-inch height range, a tee slightly higher, and a fairway from 1/2 to 1% inches depending on player preference and the grass species used. If it becomes necessary to prepare a turfgrass for drought tolerance, increase its cutting height to the highest allowable height within the use-mandated range. This will result in a deeper root system with an increased soil water extraction capability (2). Also, the higher cutting height will shade crowns and soil during periods of high temperature. It should be understood that research (5) indicates the higher cut turf will use more water by evapotranspiration. However, I believe that the deeper root system will result in a stronger plant with a greater water foraging potential and, therefore, greater drought tolerance.

Research has shown (5) that water use increases as mowing frequency increases; therefore, it is best for drought tolerance to mow as infrequently as possible, again within the confines of facility use.

As for a drought tolerance nutritional program, a soil test will indicate needed addition or adjustments of phosphorus, potassium, pH, and salt load for optimum turfgrass growth. Such correction should be made immediately, before temperatures increase. Nitrogen fertilization should be eliminated whenever possible from the management program during late spring and through the summer, especially on cool-season turfgrasses. If it is determined that nitrogen must be applied because of play or use, then light, infrequent applications should be considered, because moderate or heavy nitrogen application during the spring and summer will reduce the depth and amount of rooting and will result in a higher water use because of stimulated topgrowth. Certainly, lush topgrowth is to be avoided if drought tolerance or water conservation ‘is a consideration.

Thatch control and coring are important management practices in a dry year because both processes tend to increase irrigation efficiency. Thatch and compaction can reduce water entry into a soil profile, thereby resulting in wasted water from runoff or evaporation. Similarlv, thatch and compaction restrict nutrient and air entry ‘into the soil which reduces the rooting needed for maximum drought tolerance.

Irrigation is by far the most important management practice when preparing for drought; every effort should be made to increase watering efficiency. The following checklist can be helpful in this regard. While pursuing the points mentioned in this checklist, remember that the objective of irrigation is to replace water used by evapotranspiration of the turf as infrequently as possible.

(√) ***Determine rooting depth.*** Since the objective of irrigation is to replace water in the soil profile to the depth of turfgrass roots, knowledge of root system depth is essential.

(√) ***Determine soil water holding capacity.*** Soils differ in their ability to hold water for plant absorption. Table 2(1) indicates the amount of available water per unit depth.

TABLE 2. Available and unavailable water per foot of soil (1).

Soil Texture	Inches per Foot Available	Unavailable
Sand	0.4-1.0	0.2-0.8
Sandy Loam	0.9-1.3	0.9-1.4
Loam	1.3-2.0	1.4-2.0
Silt Loam	2.0-2.1	20-2.4
Clay Loam	1.8-2.1	2.4-27
Clay	1.8-1.9	27-2.9

(√) ***Evapotranspiration (ET) rate.*** The rate of water used is largely governed by the climate. Of extreme importance are factors such as: radiant energy (ET increases as radiant energy increases), temperature (ET increases as temperature increases), humidity (as humidity increases, ET decreases) and wind (as wind increases, ET increases). Other factors such as rainfall, soil fertility, growing season, cutting height and frequency also influence water use.

The ET rate for turf in much of the western United States can be estimated on a daily basis at a location by multiplying evaporation loss from a Class A U.S. Weather Bureau Evaporation Pan by a factor of 0.8. This will give an approximate water use amount for turf in areas of low humidity. Some water use estimates as given by Pruitt (4) for several California Climate Zones are presented in Table 3 as examples of water use in inches per month.

TABLE 3. Estimated potential evapotranspiration in California, inches per month.

	Northeastern Mountain Valleys	North Coast—Coastal Valleys and Plains	North Coast—Interior Valleys	Sacramento Valley	San Joaquin Valley	Central Coast—Coastal Valleys and Plains	Central Coast—Interior Valleys	South Coast—Coastal Valleys and Plains	South Coast—Interior Valleys	Southern California Desert
Jan	0.6	0.5	0.8	1.1	0.9	1.8	1.6	1.8	1.7	2.7
Feb	1.0	1.0	1.2	1.8	1.7	2.1	2.1	2.4	2.4	3.6
Mar	2.1	2.0	2.4	3.0	3.2	3.1	3.3	3.1	3.3	5.9
Apr	3.7	2 5	3.4	4.4	4.5	3.9	4.3	3.8	4.2	7.6
May	5.0	3.3	5.0	5.8	6.5	4.7	5.7	4.5	5.1	10.1
Jun	5.8	3.6	5.9	7.3	7.5	4.9	6.2	5.1	6.0	11.4
Jul	7.9	3.5	7.1	7.9	7.8	5.3	6.7	5.5	6.9	11.6
Aug	7.0	3.4	6.2	6.7	6.6	4.8	6.0	5.5	6.7	9.6
Sep	4.9	28	4.6	5.2	4.8	3.8	4.8	4.5	5.2	8.5
Oct	2.8	1.7	2.7	3.4	3.3	3.2	3.8	3.4	3.8	6.3
Nov	0.9	1.1	1.2	1.6	1.5	2.2	2.3	2.6	2.3	3.5
Dec	0.5	0.7	0.7	1.0	0.7	1.5	1.5	2.2	1.8	2.0
Total	42.2	26.1	41.2	49.2	49.0	41.3	48.3	44.4	49.4	82.8

(√) ***Calculate irrigation amount and frequency.*** As an example, a cool-season grass with a 6-inch effective root system growing on a soil with 11/2 inches of available water per foot of soil would have the following soil water reservoir:

H_2O available/ft (inches) X root depth (feet) = soil water reservoir

e.g., 1.5 inches X 0.5 feet = 0.75 inch available

If the daily water use is 0.15 inch (March-May in Southern California), then

$$\frac{\text{soil water reservoir}}{\text{water use}} = \text{irrigation frequency}$$

$$\text{e.g., } \frac{\text{0.75 inch available}}{\text{0.15 inch/day}} = \text{5 day water supply}$$

Of course, the amount of water to be resupplied would be equal to, or slightly greater than, the amount used in that unit time.

(√) Tensiometers and other devices. In addition to the preceding mathematical method to determine irrigation needs, soil moisture measuring devices such as tensiometers or soil probes can be used. Tensiometers also are useful to identify dry or wet spots in a golf course landscape where special irrigation design and programming may be necessary.

(√) ***Other points to consider to increase watering efficiency.***

- Late night or early morning irrigation is most effective. At these times water loss by evaporation is minimal and distribution is usually good because of good water pressure and limited wind.
- Avoid runoff by matching water application rates to soil infiltration percolation rates. Cycle water application if necessary to ensure infiltration.
- Practice good weed control methods. If they are not controlled, the weeds, not the desired turf species, will use the water.
- Calibrate all parts of the irrigation system so water application amounts and distribution are known. A can test is useful in doing this.
- Shaded areas will use much less water than turf in open sun. Therefore, shaded areas will require less irrigation. Tensiometers can be used to determine water needs of shaded areas.

Possible Redesign

Drought can be defined as a prolonged period of ab normal moisture deficiency. This definition implies that normal moisture conditions will return to an area in time. Such a situation means that temporary, minor design changes can assist a manager ride out the current water shortage.

Conversely, many areas in the western states face what can be foreseen as “permanent drought conditions.” That is, because of jurisdictional or political action, they do not have sufficient water to supply existing or increased demand. Turf managers in such water districts may consider major design changes so as to continue operation. Of course, a landscape architect will be helpful in this regard.

Listed below are some changes that may be considered:

(√) Line water storage lakes to reduce water loss:

(√) If your facility is considering the installation of a new, more effective and efficient irrigation system, then this may be the time to act.

(√) Redesign the irrigation system to increase control over water application. As examples, sun vs shade areas should be on different stations; reduce fairway width and cap sprinkler heads in roughs on golf courses; remove from irrigation, or reduce irrigation, on other areas not essential to play.

(√) Level mounds and redesign other hard to irrigate topographic features.

(√) Investigate the possible availability of effluent water, if state or local law permits its use.

(√) Remove poor performing plants from the landscape.

(√) If establishing plant material, group plants with similar water requirement so all can be irrigated for optimum performance.

(√) Use mulches l-2 inches thick to reduce evaporation water loss in plant beds.

(√) Selectively eliminate plants, if necessary, by carefully identifying which plants are most important to the total landscape.

(√) When conditions necessitate, select turfgrass species and varieties that perform well in your area and are known to have good drought tolerance.

In summary, each turfgrass manager has special, specific problems and opportunities on his facility. To deal with a drought condition effectively. the manager must know the local water availability condition, he should be aware of turfgrass management practices that will be of assistance, and he should be ready to implement major or minor design changes so the facility and play can continue.

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FINAL RESEARCH REPORT
COOL SEASON VARIETY STUDY IN HIGH SALT LOCATION

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A cool season turfgrass variety study was established in October 1970, on a newly constructed golf course fairway in San Leandro, California. The golf course was built on a land fill area; serious soil laying problems characterized the course because of previous use. It was the initial objective of this study to evaluate commercially available cultivars of four turfgrass species: Kentucky bluegrass, perennial ryegrass, red fescue, and colonial bentgrass.

The varieties given in Table 1 were hand seeded to 100

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sq ft. plots. Each treatment was replicated four times and the plot lavout was a randomized complete block design. The seeding rate of each species per 1000 sq. ft. was: Kentucky bluegrass, 3 Ibs.; red fescue, 6 lbs.; perennial ryegrass, 10 lbs.; and colonial bentgrass, 2 Ibs. Following germination, and initial establishment, the test area was mowed at lY4 inches once a week, fertilized with approximately 2 Ibs. nitrogen per 1000 sq. ft. per year, and irrigated as needed.

During 1972 reduced growth and leaf burn was observed. A composite soil test indicated an average salt bridge reading of 11.4 millimhos/cm. A High Exchangeable Sodium Percentage (ESP) reading indicated possible water permeability problems, which was also noted on certain sections in the experimental area.

Turfgrass quality was evaluated as turf scores, a visual rating system that considers color, texture, density, pest activity, and uniformity.

Turf scores were based on a numerical system ranging from 0 to 10 where 0 represented a completely dead turf sward, or one where the grass was replaced by weeds, and 10 represented an ideal turfgrass stand of that species. To further clarify the rating, the following groupings were used :

0-3 Indicated a completely unacceptable turfgrass stand with either a very high weed percentage or sward that was composed of mainly dead or dying grass. A turf stand in this range would imply that the species/variety would have to be reestablished.

3-6 The stand was unacceptable aesthetically, however, with correct management practices, it could be improved to a desirable level. There was at least 50% live grass that could "fill in" following a pesticide application, as an example. Reestablishment would not be necessary.

6-10 This range indicated degrees of acceptable turf. Most ratings fell in this range and the factors previously mentioned would be weighed to determine a final score.

The scores for the tested varieties are presented in Table 1. The turf scores are the average of four replications and six observation times during the 1973 evaluation year. Also given is the average turf score for each variety from a statewide variety trial that was conducted during the same time period. The eight locations, in the statewide trial, none of which had a salinity problem, were previously identified and results presented (1).

It can be noted that, as a species, perennial ryegrass had the highest average turf score and compared favorably with the statewide species average. It is recognized that perennial ryegrass does have intermediate to good salt tolerance and this data reflects that characteristic. The varieties Pelo and Manhattan performed the best of the perennial ryegrasses examined.

Red fescue and colonial bentgrass showed the poorest performance characteristics under the high salt stress. There was little difference in turf scores among the varieties of these species.

Kentucky bluegrass had a species average turf score of 4.6 at San Leandro in comparison to a 6.7 statewide average indicating poor tolerance of the salinity level at the test site. There was obvious differences in variety performance, however, as can be noted. Merion Kentucky bluegrass was practically eliminated at the time the ratings were made whereas Fylking Kentucky bluegrass exhibited a very acceptable turf stand through the test period. Pennstar and Victa also had comparatively good performance.

In summary, in an area with a salinity reading exceeding 11 milimhos per cm., most varieties of perennial ryegrass performed favorably whereas all varieties of red fescue and colonial bentgrass gave poor turf quality. Varieties of Kentucky bluegrass ranged in performance from quite good to very poor under the conditions of this test.

Appreciation is extended to Mr. Frank Green, golf superintendent, San Leandro Marina Golf Course, and the City of San Leandro.

TABLE 1. 1973 **turf scores for cool season varieties at Marina Golf Course, San Leandro, and the associated statewide variety average.**

Variety	San Leandro Average	Statewide Average
Kentucky bluegrass		
Campus	4.2	5.9
Common	4.3	5.9
Cougar	4.9	6.9
Fylking	6.5	7.1
Merion	1.7	6.4
Newport	4.5	6.3
Park	5.2	6.4
Pennstar	5.9	6.9
Prato	3.8	6.4
Victa	5.8	7.2
Windsor	4.0	6.9
Species Average	4.6	6.7
Colonial bentgrass		
Astoria	3.6	6.2
Highland	3.0	6.4
Holfior	3.9	6.2
Species Average	3.5	6.2
Perennial ryegrass		
Common	5.5	5.8
Kg-123	5.6	6.2
K9-124	3.6	—
Manhattan	6.5	6.6
NK-100	6.3	—
NK-200	4.9	6.1
Pelo	6.6	
Species Average	5.6	6.4
Red fescue		
Chewings	2.4	5.7
Highlight	3.0	5.4
Illahee	3.2	5.8
Pennlawn	2.8	5.8
Ruby	3.2	5.7
Import	3.1	—
Reptans	2.9	
Species Average	2.9	5.7

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ESTABLISHMENT AND EARLY CARE OF TREES-Part II*

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In the Winter, 1977, issue of California Turfgrass Culture, Part I of this article covered the topics of 1) protecting plants prior to planting, 2) preparing the planting hole, 3) planting trees in paved area, 4) and setting the plant. This article will complete the topic as presented by Dr. Harris at the 1976 Turf and Landscape Institute.

Staking. If staking is necessary, it may be easiest to plant the stake(s) with the tree (7). However, a young tree standing alone with its top free to move usually becomes a strong, well-proportioned tree better able to withstand the elements. In comparison to a rigidly staked tree, an unstaked tree will have these characteristics:

Greater caliper at the trunk base;

Less wind resistance when trees are of equal height

Greater trunk taper;

Less wind resistance when trees are of equal height because the top is free to bend;

More uniform distribution of stress along the trunk than having it concentrated at the support point;

More uniform xylem tissue (wood) for supporting the trunk upright;

No rubbing or girdling injuries; and

A larger root system.

Every one of these influences better enable an unstaked tree to support itself. In addition, stakes are expensive and usually quite unattractive.

Trees may be divided into three classes according to staking needs.

Protection Only. Many trees do not need and should not have support stakes. Most conifers, trees with upright growth habits, and trees planted bare root usually do not need staking. Trees having tops that are large in proportion to their roots may be an exception, although many of these can stand alone with some thinning out of branches in the crown. Remove up to one third of the branches or laterals to reduce crown weight and wind resistance.

All trees must be free of kinked and girdling roots that weaken the trunk at ground level where strength is most needed. Trees with girdling roots often grow poorly or break at the ground line.

Tree trunks of this class need protection from lawnmowers and other equipment. Three stakes are better than two for this purpose.

The stakes should be tall enough to be easily seen to prevent tripping and so vehicles need not hit them. Place the stakes at the edge of the root ball, 6 to 8 inches from the trunk.

Conifers with low limbs do not usually need protective stakes.

Root Anchorage. Well-anchored roots are essential if newly planted trees are to grow with upright trunks. Roots may not grow fast enough to anchor the tree before the top has such a dense head of foliage the tree cannot stand upright-especially in a wind. The frequent irrigation required for young trees adds to instability of the root system. If the root system is not well anchored, trunk movement may break the new roots growing out of the root ball into the surrounding soil.

The two or three short stakes suggested for protecting tree trunks not needing support can usually provide enough anchorage for the roots. Ties from each of the stakes to the trunk will usually be enough to keep the roots firmly in the ground but the top may need thinning to decrease its wind resistance and weight.

In most cases, these ties should be removed by the end of the first growing season. The stakes can be left to protect the trunk.

Trunk Support. Many newly planted trees are not able to stand upright without some support. This is particularly true of those previously staked, grown close together, or with their lower branches shaded or removed. The tops of these trees should be as low on the trunk as possible but high enough so that the tree will return to upright after deflection. To find the proper height, hold the trunk in one hand, pull the top to one side, and release. The height at which the trunk will just return to upright when the top is released is the height at which to attach the ties. Use two or three support stakes and tie the trunk to them.

Usually, support stakes are required through the first season. At the beginning of the dormant season, untie deciduous trees to see if they can stand alone. Because of winter storms, do not lower or remove the ties on evergreen trees until just before growth begins in the spring. Thinning the tops will improve their ability to stand alone. If they still need support, check the tying height as described earlier in this section. After lowering or removing the ties, shorten the stakes so they do not rub against the trunk. The ties can probably be removed by the end of the second growing season.

If not, check for these possible causes:

-Too little top thinning to reduce weight and wind resistance.

-Too few laterals along the trunk for adequate increase in caliper.

-A weak root system due to girdling or kinked roots.

Pruning. Light pruning of newly planted trees and shrubs will better balance the top and the root system. Even if no roots are removed in planting, the top may have such a large leaf area that frequent watering will be needed to prevent wilting. The size of the top does not have to be reduced in apparent size. Thinning out branches that are close together, crossing one another, or

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broken can remove considerable leaf area without affecting overall plant size. One-fourth of the leaf area can be removed from most plants with little visual effect on the plant except one of improvement.

The plant should be carefully examined to see that the basic branch structure is the one desired. If not, begin the necessary pruning (6).

Care following planting. Deciduous trees planted bare-root that were thoroughly irrigated at planting should not need irrigation until two to four weeks after growth begins. The soil will be at field capacity with roots actively growing into moist soil while the top has few leaves. Over watering is a real danger during this time, creating a condition that may restrict root growth and function.

On the other hand, container-grown plants, both deciduous and evergreen, may require rather frequent watering depending on the soil texture, the weather and the size of the top (leaf area) in relation to the size of the root ball. Even though most container soils are coarse textured, the shallow depth of most containers prevent the moisture content from going much below saturation following irrigation (2). However, when container plants growing in the usual coarse-textured mix are transplanted into soil of finer texture, water previously retained in the root ball will be drawn into the surrounding soil until moisture tensions are equalized. The soil of the root ball may be close to the wilting point even though the surrounding soil is at or even above field capacity. Costello and Paul (1) found that 80% of the available moisture in the soil mix of a gallon-can plant newly planted in a loam soil was lost within 24 to 36 hours following flooding. Stated another way, if a plant in a gallon-can can go two days between irrigations before wilting, it would need to be irrigated at least every day when first planted in the landscape.

At first, only enough water is needed to rewet the root ball. As the root system increases in size more water can be added to the basin and the interval between irrigations increased. If the plants can be observed frequently, delaying irrigation until the first sign of wilting of one plant will give a good indication of the maximum interval between irrigations for the next few weeks. Intervals after that should be more frequent depending on the weather.

If the plants were not fertilized at planting, they will probably respond to nitrogen applications. Apply nitrogen fertilizer to the soil surface in the basin from 0.05 to 0.10 pounds nitrogen per tree. A number of slow-release nitrogen sources are available as well as organic forms. If readily-available inorganic-nitrogen fertilizers are used, apply twice at the lower rate six to eight weeks apart.

If trees are planted in lawn areas, the turf should be kept away from the trunks during the first two to four years (4, 8). The growth of young trees is retarded by grass growing close, even though additional water and fertilizer are applied. A 30-inch diameter circle or square of bare soil at the base also will reduce damage to the trunks by lawnmowers. Mechanical damage to the trunks of young trees can have a severe dwarfing effect.

A mulch in the basin will reduce moisture loss, moderate surface soil temperatures, reduce sealing of the soil surface and reduce cracking. Coarse organic material, e.g. wood chips, bark, forest litter, or other available material is commonly used, Coarse gravel, small rock or plastic can also be used. A mulch may not be satisfactory for trees in turf since the mulch may get on the lawn and be a hazard for lawnmowers. The mulch should be one to two inches thick. A mulch stays in place better under sprinkler than flood irrigation.

Herbicides need to be used with caution in tree basins. Contact weed sprays can injure the thin bark of most young plants. Pre-emergence herbicides can be quite useful, but careful control of the rate of application is necessary. Follow the manufacturer's directions closely to prevent accumulation in the bottom of the basin that could be toxic. Plant sensitivity should also be checked before using a particular herbicide.

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UC TURF CORNER

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DO FESCUES HAVE A PLACE IN BLUEGRASS TURF?

When healthy, fine fescues can be quite attractive. They are able to persist in shade under trees and on dry, poor soils where most other grasses fail. For these reasons, glass seed mixtures formulated for shady areas traditionally have included large percentages of fine fescues.

In recent years, however, with the trend toward higher maintenance, including frequent mowing, fertilizing and mowing, the fescues have lost some of their appeal. Under these conditions, prolonged summer heat can result in the death of large patches of fescues in pure stands or a big reduction in the fescue component of a bluegrass-fescue mixture. In view of the current trend toward high-maintenance operations, how does the future look for fescue/bluegrass mixtures?

Dr. John Thorne of Washington State University points out that the Chewings fescues are too aggressive for all but a few aggressive bluegrass varieties even at only 15-20

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percent by weight. The resulting turf often is quite variable in texture, with alternating clumps of broad-bladed, dark green bluegrass and fine-bladed, light to medium green fescues. The spreading or creeping red fescues, when blended with bluegrasses, produce turf that often has reduced sod strength as well as less than desired shade tolerance, disease resistance, and stand uniformity.

If fescues have a place in today's high-maintenance bluegrass turf, the Washington State University researcher says, it would seem to be as a minor component-the exact percentage and variety depending upon the type of fescue, aggresiveness of the bluegrass variety, and type of growth conditions expected. At best, he adds, fescues would contribute only a measure of shade and possibly drought tolerance to the blend of bluegrasses (but also a safety factor should the high maintenance lawn someday revert to a low maintenance lawn, under which conditions red fescue will quickly dominate-even if only as 10 percent of the original bluegrass-fescue mixture.)

("Do Fescues Have a Place in Bluegrass Turf," by John Thome, Northwest Turfgrass Topics, Vol. 19, No. 3, December 1976.)

NITROGEN LOSSES FROM GOLF GREENS CAN BE REDUCED

Use of organic and slow-release nitrogen sources, light applications of soluble, nitrogen sources and controlled irrigation will help reduce nitrate losses in golf greens constructed to USGA specifications, say Texas A&M University researchers.

They recently concluded a study aimed at determining the amount of nitrate lost from golf greens. Individual isolated golf greens 10 feet on a side with gravel undergrains were constructed on a subgrade. The drains as well as the runoff collection troughs of greens with low infiltration rates were fed into collection barrels. Top mixtures included pure sand, sand-soil-peat mixtures which met USGA specifications, and a fine sandy loam soil typical of many older greens. Treatments were designed to provide information on nitrate losses due to the nitrogen source in the fertilizer, the time between fertilizer applications, the amount of irrigation or rainfall, the infiltration rate of the greens mixture, and the season of the year (soil temperature).

When soluble forms of fertilizer, including ammonium nitrate and ammonium sulfate, were applied, high concentrations of nitrate were found in the leachate from all greens. The concentrations were highest and occurred earliest in the greens constructed of sand alone. As much as 22 percent of the applied nitrogen was lost during the first three weeks after application, and concentrations in the leachate reached over 300 parts per million for periods of two weeks. (Such concentrations are six to seven times the permissible limit for drinking water and constitute a pollution hazard as well as a significant fertilizer loss.)

When organic or slow release forms of fertilizers, including IBDU, urea formaldehyde and sewage sludge were applied, the concentrations of nitrate found in the leachate were always low, and the water met Environmental Protection Agency standards for drinking water.

Based on the results from their study, the Texas researchers say that application rates for soluble nitrogen fertilizers should not exceed 1/2 pound per 1,000 square feet per application.

More nitrate was lost from ammonium nitrate during the winter when the grass was nearly dormant (under Texas conditions) than during the summer. Seasonal trends for the other sources were less evident. The amounts lost always increased as the application rate increased.

("Nitrogen Losses from Golf Greens," by K. W. Brown, R. L. Duble and J. C. Thomas, USGA Green Section Record, January 1977.)

EFFECT OF CUTTING HEIGHT AND NITROGEN ON IMPROVED PERENNIAL RYEGRASSES IN MONOSTANDS AND POLYSTANPS

Results from University of Massachusetts studies indicate that the competitiveness of new turf-type perennial ryegrasses is dependent upon their companion grass. When seeded in mixtures with Kentucky bluegrass, the new ryegrasses tested were persistent at cutting heights above 1.90 centimeters. In mixtures with creeping bentgrass, the ryegrasses responded as temporary grasses.

The growth and persistence of three perennial ryegrasses were evaluated in the greenhouse and growth chamber in monostands and in polystands with "Merion" Kentucky bluegrass and "Penncross" creeping bentgrass.

Cutting heights were 1/2, 1, 1 1/2 and 2 inches. Ryegrass tillering was greatest at the 1/2 inch cut, while no differences in tiller numbers were detected between 1 and 2 inch cut levels. All ryegrasses competed well in bluegrass sod at cuts of 1 to 2 inches but did not grow well in the bentgrass regardless of the cutting height.

In two field studies, several ryegrasses were seeded 25~75 (seed number basis) with Merion Kentucky bluegrass and 50:50 with "Seaside" creeping bentgrass. Mowing and nitrogen treatments were imposed on the various mixtures in both studies. "Manhattan" and "Pennfine" rygegrasses were most competitive during establishment and most persistent over 23 months in bluegrass mixtures. Shoot densities of the ryegrasses were not affected by cutting height or nitrogen treatments, but bluegrass density was. When seeded with' bentgrass, Manhattan and Pennfine were most competitive during establishment, but no ryegrass cultivar composed more than 14 percent of the stand after 23 months. Low cutting height and high nitrogen improved the competitiveness of the bentgrass but not that of the ryegrasses.

("Cutting Height and Nitrogen Effects on Improved Perennial Ryegrasses in Monostand and Polystand Communities," by R. N. Carrow and J. Troll, Agronomy Journal, Vol. 69, No. 1, January-February 1977.)

INDIRECT EFFECTS OF A THATCH-INDUCING HERBICIDE ON TURF SOIL PHYSICAL PROPERTIES

Back in 1975, University of Illinois researchers noted that use of calcium arsenate or bandane herbicides on Kentucky bluegrass turf induced thatch development and that the treated plots were devoid of earthworms, even though earthworms were numerous in untreated plots. They also observed increased wilt tendency and disease incidence in the treated turf.

Following up on that work, they have conducted another study to determine the effect on the physical properties of sdil when thatch is induced under turf by use of calcium arsenate herbicide.

Evaluation methods included: (1) the falling-head, flooding method for measuring water infiltration in the field; (2) the constant head procedure for measuring hydraulic conductivity in the laboratory; (3) a modified procedure using Tempe cells for determining soil water retention characteristics; (4) the core method for measuring bulk density; (5) a modified Walkley-Black method for determining organic matter content.

Infiltration rate and hydraulic conductivity were found to be lower for the calcium arsenate treated soils than for untreated soils. Treated soils had a higher bulk density, stored less water in the 0 to 1 bar tension range and were lower in organic matter than the untreated soils. The marked alteration of soil physical properties observed to follow calcium arsenate treatments is significant for turf management, according to the Illinois scientists who conducted this research.

("Indirect Effects of a Thatch-Inducing Herbicide on Soil Physical Properties under Turf," by I. J. Jansen and A. J. Turgeon, Agronomy Journal, Vol. 69, No. 1, January-February 1977.)

ALL ABOUT THATCH IN BERMUDAGRASS TURF

Researchers at the Texas Agricultural Research Station recently reported on results of studies focused on the identification, cause and effect and control of thatch in bermudagrass turf. Here's a summary of what they had to say:

In bermudagrass turf, thatch consists of a layer of stems and roots entwined in partially decayed leaf, stem and root tissue between the soil and the green leaves. This thatch layer is characterized as being fibrous in nature and highly resistant to microbial breakdown. As the thatch continues to accumulate, decomposition is further retarded by the increase in lignin content which renders much of the thatch layer inaccessible to microbial breakdown.

Thatch samples were collected from bermudagrass turf throughout Texas to characterize its chemical makeup. Undisturbed sod plugs including at least 1 inch of soil were collected from golf greens, tees, fairways, parks and lawns. They were analyzed for their cellulose and lignin content. A similar investigation was conducted on 150 bermudagrass selections grown under uniform management. Clippings from them were analyzed for their lignin and cellulose content. The objective was to relate thatch accumulation to either cellulose and lignin content of the grass or a ratio of lignin to cellulose.

The thickness of the thatch layer averaged 0.7 inch. Lignin content of the bermudagrass was a mean of 23.2 percent. In contrast, bermudagrass clippings averages only 4.1 percent. Accumulation of lignin in the thatch layer was attributed to its resistance to microbial decomposition. Cellulose content of the thatch was an average of 11 percent, whereas bermudagrass clippings had a mean cellulose content of 23.3 percent. According to the Texas researchers, this indicates that cellulose is readily decomposed by soil microbes. The relationship between lignin and cellulose was found to be the same for all locations and all varieties.

In another experiment, the effects of several fungicides and a growth retardent on thatch accumulation were studied. Results suggested that preventative fungicide programs may have a significant effect on thatch accumulation in bermudagrass turf. Fertilization programs may need to be adjusted to reduce thatch when preventative fungicide programs are essential, according to the Texas researchers. Where a fungicide is used routinely, they add, it is indicated that lower nitrogen rates should be used.

Results from the study also suggest that a slow-release form of nitrogen applied at a level to maintain acceptable aesthetic quality and to avoid excessive plant growth may reduce thatch. Also, since clipping residue did not greatly increase thatch, allowing grass clippings to fall to the surface may be a feasible management practice, one which would allow a recycling of plant nutrients and eliminate the clipping disposal problem.

("Identification, Cause and Effect and Control of Thatch in Bermudagrass Turf," by R. L. Duble, V. H. Meinhold, and F. B. Riley, Jr., Turfgrass Research in Texas, Consolidated PR-3X4-3376, March 1976.)

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